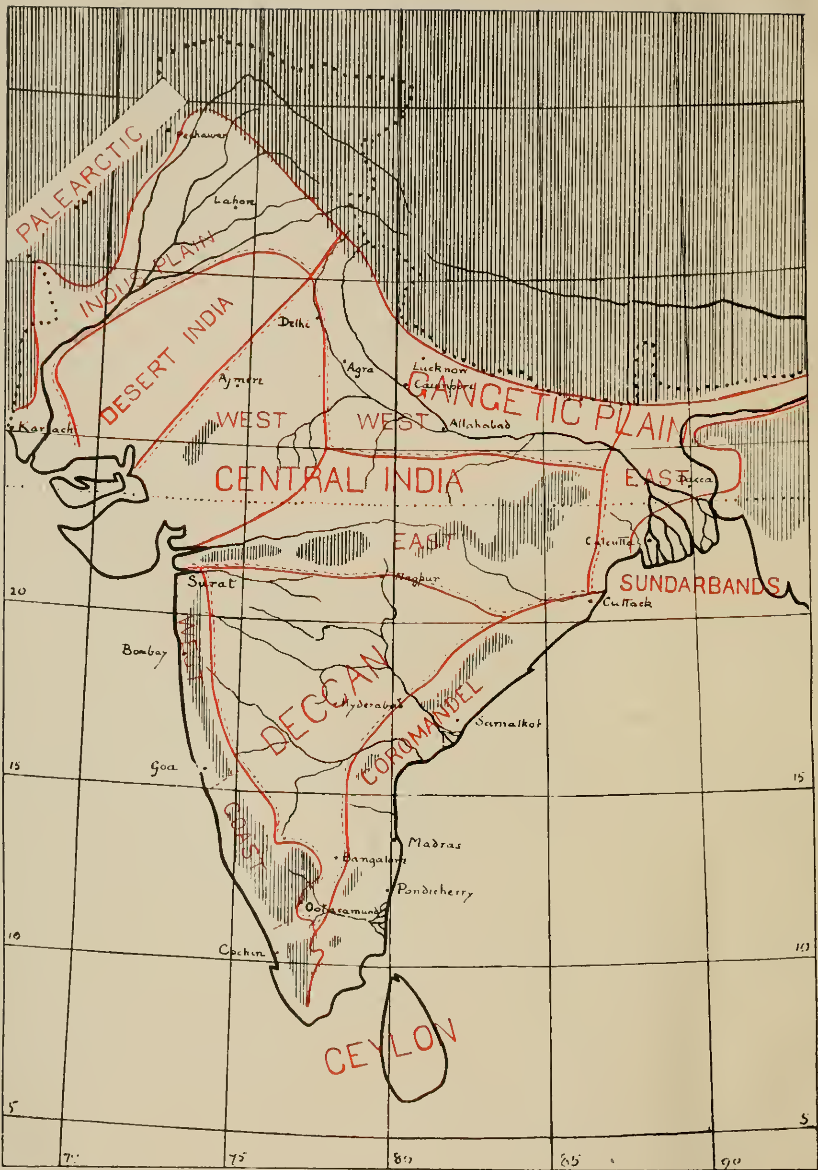
Indian Insect Life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INDUS PLAIN
DESERT INDIA
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Lahore
Delhi
Agra
Lucknow
Cawnpore
Ajmere
Karachi
Allahabad
GANGETIC PLAIN
WEST
WEST
CENTRAL INDIA
EAST
EAST
Dacca
Calcutta
SUNDARBANDS
Cuttack
Surat
Nagpur
Bombay
WEST
DECCAN
Hyderabad
COROMANDEL
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Bangalore
Pondicherry
Ootacamund
Cochin
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FRONTISPIECE.

Map of India.

The black shading indicates the Himalayan and Palearctic portions to the North and, in India, areas above the dividing line of tropical and sub-tropical India, usually above 2,000 feet. The dotted black line to the North is the political boundary, inclusive of Cashmir and Sikkim. The red lines and lettering indicate the faunal zones of Tropical India as described in the Section on Geographical Distribution below. The dotted lines dividing the West Coast indicate probable sub-regions and correspond to the Palghat and Goa gaps in the Ghauts. Sub-tropical faunal zones are not indicated.

INDIAN INSECT LIFE

A MANUAL OF THE INSECTS OF THE PLAINS

(TROPICAL INDIA)

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[**Published under the Authority of the Government of India**]

AGRICULTURAL RESEARCH INSTITUTE, PUSA

CALCUTTA & SIMLA
THACKER, SPINK & CO
W. THACKER & CO., 2, CREED LANE, LONDON

1909

PRINTED BY
THACKER, SPINK AND COMPANY, CALCUTTA.

To
My Mother

"Plus je connais les peuples,
Plus j' aime les insectes."

ACKNOWLEDGMENTS.

The sections on *Mallophaga, Diptera, Cimicidæ* and *Anoplura* have been prepared by Mr. Howlett, and the Interlude on Insects and Flowers by Mr. I. H. Burkill, Reporter on Economic Products. Illustrations marked I. M. N. are from the stock of drawings accumulated by my predecessors in the Indian Museum, and used in Indian Museum Notes. Those marked F. M. H. have been drawn by Mr. Howlett, who has directed the preparation of those illustrating the sections he has written. Where not otherwise acknowledged, all the plates and illustrations are the work of the Artist staff of this Institute under my or Mr. Howlett's direction : it may be pointed out that these artists are wholly Natives of India, trained in Art Schools of this country ; it is needless to emphasise how much the book owes to their beautiful work as also to the enterprise of the publishers, who have done the work of reproducing all the illustrations in this country. I wish to specially express my appreciation of the work of Mr. Slater of the Calcutta Phototype Company in the printing of the Colour Plates, carried out under very trying climatic conditions and for the first time in this country.

As regards the text, it is, where not stated to be a quotation, original ; I have acknowledged every direct source of information. The book owes something to the work of my staff, since it is based on the Pusa collections to which they have contributed specimens and observations. I have acknowledged this where I can. The volume is largely a product of my spare time and scanty holidays ; such a volume has been so much required that I have felt that even an imperfect one was better than none. Six years ago the work of this section commenced and if the book contains imperfections, the critic will recognise that it is based on collections, observations and reference books that have been accumulated only in that short time ; I shall be glad if those who see omissions or errors will point them out, as it may be that a better volume will be built up on this basis, when the study of Indian Entomology is further advanced. I may also emphasise the fact that where little is said, little is known and the blanks in the book are

designedly prominent to emphasise the enormous scope there is for work. I trust also that the volume may be a real stepping-stone to better things and may help those who are advancing our knowledge of the insect life of India.

PUSA :
June, 1909.

H. M. L.

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SCHEME OF CLASSIFICATION.

The following is a complete list of the families into which insects are divided, tabulated under orders. The families in heavy type, thus **Forficulidæ** should be familiar; those in ordinary type, thus Campodeidæ, are of smaller importance but occur in India: those in italics, thus *Smynthuridæ*, are not yet known to occur in India.

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INDIAN INSECT LIFE.

INTRODUCTION.

THE insects are tracheate, hexapodous arthropoda, with a distinct head bearing antennæ, with a great degree of complexity in their development during which a series of moults are undergone, culminating in the appearance of functional generative organs and wings; in the higher forms, the development is sharply divided into three distinct periods, the last of which is marked by the inactivity of the organism as a whole and the complete reorganisation undergone by the tissues; they are essentially air-breathing animals, living on land, but some have become adapted to living in fresh water. The number of jointed legs separates them clearly from other tracheate Arthropods, just as the metamorphosis, the possession of wings and the form and the number of segments does. They are regarded as being most closely related to *Peripatus* of all present forms of life, and undoubtedly represent a great branch of the tree of life whose development equals, if not excels, that of any other branch. In numbers, in species, in all but one form of mentality, the insects are the dominant form of life on the land at the present time, but the limitations put on them are of such a nature that their dominance must remain within bounds and, unless man be removed, cannot be actual and entire.

Insects are of all sizes from $\frac{1}{50}$th inch long to over six inches; their numbers are incalculable, the number of their species being put at about three millions; their lives are very short, (a week,) up to as long as over ten years, though rarely actually exceeding more than three years, and being in the larger number limited to an active life of less than three months. On the surface of the earth, as in fresh water, they are found wherever nutriment is available, even in the bodies of warm-blooded animals and man; over the three-fourths of the earth's surface covered by the sea they are practically non-existent, a very small number of species being able to support life near, in or on the sea. Their position in the animal world is shown in the table :—

PROTOZOA.
PORIFERA (Sponges).
CŒLENTERATA (Anemones, etc.).
CTENOPHORA (Jelly-fish, etc.).
ECHINODERMATA (Sea-urchins and starfish).
VERMES (Worms).

POLYZOA.
ARTHROPODA.—Crustacea (Lobsters, etc.)
Prototracheata (Peripatus).
Myriapoda (Centipedes and millipedes).
Insecta (Insects).
Arachnida (spiders, mites, scorpions, etc.).
MOLLUSCA (Snails, etc.).

BRACHIOPODA.
CHORDATA.—Hemichordata.
Tunicata.
Cephalochordata.
Craniata. Cyclostomata.
Pisces (Fish).
Amphibia (Frogs).
Reptilia (Snakes, etc.).
Aves (Birds).
Mammalia (Mammals).

Economically, the insects are the most important group of animals next to the Mammals, Birds and Fishes. Their activities affect man daily, either from the nature and extent of their injuries to economically valuable plants, or to domestic animals, or to wild animals, or to stored produce, or from their value in yielding useful products; or from the part they play in the economy of nature, in fertilising flowers, in scavenging and cleansing the earth, in rendering waste matter available as plant food, in preserving the condition of the soil and in furnishing food for birds and fishes.

INSTINCT AND HABIT.—What is the life of an insect? In what way can it be compared with our own or with the life, for instance, of any of the animals familiar to us? No answer can be easily given, for the senses, the instincts, the modes of expression of insects are so totally diverse from our own that there is scarcely any point of contact. In the case of mammals, of birds and to some extent of reptiles, we have in the eyes, in the features and in the movements, a clue to their feelings, to the emotions that sway them, to the motives that guide their actions; in insects we have none, and the great index of insect feeling, the antenna, has no counterpart in higher animals, and conveys nothing to our uninformed brains. We can judge then only from the movements of insects, from their actions, and this is so extraordinarily meagre a clue that it is not surprising that even the greatest familiarity with the life of an insect inspires no feeling that one has to do with a live organism having feelings and passions, having motives and a will, but suggests that one has before one a beautiful machine, tuned to respond mechanically to certain outside stimuli, to answer to particular influences and to behave in all things as a perfect mechanical structure; even the highest, the social insects and the fossorial wasps, inspire no other feelings, give one no sense of any relations between the individual insects but those mechanical ones concerned with daily life, and leave one with the conviction that the mentality of the higher animals is wholly absent, that no smallest trace of the emotions, of the will, of the thought processes of ourselves or other mammals, have any part in the lives of insects. Yet there are events in the lives of insects which, for a brief moment, impress us with the conviction that individuality, emotion and feeling may play their part; and though we see this exceedingly seldom, the few suggestive phenomena may be sufficient to warrant the assumption that in ways we cannot comprehend, in channels that are beyond our ken, the living active insect is in touch with every other living insect in its environment, by mental and physical processes that make no outward sign, that may proceed independently of any external sense organ that we can see or study and which possibly pass from mind to mind with no outward physical action or movement; what occurs when bees swarm, when locusts swarm, when the white ants emerge from the nest, when a stray bee from one nest enters another and is promptly attacked and killed? Are these wholly due to reflex actions and mechanical instincts, or are they the product of an individual will and mind in each and every insect; a locust swarm may be the product of a blind impulse sweeping over a host of insects just as a blind impulse ranges through a crowd of human beings by means which are certainly not normal or in daily use; the emergence of the flying ants suggests a similar blind impulse, an unreasoned compliance with fixed instincts like the blowing up of a boiler when certain physical conditions are arrived at; do the ants have councils and decide when the nest shall be moved to a new locality, or is it simply the common impulse of the community, simultaneously born of the same reaction to certain physical conditions? So wide apart are our senses from those of insects, so divergent are our means of expression, and the mechanism of our bodies, that no answer can be given to these questions; we cannot establish any connection with the individuality of insects, we can get no common basis of thought, no possible means whereby even to "tame" them or to get even so little response to our efforts as a tame bird will give. To us, the closest study of large numbers of the same species reveals no individuality, nothing but a mechanical sameness in a large number; perhaps this is because we cannot get near enough; to the ordinary man, sheep are sheep and while differing in small points are alike; to the shepherd they are as individual as human beings and have a similar mental individuality; I have never seen that this was the case with insects, and none that have been kept in activity, fed, cared for and most closely observed, have shown more than very small traces of individual mentality or even responded to advances. (That this is not the view every author takes is evident from the writings of naturalists who state that butterflies in particular become tame and welcome their captor's visits; but these cases are not sufficiently numerous or well authenticated to be valid.) It is not unreasonable to consider that, in freedom and living under natural surroundings, nearly every insect is solitary; an individual insect appears to take no notice of any other, save such as it may prey on or parasitise; it goes about its business of food-getting and the like, it makes no smallest sign that it is aware of the existence of any other insect, and so far as can be judged from its actions, is leading an absolutely and wholly solitary life; there are exceptions, of course, but very few; the social insects are apparent exceptions, but even there it is extremely doubtful how far individuals are not isolated; they work together it is true, but in a manner that suggests two machines under the same controlling conditions, not two sentient reasoning organisms acting in agreement due to any mental process. The same is true of termites, of locusts, of all the social insects which exhibit such wonderful phenomena. The Pyrrhocorid *Iphita limbota* is gregarious and lives in colonies on the bark of trees; is there any communication, any individuality, any mental process other than a blind reaction to some outside stimulus, under which all alike find that a particular spot is perhaps the warmest or the best suited for some such reason? There are other exceptions which are perhaps more valuable; the courtship of butterflies is a beautiful thing, suggesting two perfectly happy beings enjoying to the full the delights of each other's company and the perfect happiness of the crowning moment of life; there is no doubt of their being aware of each other's presence, but the cold thought creeps in that it is after all a mechanical process, born of peculiar instincts, with nothing more "living" than the reaction of two parts of an engine. The dances of flies and other small flying insects suggests mentality, social insects thoroughly enjoying each other's company and the extraordinary pleasure that human beings find in concerted movement; it is possible that we can compare insects with ourselves in this respect, but the balance of evidence is certainly against it; one comes inevitably to the feeling that insects are a supreme expression of living matter adapted and co-ordinated to physical conditons, responding perfectly to mechanical stimuli, without mind or mental processes as we know them and as we can see them in birds and mammals; they are the highest expression of life as evolved by natural processes, perfect machines without emotions. No thinking man questions the existence in higher mammals of mind-processes akin to our own if far lower, of some slight evidences of that higher mentality we call the soul, and which we hold to be the essential life, for which the objective life and the material body is but a case. No one would credit an insect with such forms of mentality, and the most sympathetic student of insect life has not advocated such a point of view. An insect is a living machine, responding to definite physical stimuli, with well-defined and very complex instincts, which are mechanical forms of mental action and take their origin in outward conditions. Were they possessed of higher forms of mentality, such as reason, judgment, volition and the like, no one can say what might be the course of the world's history; a combination of the red ants (*Œcophylla smaragdina*) could probably drive human beings out of India and render the continent uninhabitable to any form of life inimical to them ; an organised campaign of the common black ant (*Camponotus compressus*) could effect a great deal and human methods of warfare would require to be revolutionised to deal with it.

In practice we can consider insects as consisting of organisms whose actions will be definite responses to stimuli, whose movements and activities will, under the same circumstances, be the same ; given the same conditions, all the individuals of a species will behave alike with only very minute variations which we have great difficulty in seeing. If we find that one of a species has a certain definite life history we are safe in concluding that under the same circumstances all of that species will have the same life history and that with a given departure from normal circumstances all will behave alike ; when we have worked out the life history and habits of one of a species, we can confidently assert that all will have that life history, with only small variations due to changed conditions ; a leaf-eating caterpillar that feeds on maize leaf in Behar, might quite well feed on juari leaf in Gujarat where maize is not grown, but it would not, for instance, become a borer in the Punjab and a predaceous caterpillar in Madras. We may, therefore, treat a species as an individual, and not expect to find different habits in different individuals of the same species. At the same time we must allow for the variation consequent on changed conditions ; the limit of adaptation to changed conditions is a very variable one ; as an example, many caterpillars have but a very few foodplants and cannot live on others ; a few have many, and the Gram Caterpillar (*Chloridea obsoleta*) feeds on the seeds of gram, the heads of opium poppy, the heads of bajra or sunflower and a variety of other plants ; in the United States it is the boll worm feeding on the seed of cotton and accordingly has slightly different habits ; in this there is a certain amount of variation in habits due to changed foodplants. Such cases are frequent, but the variety of habits lies within perfectly clear and definite limits, varying slightly from species to species. On the above reasoning, a species is definable not only on structural characters but also on its habits and mode of life ; if we look on a species as composed of individuals reacting mechanically to stimuli, with a limited play of adaptation to changing conditions, habits and mode of life are as much specific characters as is structure ; if our structural distinctions are sound, they will be in agreement with habits and life history, and the one aspect is as important as the other. Our knowledge of structure is far greater than our familiarity with the habits of insects, but the latter will increase. It is all important for the student to grasp clearly from the beginning that a "species" is a distinct individual as much in habits, mode of life and all details of its life as in its colour, form, or any structural detail on which it is declared to be a distinct species. We are here far more concerned with the living insect as a living reality than with the dead shell on which its place in the insect world is determined and on which it is described and named; the characters of the living insect, its method of flight, its walk, its feeding habits, its expressive antennal movements, all the details of its daily life are of as great value as its structure and are of far greater importance to us in these pages; a realisation of this fact and an understanding of what a species really is, must come to every student sooner or later if he is to become anything more than a systematist and a classifier of insects on purely structural details; the individuality of a species is as much discernable in the field as in the museum and takes in every detail of the insects life. For that reason, we have considered this abstruse point at some length and we would emphasize the point of view given, though it may seem at first sight an incorrect one. Variations in habits between two members of a species are so small that what we find out of a single individual, applies to every individual of that species with due allowance for variable conditions; a very large part of our work lies in determining how far different conditions modify the habits of an insect and the limits of this variation are becoming clearly established; if, therefore, the habits of an insect are observed in Peshawar, we know that the individuals of that species will have in the main the same habits at Madras, that we can predict the variations likely to be found, and that if we knew enough we could absolutely say how far they would differ.

We may touch very lightly upon one more point; whence come the instincts and beautiful habits of our present-day insects? According to the accepted theories of evolution, insects, like other animals, are descended from more primitive forms of life which existed in earlier geologic periods; if we imagine the primitive types of insects being evolved and multiplying, and supposing them to feed on the abundant decaying vegetable matter, we shall get a great development of simpler forms scattered over large areas of land, and living in a diversity of physical conditions; remembering their less specialised and complex structure, we can see that the influence of altered conditions might produce great variations in structure, in habits, in life history; the pressure of competition would arise, supposing there were fewer checks; (what checks there may have been is doubtful but both parasitic and predaceous insects, as well probably as insectivorous birds arose later and these are now the main checks); some, from feeding on decaying vegetable matter, might come to feed on decaying animal matter, with a consequent change of habits, of structure, of senses, possibly of life history; others might find growing plants provided an ample supply of food and their descendants gradually get modified to suit these circumstances; in time we can imagine some becoming predaceous, the descendants perhaps of insects that fed on dead insects; we can still see the stages between land and aquatic insects, and it requires little imagination to picture the necessary gradations from an insect feeding on decaying leaves by a riverside, to one that entered the river water and found its food there. Given a plastic structure capable of modification, granted growing competition and a free unoccupied field, one can readily see how, in earlier ages, the various groups may have arisen; with the altering conditions of successive geologic periods, with the evolution of higher plants and animals, with alterations of climate and natural conditions, one can realise how the diversity of forms of insect life would be evolved. That this has occurred with other forms of life one can read; that the steps cannot be traced so clearly in insects is due to the imperfection of the geological record, insects being small, soft and not so fitted for preservation as are bones or shells. Granting that in previous ages this occurred, and seeing the present dominance of insect life on the earth and in fresh water, it is easy to see that the competition might be so severe that more and more complex structures, instincts and habits might be evolved leading steadily away from plasticity to more and more fixed and unalterable types; the more primitive and simple insect feeding on decaying leaves, having simple biting mouthparts, laying eggs in the ground, requiring no special colouring or protective devices disappeared; predaceous insects require more complex trophi; quick flight necessitates better wings and a more consolidated thorax; protection from birds implies protective attitudes, colouring or form, and may require possibly the nocturnal habit, which implies better sense organs; all crystallises down to a specialised form with fixed instincts. So too, for instance, with parasitic insects, the new habits imply new structure, the petiolate body and the ovipositor are developed to lay the eggs, and with the necessity for flying by day comes warning colouring and unpleasant taste or odorous glands, since birds are developed also and are taking to eating insects. Consider a Sphegid catching live insects, paralysing them, laying them up for its young; imagine the development of such forms, the gradual acquirement of more and more perfect structures, and with them of more and more fixed instincts till we have the perfect insect, with intensely modified life history, with fixed and complex structure and with nearly *all plasticity and power of change gone.*

This is the point I wish to make; we are now at a stage in the earth's history when competition has produced an amazingly complex number of forms of insect life, which adapted themselves to every condition of life but that in saltwater, which have, by the improvement of more and more perfect forms, become increasingly complex, specialised and fixed; variation, except in each special direction, makes for destruction; from the increasing competition plasticity is gone, the forms are fixed and unalterable, and what may once have been forms of active mentality implying some choice, some volition, are now fixed instincts, crystallised reflex and, possibly, voluntary actions. It is true that all are not equally complex or specialised, but I believe it to be true that almost all, simple or complex, are fixed, are no longer alterable except so minutely and so slowly that we can no longer see it. It is questionable whether there is any form with which we could people a part of the earth, say an island, that was absolutely devoid now of insect life, and in which we could see this process of differentiation and specialisation take place, but could we find such a form, could we give it the same free field and let it multiply and increase, we should get a similar differentiation and an ultimate specialisation of equally fixed forms.

The student may read this for himself at greater length in text-books of palæontology, geology and evolution; he must realise it if he is to grasp the meaning and origin of the forms and habits of insects; and in no other group is it so marked as in insects; when we consider the abundance of forms of life in the insect world, their absolutely universal occurrence on land and in fresh water, the extraordinary variety in habits, food and ways of life, as compared with any other group or with all groups together, we can see that in no other class in the animal world is competition so keen, are instincts and habits so fixed, is the whole of life for each species so unalterable and delicate. Insects have lived, have dominated the earth, have become what we see them by carrying to an extreme the principle of adaptation to circumstances, of making the most of natural conditions; man has become what he is, because he has carried to an extreme the principle of adapting natural conditions to himself while only adapting himself to them to a limited extent; the two classes dominate the land, and when man cannot alter the conditions to make life permanently bearable, insects can adapt themselves and do. But in the process man has developed one form of mentality implied in the terms free-will, choice, volition, while insects have become perfect mechanical structures reacting in a definite way to natural forces and stimuli, their lives ruled by fixed and most perfect "instincts."

It is not my intention to give the impression that instincts are *absolutely* fixed but only that they are fixed as compared with the plasticity of earlier insects and as compared, say, with man. There is a certain latitude still, more in some groups than in others, but even in them not much and in the most specialised probably very little. I imagine that such simple forms as *Machilis* are fixed in their simple habits as compared with a Sphegid fixed in complex habits, but to both there is a certain small latitude within which they can still alter. The instincts of a polyphagous caterpillar such as *Chloridea obsoleta* are probably much less fixed and specialised than are the instincts of the caterpillar of *Scirpophaga auriflua*, for instance, and in each case possibly their degree of specialisation, low or high, makes for success, success being purely the ability to get food and lay eggs freely. Some are successful because they are fixed in delicate mechanical instincts, notably the insect-stinging wasps; others are successful because they can adapt themselves still to a limited variation of circumstances, such as food, temperature, etc., and they are still to some extent plastic. But it is a very limited plasticity, little akin to the plasticity of the earlier forms from which our present insect life has arisen.

Classification.—When insects were first studied in some detail, the complexity of the increasing number of recorded species led to a system of grouping, say, the beetles under one title, the moths and butterflies under another, and so on, the insects most obviously similar being put into one group chiefly as a matter of convenience. As the subject grew, the morphological characters of the collected insects were utilised to an increasing extent, and the more the number of known insects increased, the more minute and detailed was this classification. When the evolution theory was accepted, it was evident that every scrap of available information would be required to give data on which to make a natural grouping of insects; what was the origin of insects? from what had they developed? how far had different insects remained for a long period in the same condition, and how far was the evolution either continuing still or had it been continuous up to the recent past? These were the questions to be answered, and the answer is embodied in the present-day system of classification which is believed to be so far natural that it conforms, as far as possible, to the actual developments of insects during the earth's history and does represent actual relationships. On these terms all the members of one group are more closely interrelated than each one is to any other insect not in that group.

In making this classification, there are practically three main sources of evidence: (1) the morphology of the insect in all its stages; (2) the processes of embryological and post-embryological development; (3) the evidence of fossil and extinct insects.

In the beginning, the first alone was utilised, and it is still the main source of information; at first superficial characters were used, then more detailed ones such as the structure of the trophi, finally the fuller evidence afforded by all parts of all stages is being utilised, though this is by no means near completion. The second has been utilised, but not to a great extent. The third has been utilised as far as it is available, but the geological record is scanty, and what there is, is very imperfectly available as yet. There is a great bulk of literature on this question, and it is impossible to more closely enter into the subject here. How little is really known can be gauged from the great changes made in the classification of Heterocera, for instance, as well as from the fact that entomologists have arrived at no definite conclusions which are generally accepted. The most diverse views prevail, and there is no standard classification that is or can be universally employed even if it be admittedly not academically accurate, but sufficiently so for practical purposes. As knowledge grows, as groups are revised, new views are expressed, new systems adopted. This would matter little if there were, for instance, agreement as to one unit, say the family, if it could be decided that Coleoptera, for instance, are a homogeneous group of say 80 families : unfortunately this is impossible at present. Actually, insects are primarily divided or have been divided into primary divisions called orders. Thus Coleoptera are a distinct enough order ; when we go below this, we should have a definite number of sub-orders, each containing a definite number of families ; the sub-family is the next division containing a number of genera. Unfortunately superfamilies, legions, cohorts, tribes, etc., have been used, and it is rare to find all authorities on an order or sub-order using the same classification.

In this volume, we propose to follow the Fauna of India, in using the terms order, sub-order, family, sub-family, division, genus, species, but as classification is not our main object, we can largely simplify the system actually used in the Fauna.

Entomologists have adopted the family as the unit of classification trying to group insects first into divisions which must have had a common ancestor ; on this basis we get nearly 300 families, each of which represents a fairly homogeneous assemblage, derived from one branch of the tree ; the difficulty is greater when we try to group these families to find the main limbs of our tree or to find how many separate limbs we should have, derived each from some lower form of life ; for instance, Lepidoptera are a very homogeneous order, the families derived from one branch ; Orthoptera on the other hand are by no means uniform, and so far as can be seen, the order instead of coming from one branch may really come from three ; none the less, in the absence of sufficient data to find really how many branches there are, the order Orthoptera as here adopted is a very convenient one. Our nine orders are constituted then with a regard both to truth and convenience and a student should think in terms of families, grouping these families into aggregates which we may call sub-orders and orders.

In practice we have to utilise a conventional system that embodies as much truth as possible and which is reasonable for working purposes.

Of the nine orders we adopt here, seven are generally accepted by entomologists, but there is great divergence of views over the *Neurop-*

tera. With regard to this, the following tables show the terms used by other authors :—

Orders.	Sub-orders.	Families.	Smith's orders.	Woodworth's orders.
	Mallophaga.		Mallophaga.*	
	Pseudoneuroptera	Embiidæ.*		
		Termitidæ ..	Isoptera ..	Corrodentia.
		Psocidæ ...	Corrodentia.*	
		Perlidæ ...	Plecoptera.*	
NEUROPTERA	Amphibiotica .	Odonata ...	Odonata. ..	Odonata.
		Epheneridæ .	Ephemerida ...	Ephemerida.
		Sialidæ ...	Platyptera *	
	Planipennia .	Panorpidæ ...	Mecoptera.*	
		Hemerobiidæ	Neuroptera *	*Neuroptera.
	Trichoptera ..	Phryganeidæ	Trichoptera.*	

We believe the most logical and workable system of insect classification to be the following :—

1. APTERA.
2. FORFICULIDÆ.
3. BLATTIDÆ.
4. ORTHOPTERA (5 families).
5. TERMITIDÆ.
6. MALLOPHAGA.
7. PSEUDONEUROPTERA. (Embiidæ, Psocidæ).
8. NEUROPTERA AMPHIBIOTICA.
9. NEUROPTERA PLANIPENNIA.
10. TRICHOPTERA.
11. HYMENOPTERA, PHYTOPHAGA. (Sessiliventres).
12. ,, PARASITICA.
13. ,, TUBULIFERA.
14. ,, ACULEATA.
15. COLEOPTERA.
16. LEPIDOPTERA.
17. DIPTERA, ORTHORHAPHA.
18. ,, CYCLORHAPHA.
19. SIPHONAPTERA.
20. RHYNCHOTA, HETEROPTERA.

21. Rhynchota, Homoptera.
22. Phytophthires.
23. Anopleura.
24. Thysanoptera.

It is, however, impossible to express accurately the relationship of insects by adopting any one sub-division of equal value throughout, and the student may be warned against getting to attach too much importance to any classification systems except as working conventions which have as much regard to truth as circumstances will allow.

What systems of classification we adopt is, in the present state of confusion, immaterial ; the Fauna covers only parts of four orders and we can there adopt the system in use ; beyond that we must unfortunately anticipate the "Fauna." The system adopted is the following; it is as near to Sharp's insects as possible, and we have contrasted it with the system in use in America as a guide to the student who wishes to refer also to American literature. We may remark that classification is not an end in itself but is the means to an end ; with so vast and complex a subject, it is imperative that we should be able to classify, to fix the position of an insect with regard to its fellows, simply for ease of working. Our main object being the observation of living insects as they affect man, classificaton in this case becomes necessary to enable us to record and collate our observations ; for this reason we aim at a simple system, on which we can arrange our collections, file our notes and, by working with one system, follow each other's work at once without having to readjust our ideas or bother more than is necessary with the way our things are arranged. The insects in one collection are arranged exactly as they are in another ; a worker from a distance can take up work in Pusa without mastering a fresh system, and whether our classification be correct or not, it is, and must be, the standard and will be, we hope, with small modifications, the standard in India for many years.

Number of Species.—Blanford in 1881 published a numerical enumeration of the known Fauna of India (J. A. S. B., p. 263). He includes Beluchistan, Kashmir, the Himalayas, Nepal, Sikkim, Bhutan, Assam, British Burma, Tennasserim, Ceylon, Andamans, Nicobars, which is practically the area now covered by the "Fauna of British India." We reproduce his figures :—

Orthoptera	350 (?)	1,700
Neuroptera	350	400
Hymenoptera	850	3,600
Coleoptera	4,780	6,000
Lepidoptera	4,620	10,000
Diptera	500 (?)	1,000
Rhynchota	650	3,000
TOTAL	12,100	29,700

giving also an enumeration of our own based on the available figures. Thus the Fauna of India and Hampson's later papers enumerate about 8,000 moths, there are about 1,500 butterflies, and we estimate 500 Tineids, etc. Mr. Distant has already enumerated 2,500 Rhynchota, and we anticipate 400 more with 100 Coccidæ.

Nomenclature.

Could we divide all known insects into, say, 300 families of roughly 1,000 species each, and group these systematically, our nomenclature would be a simple matter.

As we have explained above, the general object is to make *families* the basis of classification ; but we have in this volume to steer a middle course between the really accurate classification of the pure systematist, which changes as knowledge grows, and the practical point of view of those for whom we write ; we cannot keep remodelling our arrangement and nomenclature. *Odonata*, for instance, may be a sub-order composed of say seven families ; for us and for all field entomologists it is practically a family.

Whenever possible, family names end in—*idæ*, sub-family names in—*inæ*, and the names of tribes or sub-divisions of families in—*ini* ; the student must, however, remember that sub-family names frequently end in—*ides* ; and tribes in—*ines*. It is to be regretted that no uniform system can be introduced, and that were we to rigidly adhere to some system in this volume, the student would be puzzled when reading foreign text-books or literature.

IDENTIFICATION OF SPECIMENS.—Insects are known by names, nominally of Latin or Greek form, given to them by the entomologist who first describes them. That is, every distinct species of insect that has been described or accurately figured is designated by the specific name assigned to it by its first describer. The problem then is, with living or preserved insects on one side, and the mass of descriptions or figures on the other, to correlate the two.

Only working entomologists ever realise the immense labour involved in this work, except in the case of the fauna of a locality such as England where the insects have been studied very closely, where there are ample books, and reference collections. Where one has either a description of every species of insect of a country or a good reference collection, identification is a matter of so much comparison, but where as in India, the only handbooks contain descriptions only of part of the known insects, or where there are no handbooks at all, only scattered descriptions, and where there are no reference collections and access to the National Collections at the British Museum is impossible, the actual identification of an insect is not an easy matter and is not, as a rule, even possible in India. The question must remain so until there are complete handbooks such as the Fauna of India, which are kept up-to-date, and also complete reference collections of Indian insects, accurately named; progress to these is being slowly made, but very slowly indeed.

Actually if an insect belonging to one of the families described in the Fauna of India is sent in for identification, it is examined, referred to some division of its family, worked out with the generic key in the volume and compared with the descriptions in the volume ; if it exactly agrees with the description of a particular species, it is believed to be that species and is, if possible, compared with a specimen that has been identified by a specialist in that family. If it agrees with no species in the volume, it may be either a species described since the volume was prepared, or a species known from another country but not from India, or a new species ; to determine this requires an expert knowledge of the family, a complete literature of the family and a reference collection. On the other hand, if a beetle, for instance, is sent in, it is examined, referred to its family, and compared with any accurately named specimens of its kind which are available ; if it agrees with none of them it must be sent to a specialist in that family who has the literature, the reference collection, and, after years of work on that particular family, the requisite special knowledge. If proper attention was devoted to entomology in England, all specimens could be sent to the National Collection at the British Musuem and there compared: at present this is not possible, and we are largely dependent on the kindness of workers in Europe and the United States.

It can be seen that the accurate identification of an insect is no easy matter in every case; in many cases it means months of waiting, and even years, as there are no workers for a large number of groups. As an accurate identification is necessary before publishing matter about any insect, this question is one of great importance; a large number of insects have been accurately identified and can be seen in the Pusa Collections; every assistance will be given in identifying insects, but the reader must realise what it means and be prepared to do the only thing he can to help, namely, to always send enough good specimens to allow of some being sent on to Europe, if the species is one that cannot be named from the Pusa Collection. This matter is discussed here because requests are constantly received for the name of an insect of which perhaps one mangled specimen is sent, and surprise is expressed because the identification is not immediately forthcoming. (See also Indian Insect Pests, page 57.)

Entomology in India.—This volume has been compiled primarily for the use of students of entomology in India and for those interested in the subject. A few words as to the present state of the subject in India will not be out of place.

Entomology, as a subject, occupies the whole time of one section of the Agricultural Research Institute, Pusa, and in this Institute alone there are three Entomologists with English University qualifications, and a staff of trained native workers. In connection with this Institute, there are a limited number of entomological assistants employed by the Agricultural Departments of each province for purely agricultural work and simple teaching. Whilst the ultimate object of work at Pusa is mainly agricultural and directed to useful practical ends, the work must rest on a scientific basis, and the collection, study, and classification of all insects of the agricultural areas of India is a necessary part of the activities of the staff. It is open to any worker in India to visit Pusa or to write there for advice or assistance, which will be freely given.

Our aim is to be in touch with every worker in India and to invite co-operation and mutual help. Elementary and advanced teaching in entomology is also given at Pusa and at no other place in India at the present time.

For many years, the Indian Museum, Calcutta, was the centre of entomological work, where a special staff was devoted to this subject, including the economic aspect. At the present time, the economic work has been transferred to Pusa, and systematic entomology takes its place as one branch of the systematic zoology which forms the work of one section of the Musuem.

Collections of insects are preserved there, are constantly added to and are sent to specialists to Europe, just as the Pusa collections are. There is a large exhibit collection open to the public and the reference collections, while not open to the public, are generally available to workers in entomology.

Forest entomology is solely dealt with in the Forest Research Institute, Dehra Dun, by the Imperial Forest Zoologist and his staff, and all enquiries regarding insects injurious to forests are referred there. The study of insects injurious to tea is the work of the Entomologist to the Indian Tea Association stationed at Hilika, Assam.

Apart from minor and inconsiderable collections in Provincial Museums, the only other public collections exist at the rooms of the Bombay Natural History Society; members of this society refer specimens to the Committee who, if the Society's collection and library cannot furnish the required information, refer them to either of the above Indian Institutions or to Entomologists in Europe.

Excepting private workers who own private collections, there are no other centres of entomological activity in this country.

Publications dealing with entomology in its different aspects are issued as follows: The Imperial Agricultural Department issues, from Pusa, the "Agricultural Journal of India," in which are contained articles and notes relating solely to those insects injurious to crops or to those of economic value. Other and similar work is issued in bulletins; the more scientific or lengthy work is issued in memoirs and purely popular and useful information as leaflets.

The Imperial Forest Research Institute publishes information relative to Forest Entomology in "Forest Records and Memoirs," and some has appeared in the pages of the "Indian Forester." "The Bulletins of the Tea Association" contain the bulk of the work on insects injurious to tea, supplementary to the volume on Diseases and Pests of the Tea Plant by Watt and Mann. The Indian Museum, in "Indian Museum Records" and "Memoirs of the Indian Museum," issues articles mainly on systematic entomology but also bionomic work.

The "Journal of the Bombay Natural History Society" is the recognised medium for most purely systematic work and for some bionomic work; the papers in this Journal are of extreme value and must be consulted. We have referred below to the more important papers. The Journal of the Asiatic Society of Bengal contain also papers on general entomology and on systematic work.

This exhausts the present publications dealing with the various aspects of this subject in India; occasional papers on systematic entomology appear in the proceedings of learned Societies in England, Europe, the United States. A summary of these is contained in the Annual Report of the Board of Scientific Advice in India, as is a summary of all entomological work and publications in India.

It is necessary to mention one further publication no longer in existence. For over fifteen years, "Indian Museum Notes" was issued from the Indian Museum, Calcutta, and contained papers, notes, etc., dealing with economic and systematic entomology. We have made constant reference to it below and practically all information contained in it. dealing with the insects of the plains, is abstracted or referred to here, or is amplified in Indian Insect Pests. The best feature of this publication was its beautiful photogravure plates; the originals of many of these are here reproduced as text figures. Sets of this publication are still available at Pusa, and complete sets can be consulted in most official or public libraries in India.

With the exception of the Bombay and Asiatic Societies, the above publications are issued by Government and copies of most of them are available to serious workers. All can be seen also in most public libraries, and the published work in entomology is generally available. It is impossible to refer here to other literature; the reader will see below from how many sources we have drawn the published information of past years and these scattered papers are often very difficult to see. The best entomological libraries known to me in India are that of the Indian Museum, Calcutta, and of the Pusa Research Institute.

Of books dealing only with Indian Entomology, the Fauna of India is the only systematic one of real value now. It covers Aculeate Hymenoptera (2 vols.), a small part of Coleoptera (2 vols.), nearly the whole of Lepidoptera (6 vols.), Rhynchota to the end of Jassidæ (4 vols.). Progress with this is being steadily made and the student should ascertain what volumes have since been issued. They are the standard guides to the systematic entomology of India, Burmah and Ceylon and are essential in the arrangement and identification of species. Westwood's Cabinet of Oriental Entomology is with Donovan's "Insects of India," remarkable chiefly for beautiful plates in colour of many striking Indian insects, mainly butterflies, moths, large beetles and Fulgorids. It is the only book of its kind but is of little value at the present day except (in the words of Westwood), "that, by finding its way to the table of the Indian drawing room, it may gain additional converts to the study of a science full of curiosity and awaken an interest in the objects of pursuit, thus supplying an engaging occupation to our Indian friends."

A very short introduction to entomology is given in "Indian Insect Pests," which also treats of insects injurious to agriculture. It is the only general book on pure entomology relating solely to India published recently (1906), and contains short instructions regarding necessary apparatus, methods, etc. We assume every reader to have as much general knowledge as is included in the first part of that volume and in the second appendix.

Zoo-Geographical Divisions.—British India is not a distinct zoogeographical area, and it is necessary to define very carefully the faunal zone that is dealt with in this volume. The "Fauna of India" series deals with the Fauna of the Indian Empire and Ceylon, *i.e.*, Himalaya, Hindustan, Assam, Burmah, Ceylon, regardless of faunal zones, and we endeavour here to indicate the zoo-geographical status of this region.

In the first place, we wish to make clear that a fundamental point is elevation; starting from the plains of North India at an elevation of, say, 1,000 feet and going steadily up the Himalayas to say, 10,000 feet, one passes from, through and into three distinct life-zones, which we may call tropical, subtropical and temperate; the tropical extends to 2,000 feet elevation; it is marked by one period yearly of intense dry heat or a limited season of moist weather; the subtropical covers 2,000 feet to between 5,000 and 6,000 feet and is marked by a greater humidity, a more even and less intense temperature, a less limited period of rainfall; the temperate extends above about 6,000 feet. To accurately define the limits of the subtropical zone would require much elaborate detail; it commences for instance at an elevation of about 500 feet at the foot of the Eastern Himalayas, at about 2,000 feet at the foot of the Western Himalayas; in the Nilgiris it commences at about 2,500 feet on the Mysore plateau side but runs down to well under 1,000 feet on the Western Ghaut side; a large part of the Deccan above 1,000 feet is tropical; the Western Ghauts from 600 to 2,000 feet and over are subtropical, and in this case the dry tropical area (as at Poona and Nasik) is at a greater elevation than the moist subtropical belt. The zone is of course not definable merely on elevation; it is the moister more agreeable climate produced by the abundant rainfall falling on the slopes of moderate elevation which run up from the level plains to the Himalayas or to the various ranges of hills; it is a zone of varied vegetation, often forest or dense jungle; it is the zone in which tea, coffee, rubber, and similar crops are grown, and it is, in India, a belt along the hills, running up the valleys, as well as more or less isolated patches on the hill ranges of Central India, the Deccan and South India. The student can get some idea of it from the 2,000 feet elevation line on Eliott's meteorological atlas of India. The fauna of the subtropical zone is far more varied than that of the tropical zone or of the temperate zone and is quite distinct.

There are some prominent features of the tropical and subtropical faunæ which may be very briefly discussed here. We omit any discussion of the temperate fauna as, except in South India, it is certainly not "Indian" but is holarctic or Indo-Chinese. The subtropical fauna is far more varied than the tropical; the number of species that can find food and can support existence in the extremely varied vegetation and moist equable climate of the former is far greater than those that can endure the intense dry heat and more limited vegetation of the latter.

In addition to this, which is true of nearly every family of insects, there are families which are confined to the subtropical region, or which immensely predominate there as compared with these families in the plains, and there are also families which occur far more abundantly in the tropical plains. The *Phasmidæ*, *Siricidæ*, *Tenthredinidæ*, *Sialidæ*, *Panorpidæ*, *Passalidæ*, *Lucanidæ*, *Simuliidæ*, *Aradidæ*, *Phymatidæ*, *Sesiidæ*, *Zygænidæ* are practically confined to the moist forested lower hill slopes; the *Rhopalocera* are characteristic of the subtropical region, especially the *Nymphalidæ* and *Papilionidæ*; the *Cicadidæ*, *Tipulidæ*, *Mycetophilidæ*, *Locustidæ*, *Dynastidæ*, *Cetoniidæ*, *Erotylidæ*. *Endomychidæ*, *Bostrichidæ*, *Scolytidæ* are found abundantly in the subtropical, rarely in the tropical areas; *Chrysomelidæ*, *Buprestidæ*, *Capsidæ*, *Syrphidæ* occur in both but in immense profusion only in the former; *Limacodidæ* and *Phryganeidæ* stand out conspicuously in the same way. On the other hand, the *Acridiidæ*, *Carabidæ*, *Dytiscidæ*, *Hydrophilidæ*, *Gyrinidæ*, *Tenebrionidæ*, *Myrmeleoninæ*, *Ascalaphinæ*, *Scarabæidæ* are far more abundant in the plains, though occurring also in the lower hills. Allowing for the fundamental excess of species in the subtropical region owing to its varied flora, the other large families are more proportionately represented in both areas. We would suggest also that the varied surface fauna of the plains is less marked a feature of the subtropical region, possibly because the surface soil offers protection from heat not required in the hills and because the usually dense perpetual vegetation of the hills produces a fauna centering more round the bushes and low vegetation (see below "Where Insects Live" under *Forficulidæ*).

This fundamental distinction is of the very greatest importance, and unless it is fully realised and clearly kept in mind, any conception of the faunal zones must be imperfect. We sharply mark off the fauna of the plains of India (usually below 2,000 feet) from that of the forested slopes of the hills and from that of the upper hills; and, in this volume, we deal only with the tropical zone except where the number of species occurring in India is stated when we mean British India exclusive of the temperate upper Himalayas.

India is placed by Beddard (Zoogeography 1895) in the Oriental Region as the "Indian" subregion; Ceylon is distinct as a subregion and is taken to include part of South India. The Himalayas, inclusive of Kashmir, Nepal, Sikkim, Bhutan, are not part of the Indian subregion at all, being holarctic, and we take the dividing line to be at about 6,000 feet. The extreme North-West of India is also not strictly " Indian " but is holarctic. Burmah, we exclude, as being Malayan and Indo-Chinese, and the hills of Assam are strictly Indo-Chinese in part. " India " proper then does not include these areas at all and it must be clearly borne in mind that in these pages we do not use India in the sense that the " Fauna of India " does : the term " British India " is used throughout this volume for the political India covered by the Fauna ; the term " India " includes tropical and subtropical India, *i.e.*, up to about 6,000 feet ; " subtropical India " denotes the moist forested slopes of the hills usually between 2,000 and 6,000 feet ; " tropical India " or " the plains " means the great stretches of India lying between sea-level and about 2,000 feet, usually not forested and extending from Tinnevelly in the South to Rawal Pindi in the North, from the border of Sind and Baluchistan in the West to the Assam and Surma valleys in the East. It is the insects of this area that are discussed in these pages and for one insect in this area there are at least five in " subtropical India. "

The frontispiece illustrates the divisions of tropical India according to fauna so far as we are able to tentatively delimit them ; the faunal zones of subtropical India are not indicated. In considering this question fully, the factors to be considered are (1) the physical features of the country ; (2) the geological formation composing it ; (3) its climate ; and (4) its flora. The first three probably affect insects in much the same way as they affect plants, and we may take the flora as the basis of our divisions ; Sir J. D. Hooker, in his sketch of the flora of British India, divides the whole area into nine provinces as follows :—

(1) *Eastern Himalayas.*—Sikkim to Mishmi mountains in Upper Assam.

(2) *Western Himalayas.*—Kumaun to Chitral.

(3) *Indus Plain.*—Punjab, Sind, Rajputana, west of the Aravalli range and the Jumna river, Cutch and Gujarat (to the Tapti).

(4) *Gangetic Plain.*—From the Aravalli Hills and the Jumna river to Bengal, the Sundarbans, the plains of Assam, the low country of Orissa north of the Mahanadi.

There are three distinct sub-provinces; the dry upper area, the United Provinces and Behar; the lower humid area, the Assam plain, Lower Bengal and Orissa; and the Sundarbans.

(5) *Malabar.*—The Western Ghauts from the Tapti river to Cape Comorin; the Konkan, Kanara, Malabar, Cochin, Travancore, Laccadive Islands. This is better termed the West Coast.

(6) *The Deccan.*—The high plateau lying between the Eastern and Western Ghauts, south of the Gangetic and Indus plains; the Coromandel Coast on the East Coast from the Mahanadi to Cape Comorin is included as a sub-province.

(7) *Ceylon and the Maldive Islands.*

(8) *Burmah.*

(9) *The Malay Peninsula.*

With the last three, as with the first two, we have no concern here. If on the basis of the above divisions we omit subtropical forest hill areas, and we take into account the influences on the fauna of these neighbouring areas, we shall get divisions as follows:—

(1) The Indus Plain.
(2) Desert India.
(3) Central India, West.
(4) Gangetic Plain, West.
(5) Gangetic Plain, East.
(6) Sundarbans.
(7) Central India, East.
(8) Deccan.
(9) West Coast.
(10) Coromandel Coast.

1. *The Indus Plain* has a fauna containing many holarctic forms. The winter is cold, the hot weather is dry and intense and these two seasons are well marked.

2. *Desert India* is similar, but with a peculiar fauna and flora, owing to the arid conditions.

3. *Central India, West.*—An area of greater rainfall, a more definite period of humidity and less alternation of day and night temperature.

4. *Gangetic Plain, West.*—Well marked winter with moderate cold and rain, dry hot weather and moist rainy weather. Immigrants from the Himalayas for the cold weather.

5. *Gangetic Plain, East.*—No well-marked dry hot weather, the humidity higher in the cold weather and hot weather. Immigrants from the Himalayas and other hills for the cold weather and insect activity more general in the hot weather; there is a marked Malayan element. (A feature of this area is the flooding that occurs over large stretches of land; the influence this exerts on the fauna may be a very marked one.)

6. *Sundarbans.*—Doubtfully distinct. Little alternation of temperature or humidity. Peculiar flora. Strong Malayan element.

7. *Central India, East.*—Well-marked dry hot weather when insect activity is suspended, followed by a prolonged moist warm period. Fewer insects hibernate than in the regions North and West.

8. *Deccan.*—Well-marked seasons, the dry hot weather following a marked cold weather, when hibernation sets in.

9. *West Coast.*—The fauna is influenced by the neighbouring sub-tropical region of permanent forests and high humidity which produce a very large fauna equalled only by the lower slopes of the hills in Assam and the Eastern Himalayas. No hibernation in the plains below ghauts. Many Ceylonese forms.

10. *Coromandel Coast.*—Less well marked seasons to the Deccan, and a smaller flora to the West Coast. A large proportion of Ceylonese forms.

We may roughly indicate the separate faunal zones into which we would divide British India as a whole exclusive of Burmah and Ceylon:—

1. *Indus Plain.*—Tropical.

2. *Himalaya, West.*—Western Himalayas above 6,000 feet, including Kashmir, Nepal and Kumaon. Holarctic.

3. *Sub-Himalaya, West.*—Lower slopes of Western Himalayas 2,000 to 6,000 feet. Subtropical forest fauna.

4. *Desert India.*—Tropical.

5. *Central India, West.*—Tropical.

6. *Central India, West, Hills.*—Subtropical.

7. *Gangetic Plain, West.*—Tropical.

8. *Gangetic Plain, East.*—Tropical.

9. *Sub-Himalaya, East.*—Lower slopes of Eastern Himalayas 700 to 5,000 feet. Subtropical.

10. *Himalaya, East.*—Eastern Himalayas above 5,000 feet. Sikkim to Mishmi Mountains. Holarctic.

11. *Assamia.*—Hills of Assam and Assam-Burmah border, inclusive of Khasi hills, above 6,000 feet. Indo-Chinese.

12. *Sub-Assamia.*—Lower slopes of Assam hills, 500 to 5,000 feet. Subtropical with strong Malayan affinities.

13. *Sundarbans.*—Tropical.

14. *Central India, East, Hills* above 500 to 800 feet. Subtropical.

15. *Central India, East, Plains.*—Tropical.

16. *Deccan.*—Tropical.

17. *West Coast, Plains.*—Tropical.

18. *Western Ghauts.*—Hills up to 6,000 feet. Subtropical. This is probably divisible into three ; (*a*) Surat to Londa-Goa gap ; (*b*) Goa gap to Palghat gap with the Nilgiris, Coorg, Mysore Hills ; (*c*) South of Palghat gap, including Travancore, Pulneys, etc.

19. *South India Hills.*—Hills of West Coast and South India above 6,000 feet. The fauna of this zone is not sufficiently known, as apart from the fauna below 6,000 feet, for this division to be more than a doubtful one.

20. *Coromandel Coast.*—Tropical.

21. *Eastern Ghauts.*—Subtropical.

Classing these zones under elevation and climate we get :—

Temperate.	Subtropical.	Tropical.
Himalaya, West ...	Sub-Himalaya, West ...	Indus Plain.
		Desert India.
	Central India, West, Hills	Central India, West.
,, East ..	Sub-Himalaya, East ...	Gangetic Plain, West.
Assamia	Sub-Assamia ...	,, ,, East.
		Sundarbans.
	Central India East, Hills ...	Central India, East.
	Western Ghauts .	Deccan.
		West Coast.
South India Hills ..	Eastern Ghauts ...	Coromandel Coast.

(Holarctic.)

Himalaya West.
Baluchistan.
Afghanistan.

(Scheme of Indian Region.)

(Indo-Chinese)

Assamia.
Himalaya, East.
Burmah Hills.

Indus Plain.
Desert India.
Central India, West.
Gangetic Plain, West.

Sub-Himalaya, East.
Sub-Assamia.

Central India, East.

West Coast.
Western Ghauts.
South India Hills.
Coromandel Coast.
Eastern Ghauts.

Gangetic Plain, East.
Sundarbans.

Ceylon.

Burmah Plains.
Malayia.

(Singhalese.)

(Malayan.)

Food and Habitat.

Insects live in a great diversity of ways, but it is possible to roughly classify these into groups ; this classification is of considerable value to the student in placing his insect ; for instance, a tree-boring insect will be a member of one of a small number of families, and it will often assist in placing an insect to look up the families which have a particular habit *i.e.*, it is useful to classify insects according to food and habitat, as well as by structure and genealogy. For this purpose we tabulate below the principal families that live in distinct ways, using food and habitat together as the basis of our classification.

I.—LAND INSECTS.
- A. Herbivorous.
  1. Live in Fruits.
  2. ,, on Seeds.
  3. ,, ,, Flowers.
  4. Leaf and Stem Miners
  5. Leaf and Stem Suckers.
  6. Leaf and Stem Eaters.
  7. Gall Makers.
  8. Tree Borers.
  9. Stem Borers.
  10. Root Eaters.
  11. Root Borers.
  12. Root Suckers.

- I.—LAND INSECTS—*contd.*
  - B. Parasites and Predators.
    - 13. Parasites, Internal of Vertebrates.
    - 14. Parasites, External of Vertebrates.
    - 15. Parasites, Internal of Insects.
    - 16. Predators, Stinging.
    - 17. Predators, Biting and Sucking.
  - C. Scavengers.
    - 18. Scavengers, Animal Matter.
    - 19. Scavengers, Dead Wood.
    - 20. Scavengers, Vegetable Matter.
    - 21. Household Insects.
- II.—SALT WATER INSECTS.
- III.—FRESH WATER INSECTS.
- IV.—MYRMECOPHILOUS INSECTS.

1. Fruit Insects.—The *Trypetidæ* are conspicuous, as are such Tortricids as the Codlin Moth (*Carpocapsa*) and *Tineidæ*. Noctuids and Curculionids are found. In all cases it is the larvæ that live thus; *Tenthredinidæ* are rarely known. Some large moths (*Ophidcres*) live on fruit juice. We exclude all "Scavengers" in decaying fruits, of course, referring only to fruits on plants.

2. Seed Eating Insects.—Many insects feed habitually on seeds while ripening; *Bruchidæ, Scolytidæ, Tortricidæ, Tincidæ, Pterophoridæ* (*Exelastis, Sphenarches*), *Noctuidæ* (*Chloridea, Earias*), *Pyralidæ* being typical examples; the Lycænid (*Virachola isocrates*) is an exceptional case. We omit all insects living on harvested seeds, classing them as Scavengers or household insects.

3. Flower Insects.—*Forficulidæ* eat pollen, *Masaridæ* and *Apidæ* collect pollen. *Fossores* collect pollen, or feed on nectar. *Phalacridæ* (larvæ), *Nitidulidæ* (larvæ and adults), *Melyridæ* (adults), *Lampyridæ* (adults), *Mordellidæ* (adults), *Curculionidæ* (adults), *Melolonthidæ* (adults), *Cantharidæ* (adults) feed on pollen or flowers. Most moths and butterflies and many flies, especially *Anthomyiidæ, Syrphidæ* and *Bombyliidæ*, feed on nectar. *Tineidæ, Pterophoridæ, Cecidomyiidæ, Thysanoptera, Tingidæ* also live in flowers, as larvæ or nymphs.

4. Leaf and Stem Miners.—The Hispids and Halticids among Chrysomelids, and many Tineids mine under the epidermis of green leaves and green stems. Exceptional Micropterygids, Buprestids (*Trachys*), and Acalyptrate Muscids are also recorded.

5. Leaf and Stem Suckers.—The *Thysanoptera*, the whole of the *Homoptera* and *Phytophthires*, as well as most of the species of the following families of Hemiptera live by sucking the sap of green parts of plants :—*Pentatomidæ, Coreidæ, Berytidæ, Lygæidæ, Pyrrhocoridæ, Tingidæ, Capsidæ.*

6. Leaf Eating Insects.—All *Phasmidæ* and *Acridiidæ*, most *Locustidæ*, some *Gryllidæ* feed on leaves, as too do the larvæ of *Tenthredinidæ*, Melolonthid beetles, a few exceptional Carabids and Silphids, Epilachnids in both stages, Cantharid beetles, Chrysomelids in both stages, and Curculionids (rarely in the larval, almost always in the imaginal stage) have the same habit. The larvæ of *Lepidoptera* in most cases are purely leaf eating.

7. Gall Insects.—In India, the known gall insects are typically Psyllids, Tineids, Chalcids (fig insects) and Cecidomyiids, the first predominating. Other families recorded elsewhere are *Tenthredinidæ* (*Nematus*), *Cynipidæ, Buprestidæ* (*Ethon*), *Curculionidæ, Thysanoptera, Aphidæ and Coccidæ.*

8. Tree-Boring Insects.—The following families make tunnels in trees ; *Siricidæ, Buprestidæ, Cerambycidæ, Curculionidæ, Scolytidæ,* (? Brenthidæ), *Sesiidæ, Cossidæ, Hepialidæ, Arbelidæ.*

9. Stem Borers.—A large number of borers live in green succulent stems as opposed to those living in hard woody tissues. The families concerned are, *Gryllidæ* (*Cylindrodes*), *Cephidæ, Tenthredinidæ, Phalacridæ, Erotylidæ, Buprestidæ, Mordellidæ, Curculionidæ, Scolytidæ,* (*Castniidæ*), *Noctuidæ, Pyralidæ, Cecidomyiidæ, Chloropidæ, Agromyzidæ, Geomyzidæ, Ortalidæ.*

10. Root Eating Insects.—Very little is known of the lives of underground insects, but the following groups contain species that feed on plant roots in the soil.

Melolonthid larvæ.
Elaterid „

Curculionid larvæ.
Pyralid ,, (*Crambidæ*, etc.).
Noctuid ,, (rarely).
Gryllid nymphs and adults.
Tipulid larvæ.

A few of the *Silphidæ* (*Anisotomides*), *Dascillidæ* and *Bibionidæ* (*Dilophus*), have apparently the same habit.

11. Root Borers.—The *Hepialids* are conspicuous as root borers ; the *Sagridæ* are said to have this habit as have some *Eumolpids* (*Scelodonta*) and *Galerucids* (*Diabrotica*, probably *Aulacophora*) ; some *Pyralids* have it, *e.g.*, *Schœnobiinæ ;* exceptional *Buprestidæ* (*Sphenoptera*) and *Curculionidæ* (*Cylas*) are also known.

12 Root Sucking Insects.—Just as there are insects which suck plant tissues above ground, so others do below ground, but we know little of them. Probably a considerable number of species in the following families are concerned : *Pentatomidæ*, *Lygæidæ*, *Cicadidæ*, *Fulgoridæ*, *Aphidæ*, *Coccidæ*. In most cases it is probably the immature stages that have this habit. The best known example is the *Phylloxera* of the vine.

13. Internal Parasites of Vertebrates.—The *Oestridæ* are the important group in which this habit is universal ; the Muscids that cause Myiasis may perhaps be included. We omit the many recorded cases of insects bred in the human alimentary canal as being exceptional.

14. External Parasites of Vertebrates.—So much is written of these we need only tabulate the families : *Hemimeridæ* (on rats), *Mallophaga*, *Platypsyllidæ* (on beavers), *Hippoboscidæ*, *Streblidæ*, *Nycteribiidæ*, *Aphaniptera*, *Polyctenidæ*, *Cimicidæ*, *Anoplura*. We omit the non-parasitic biting flies.

15. Parasites of Insects.—The *Parasitica* among the Petiolate Hymenoptera, the *Chrysididæ*, the parasitic *Apidæ*, and the *Tachinidæ* are the common parasitic insects. Other groups are the *Mantispides* (on spiders eggs), the *Mordellids* (*Emmenadia*, etc.) (the Clerides), the *Cantharidæ* and *Stylopidæ*. Of Diptera, little is known, but we may mention *Nemestrinidæ*, *Bombyliidæ*, *Pipunculidæ*, *Cyrtidæ*, *Conopidæ*, *Anthomyiidæ*, *Tachinidæ*, *Sarcophagidæ*, *Muscidæ*, *Braulidæ* (external).

16. Predators, Stinging.—A peculiar class are those insects which sting insects to paralyse them and lay them up for their young; they include only *Eumenidæ*, *Pompilidæ*, *Sphegidæ*, *Scoliidæ*.

17. Predators, Biting and Sucking.—It is impossible to indicate with any accuracy the families containing predaceous insects; probably a very large number of insects living in soil and under bark are predaceous, notably beetles and smaller bugs. We tabulate a number of families with remarks.

Forficulidæ; ?
Mantidæ; all.
Locustidæ; some.
Gryllidæ; some, *e.g.*, *Schizodactylus*.
Odonata; larvæ and imagines.
Raphidiides; imagines.
Panorpides; imagines.
Myrmeleonides; larvæ all; imagines ?
Ascalaphides; ,, ,, ,,
Mantispides; some.
Hemerobiides; larvæ.
Chrysopides; larvæ ? imagines.
Coniopterygides; larvæ.
Eumenidæ; the wasps eat insects.
Vespidæ; ,, ,, ,, ,,
Cicindelidæ; all.
Carabidæ; practically all.
Silphidæ ?
Staphylinidæ; probably all.
Histeridæ; some, under bark.
Trogositidæ; some.
Colydiidæ; some.
Cucujidæ. ,,
Coccinellidæ; nearly all.
Malacodermidæ; larvæ all; imagines ?
Cleridæ; all.
Anthribidæ; some.
Brenthidæ; imagines, larvæ ?
Lycaenidæ. (*Spalgis*).
Noctuidæ; } A few species feed
Phycitinæ; } on Coccids.
Tineidæ. (*Hypatima*).
Some Culicid larvæ.
Blepharocerids ?
Therevids; fly and larvæ.
Muscids (Ochromyia).
Some Anthomyiids & Ephydrids.
Some Seatomyzids.
Leptidæ; larvæ and flies.
Tabanidæ; ,,
Asilidæ; all.
Empidæ.
Dolichopidæ.
Phoridæ; larvæ.
Syrphidæ; ,,
Bombyliidæ ?
Pentatomidæ; some.
Lygæidæ ? many.
Aradidæ ?
Henicocephalidæ.
Reduviidæ.
Phymatidæ.
Saldidæ.

18. Scavengers of Animal Matter.—There is a very large class of insects that live upon refuse animal or vegetable matter as apart from those feeding on live plant tissue or on the blood or tissues of animal life. Of this class, a portion feed in dung, corpses, etc. The family *Scarabæidæ* are a notable example of the dung feeders, the *Sarcophagidæ* notable as breeding in corpses, the *Formicidæ* notable as carrying off dead insects. Other families are *Blattidæ, Silphidæ, Staphylinidæ, Histeridæ, Nitidulidæ* (?) *Cleridæ, Mycetophilidæ, Rhyphidæ*, several *Muscidæ Acalyptratæ* (*Borboridæ, Sepsidæ*) and many *Calyptratæ*, (?) *Phoridæ*.

19. Scavengers of Wood.—The insects that feed in dry or decaying wood are a distinct class, but it is difficult in some cases to distinguish them from the insects that prey on them. The following nine families are well known: *Termitidæ, Bostrichidæ, Ptinidæ* (*Anobiides*), *Lymexylonidæ, Oedemeridæ, Cerambycidæ, Anthribidæ, Scolytidæ*. Occasional Tenebrionids and Tineids may be added.

20. Scavengers of Vegetable Matter.—This is perhaps our largest individual class since we have not the data on which to break it up into such groups as in the case of Herbivores. It is of extreme importance in the daily routine of agricultural entomology to be able to distinguish the harmless insect eating dry dead leaves from the injurious one eating living parts of the plant. We can here only enumerate the more important families or those in which the habit is known, with the remark that fungi are included as food of this class as well as decaying leaves, fruits, blossoms and other soft parts of plants.

Aptera.
Blattidæ.
Embiidæ.
Psocidæ (? feeding on living fungi).
Passalidæ (larvæ).
Lucanidæ (larvæ).
Melolonthidæ (larvæ).
Scaphidiidæ (fungi).
Histeridæ ?
Nitidulidæ.
Trogositidæ (*Peltides* on fungi).
Colydiidæ.
Cryptophagidæ.
Erotylidæ (? fungi).
Endomychidæ (? fungi).
Mycetæidæ (fungi).
Latridiidæ (fungi).
Byrrhidæ (plant sap).
Cioidæ (fungi).
Sphindidæ (fungi).
Dascillidæ (*Eucinetus* on fungi).
Elateridæ (? larvæ).
Nilionidæ (fungi).
Melandryidæ.

Anthicidæ.	*Lonchopteridæ.*
Calandrinæ.	*Syrphidæ.*
Mycetophilidæ (fungi).	*Phoridæ* (larvæ).
Chironomidæ.	*Trypetidæ.*
Psychodidæ.	*Sapromyzidæ.*
Tipulidæ.	*Anthomyidæ* (larvæ).
Bibionidæ.	*Thysanoptera* ?
Rhyphidæ.	*Aradidæ* (? fungi).

21. Household Insects.—We cannot separate this class of insect clearly from the last or from some others logically, because our household insects are simply originally free-living ones that have found a living in man's dwellings. Nor can we make a separate division of them on the same scale as the Myrmecophilous insects, as we should perhaps logically do. The student will find further information under the heading Cosmopolitan insects below. The families concerned are :—

Thysanura.	*Cucujidæ.*
Blattidæ.	*Nitidulidæ.*
Gryllidæ.	*Ptinidæ.*
Psocidæ.	*Bostrichidæ.*
Termitidæ.	*Bruchidæ.*
(*Nemopterides*)	*Cerambycidæ.*
Formicidæ.	*Pyralidæ* (*Galleriinæ, Phycitinæ*).
Silphidæ.	*Tineidæ.*
Trogositidæ.	

We have excluded external parasites of mammals, though they may rightly be included here, since they are classed as above.

II. Marine Insects.—Very few insects live in, on, or within reach of salt water, probably on account of the difficulties of respiration due to the deposition of salts on evaporation of the water.

Anurida among *Aptera*, *Æpophilus* among *Coleoptera*, *Campontia* among *Chironomidæ*, *Eristalis* and some allies among *Syrphidæ* live in sea water, *Halobata*, a genus of *Hydrometridæ* lives on the sea. Some *Forficulidæ*, *Carabidæ*, *Cicindelidæ*, *Staphylinidæ*, and *Muscidæ* live in sea-weed on the beach.

III. Freshwater Insects.—The student will find fuller information under the heading Aquatic insects after the family *Odonata* below

We give here simply a bald list of families, but we make no attempt to class them into Herbivores, Parasites, Predators, and Scavengers as could well be done :—

Collembola.
(*Blattidæ*).
Ephemeridæ.
Odonata.
Perlidæ.
Sialidæ
(*Hemerobiidæ*).
Trichoptera.
(*Chalcidæ*).
Amphizoidæ.
Pelobiidæ.
Haliplidæ.
Dytiscidæ.
Gyrinidæ.
Hydrophilidæ.
Heteroceridæ.
Parnidæ.
Dascillidæ.
Chrysomelidæ.
(*Curculionidæ*).
(*Eupterotidæ*).
(*Pyralidæ*).
Culicidæ.
Chironomidæ.
Psychodidæ.
Dixidæ.
Tipulidæ.
Blepharoceridæ.
Simuliidæ.
Stratiomyidæ.
Tabanidæ.
(*Syrphidæ*).
(*Acalyptrate Muscids*).
Hydrometridæ.
Pelogonidæ.
Nepidæ.
Naucoridæ.
Belostomidæ.
Notonectidæ.
Corixidæ.
(*Aphidæ*).

IV. Myrmecophilous.—The student will find fuller information regarding Myrmecophilous insects under *Paussidæ*. The more important families of which species are found in ant's and termite's nests are :—

Gryllidæ.
Melolonthidæ.
Paussidæ.
Silphidæ.
Gnostidæ.
Pselaphidæ.
Staphylinidæ.
Histeridæ.
Thorictidæ.
Cossyphodidæ.
Syrphidæ.
Psyllidæ.
Aphidæ.
Coccidæ.

Insects and Man.—With the exception of domestic animals there is no single group of animal life which enters more into the daily life of man than insects. They live on us and around us; in our food, our clothes, our furniture, our houses; we eat them or their products, we collect them and even sew them on our clothing. All people eat honey, use bees-wax, clothe themselves in silk, and there is no one who has not, at one time or another, been dependent upon some member of the insect world. The luxury of the present age of civilised peoples has brought into being industries connected solely with the collection of the more beautiful and striking forms, which are worked up into wall ornaments, paper weights, etc., and form a part of the art of this age. (Witness the advertisement in the Studio "Artistic Cases of Tropical Butterflies, exquisite colours and designs, supplied to many Art Schools, etc.") Man is, therefore, dependent on the insect world for so much, and though science may devise substitutes for the products derived from insects, some of them at least will never replace the genuine thing. No artificial honey will ever compare with the honey gathered by bees from thousands of flowers, fragrant of thyme or heather or logwood, though in this commercial age, chemically-prepared substitutes, composed of glucose and coal tar flavourings, are sold and accepted as genuine; no substitute for bees-wax has been found, nor for shellac. It is likely that silk, as a commercial article among commercial nations, will be partly replaced by artificial substitutes, because the greatest value of true silk—durability—is of no value to an advanced civilisation which does not require to be clothed but costumed. Lac dye has been replaced by aniline, and though cochineal still holds its own for food colouring to some extent, it is probable that no insect-made dye will continue to hold its own against aniline dyes.

These are the useful insects; there are many that affect man in other ways. Why is it that almost every dry form of food sold and dealt in by commerce must be placed in a sealed package? Why are millions of tins used yearly in a single city? Why do we pay at least a fourth again of the value of biscuits, simply because of the tin? Very largely because of the ubiquitous insect, who would get in and eat them, if these things were not thus protected. Let any house-keeper in India think for a moment of her store-room and the precautions she takes. Sugar must be isolated or ants will carry it off ; flour must be in a tightly-closed tin, or moth, weevil or beetle gets in ; no sweet thing is safe, once opened, unless isolated on water, dried fruits of every kind are spoilt by beetles, grain is eaten by weevils ; pulse of all kinds harbours moths or beetles ; even tobacco and dried drugs are not exempt. Daily and hourly mankind is fighting the ravages of the insect world, which seeks to take from him his last ultimate asset, his stock of food. Think of the countless sealed mud grain-stores there are in India, many in every village, and all because of the insect life around us.

Let us take another aspect, that of disease ; malaria, enteric, typhoid, yellow fever, plague, filariasis and elephantiasis, sleeping sickness (? kala azar, black water fever), each and every one of these means a yearly total of deaths, premature and unnecessary, caused by the agency of insects. Think of the enormous total of deaths from plague in India, since plague came into India little more than a decade ago ; think of the desolation caused by sleeping sickness in Africa, of the countless cases of malaria in the tropics, of the extraordinary mortality from yellow fever, in old days, in the West Indies ; go to the West Indies and see the numerous cases of elephantiasis ; men with legs like trees, men suffering from fever and ague for years which finally leaves them possessed of an elephant's leg or arm ; think of the death-roll from enteric ! And after all this we may dimly realise the important part the insignificant insect world around us plays in our lives.

This may be equalled by that part played by insects in inducing disease among our domestic animals. This is a purely artificial case largely brought about both by our careless transfer of stock from one part of the world to another and by our own reckless disregard of the rudiments of science and of all reasonable precautions. Think again of the agriculturist and his foes ; of the locusts which lay waste a district, of the bollworm that takes a tenth of the cotton-crop in India, or perhaps three-quarters of it in an occasional year ; of the mothborer that kills one cane-shoot in three ; of the rice hispa that causes famine or the rice grasshopper that destroys the paddy over a whole division ; think of the trials of new and promising crops abandoned in the past, because insects ruined every plant on a small plot. Why does not tree cotton grow successfully in India, or improved American maize ; why has no fruit industry been established in places where fruit grows ; why is shade-grown tobacco not a success, or the cultivation of sunflower or ground-nuts in North India ? What takes toll of every crop grown in this country to a greater or lesser extent ? Insects in every case insects ; and insects are a factor to be taken into account in agriculture all the world over.

Think of one's daily life ! There are cockroaches that smell, fish insects that eat our papers, ants that carry off our sugar, "gundies" and other smelly things that flavour our food when they fall in, wasps and hornets that sting, mosquitoes that bite and annoy, to say nothing of sand-flies, that no mosquito net keeps out, and the bug and flea which continually pester us, the mud wasps that build nests in our books and close our locks ; furniture beetles that wear out our chairs, the cheroot beetles that spoil our cigars, the book beetle that tunnels in our books, the moth that destroys our clothes. Daily and hourly we come in direct contact with insect life. Read the doleful comments of the Calcutta resident in August, asking why science cannot check the insects that come to his lamp during dinner and make his life a burden ; or the sad tale of the District Officer who had to vacate his bungalow because the wasps wanted it and had been accustomed to have it ; or again the tale of the telegraph stores which were hurriedly wanted in large quantities, but could not be touched because hornets had built nests among them and actively resented any interference ; or that of the greatcoats ready to be distributed to the army, each being found with neat little holes eaten out by beetles. Impartial judgment and a dispassionate consideration of facts will show that insects have fully exploited man, and, that though man may think that he is dominant, he really is not, and that not the least among his functions is that of providing food and occupation for insects.

It has been the custom of authors of all periods to refer all insects in some way to man's well-being and economy. Every insect was, to them, created with some definite object from man's point of view ; and one has only to accompany a party of visitors round a collection, even in this twentieth century, to find this view still expressed. "What is the use of this ?" "Why was that created ?" Man may or may not be the central being of this earth, but to attempt to refer the activities of all insects in some way to his welfare is, at least, a problem that none would attempt. An American author says : " fleas are good for a dog, because they keep him from brooding over being a dog," and explanations of this kind are possible where our domestic insects are concerned. But, were insects given to that kind of mentality and speculation (as they may be), it would be interesting to get their views on man and his place in their nature. Assuredly it would not agree with ours ; equally it may be, that, from any standpoint, whether material, mental, moral or spiritual, man is on no higher a level than insects ; and it might be better to classify our activities as they affected insects than to refer each insect to its " use " to us.

A rough classification of the ways in which insects affect man may be attempted, chiefly with a view to securing clearness of idea :—

1. Cause damage to growing plants directly.
2. ,, ,, ,, ,, ,, indirectly.
3. ,, ,, ,, stored products.
4. ,, ,, ,, domestic animals directly.
5. ,, ,, ,, ,, ,, indirectly.
6. Personally distasteful.
7. Transmit disease to man.
8. Assist agriculture directly.
9. ,, ,, indirectly.
10. Yield useful products.

It is needless to dilate upon the first class ; all the insects that feed upon, or live in growing plants that are useful to man, are included. Of the second, we would say that very little is known, but that there may be a very large class whose quite unimportant attacks on plants open the way to the entry of fungoid or bacterial diseases, which may then become of great importance. There is a great difference between the small damage caused by the cane-borer direct and that of the fungus it brings or lets in ; and the broader aspects of this question are as yet but little known. The insects injurious to stored products, to grain, flour, dry food-products of all kinds, to timber, furniture, books, paper, fabrics, to every kind of human merchandise, made of material of animal or vege table origin, these are only too painfully familiar to us all, and, in the genial warmth and moistness of the Indian climate, they find conditions admirably suited to their plentiful increase. Insects that directly injure domestic animals include lice, ticks, fleas, horse-flies, bots, warbles and other parasites of cattle, horses, sheep, dogs, etc. Under the head of indirect injury is the transmission of disease, of which flies and probably lice, fleas and horse-flies may be especially important.

Of those personally distasteful, it is hard to speak. The mosquito that bites and sings, the cockroach that flies around before rain, the eye-fly that thinks its proper sphere is man's visual organ, the crawling caterpillar that falls from on high, each (and many more) is distasteful in some degree to different individuals. The dweller in Bengal is harried by hordes of perfectly amiable and delightful insects which join him when the lamps are lit. As I write, they swarm around me, in great variety, in pleasing profusion, adding, by their mere number and senseless gyrations, to the irritation caused by climate, weariness, liver, etc. In some places "gundies" (*Cydninæ*) are pre-eminent, in other places green fly (*Jassids*); the geranium (*Cydnus*) is familiar to some, while our curse here is varied but largely composed of beetles (*Scaritids* chiefly). Whatever they are, their profusion, their ubiquitousness, their buzzings and their singed or oily corpses cause an annoyance only to be appreciated by experience, and which forms not the least of the ills we bear.

Elsewhere the reader will find an account of the insects transmitting human disease, the go-betweens, which add so enormously to the death-roll, which cripple so many lives and which constitute the first and greatest menace to human life in tropical countries.

So far all is ill and were we to consider this only, then insects would have but a sinister significance. There is another side and still taking our anthropocentric view, we may consider the classes of insects on which man's welfare depends. A very large class of insects promote tillage, by burrowing and excavating in the soil; they sweeten the soil and render the growth of plants possible. This is especially the case in tropical India, where worms are not so abundant; it is impossible to bring accurate proof of this, but it is easy to observe the countless borings of insects in undisturbed soil, especially under trees and where there has been no cultivation. In addition to this, insects do much directly to enrich the soil by carrying down dung, by burying carcasses, by causing the decay of fallen vegetable matter. It requires but little observation and thought to see how large a part insects play in this, and how greatly they assist in keeping the earth sweet and wholesome, and in rapidly restoring to the soil available food ; with the bacteria, the fungi and similar organisms, they play a great part in the constant cycle of matter through the soil to some form of life and back to the soil again. In these ways insects assist agriculture directly. Another great function they exercise is in pollination ; a large proportion of plants are dependent upon insects for their fertilisation and we largely owe the beauty of many flower forms of the plant world to the need the plant has of attracting the insect and of inducing it to carry the pollen. The significance of insects in this respect requires no proof ; one can observe it both in the plants themselves and in their numerous insect visitors.

Indirectly insects are also a benefit as they check themselves and also help to keep down the undue prominence of weeds and particular forms of plant life. It is perhaps a paradox to ascribe as a virtue to insects the fact that they check themselves, because, if they did not exist, no check would be needed ; still it is a sober fact that parasitic insects are an important part of the insect world, and if they were absent for a few weeks, India would starve. Finally, there are the useful insects. These are connected with :—(*a*) silk, (*b*) lac, (*c*) wax, (*d*) dyes, (*e*) medicine, (*f*) food for man, (*g*) food for domestic animals, (*h*) ornament.

Those that yield silk are perhaps pre-eminent at present since important industries are dependent upon the silk excreted by the pupating caterpillar of one of four moths. The value of the exported silk in 1906-7 was 204 lakhs, but much more was produced and used in the country itself.

Lac is a large industry, one of the big staples of India, and, since its use is yearly growing and the source of supply is limited, it is an industry that brings increasing wealth to this country. The export in 1904-5 was valued at Rs. 3,47,00,000 and, besides that, a large amount was used in India.

Wax is still an article of export, fetching a high price and we may see established in the future a large industry in the domesticated bee. for the production of both wax and honey. The yearly export for the last twenty years has fluctuated between 3,000 cwt. and 7,000 cwt. ; the value being between $2\frac{3}{4}$ and 7 lakhs.

The importance of insects as dye producers is gone. Even lac is of no value except on a small scale. Medicine is still dependent upon insects for Cantharidine, and these beetles may become a source of profit instead of a source of loss. As food, the bodies of insects are valuable to all but the most civilised nations; while a not unimportant branch of trade is the collection of immature *Formicidæ* ("Ant's Eggs") for feeding tame game birds and the capture of flies and other small insects as food for cage birds and the like is carried out on a large scale.

Finally, insects are enrolled, with every other description of natural product, in the list of materials used by woman in her personal adornment. This is not as insignificant as it may appear and, though few insects can be used directly (*e.g.*, Buprestids) many provide models for both art and millinery.

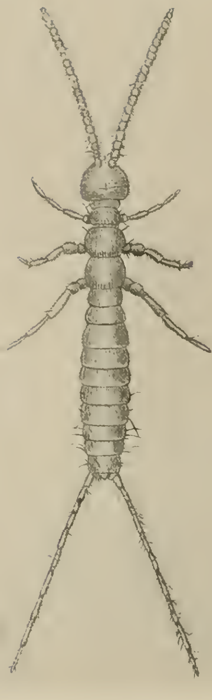


Fig. 1—Campodea staphylinus × 12.
(*From Lubbock*).

APTERA.

Wingless insects, the mouthparts mandibulate. Antennae and legs simple, the integument soft, clothed in scales or hairs, the segments undifferentiated and little co-adapted. There is no metamorphosis, the development being gradual.

The order includes only a small number of minute wingless insects of extreme delicacy, supposed to be scavengers. The mouthparts are concealed, formed for biting. The legs are often long, and there are frequently abdominal appendages in the form of cerci, springs, etc. The body may be completely clothed with fine scales. There is no metamorphosis and no changes take place in external appearance during life, except growth in size. Most of them live in concealment, their food consisting of dried or decaying vegetable matter, so far as is known. None are of importance economically, one genus, *Lepisma*, being a minor household pest.

Aptera are divided into two suborders and eight families. The *Thysanura* have ten abdominal segments and consist of four families. The *Collembola* have six abdominal segments with a peculiar tube-like structure below the first.

THYSANURA.	*Campodeidæ.* *Japygidæ.* *Machilidæ.* *Lepismidæ.*	COLLEMBOLA.	*Lipuridæ.* *Poduridæ.* *Smynthuridæ.* *Neelidæ.*

CAMPODEIDÆ.

The abdomen terminates in a pair of jointed cerci; the mouthparts are concealed.

The cosmopolitan insect *Campodea staphylinus* Westd. (Fig. 1) or a form very close to it occurs in India in damp moss, among damp decaying vegetation and in similar positions. It is a slender white insect, with moderately long antennæ, with cylindrical body and with two anal cerci.

Japygidæ.

The mouthparts are concealed. The body terminates in a pair of forceps.

Fig. 2—Japyx sp. × 8.

These delicate insects will be readily mistaken for young *Forficulidæ*, though the hidden mouthparts serve to distinguish them. They are said to live in moss and under leaves, stones, etc., on the soil, though nothing is on record as to their habits in India. Wood-Mason records finding a single species in Calcutta. (Journ. Asiat. Soc., Bengal, 1876; Ann. Nat. Hist. IV, 18). *Japyx oudemannsi*, Par., and *J. indicus* Oudem., are reported from Burmah. We have found one species (Fig. 2) common among decaying vegetation and in soil; it is a delicate white insect, with the forceps chitinised and brown. It is common in Pusa and in Nagpur, and is probably common throughout the plains.

Machilidæ.

Well developed compound eyes are present. The mouthparts are exserted and visible.

Apparently more than one species of this family occur in India, one on rocks and another among dry decaying leaves.

The latter is a dark grey insect found in the open. The body is elongate, a little over a quarter of an inch long (without the cerci) tapering from the base of the abdomen to head and tail. Compound eyes are situated at the vertex of the head; the antennæ are simple and tapering. The mouthparts are inconspicuous with long maxillary and shorter labial palpi. The body is densely scaled and ends in three

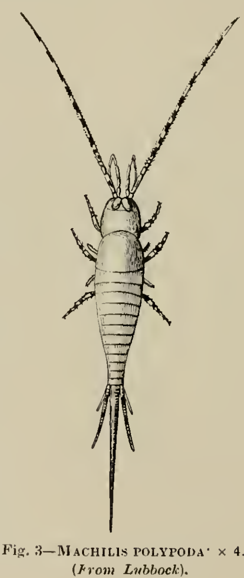


Fig. 3—Machilis polypoda × 4. (*From Lubbock*).

cerci of which the middle is the longest. On the ventral surface of the second and third thoracic and each abdominal segment is a slender jointed appendage, those on the 6th, 7th and 8th abdominal segments being longest. The legs are simple, tapering, the joints little differentiated, the tarsi two jointed. The female has a straight slender ovipositor. These little insects run on rocks and live in the cracks; they are apparently nocturnal and appear to feed on lichens on the rocks.

Assmuthia is a termitophilous genus constituted by Escherich for the reception of *A. spinosissima* and *A. inermis* from India (Zool. Anz. 30, p. 744). *Platystelea barbifer*, Esch. is also recorded from nests of termites in India.

Fig. 4—Lepisma saccharina × 6.
(*From Lubbock*).

Lepismidæ.

Body flattened, clothed in scales; eyes small, mouthparts exserted.

The common fish insects of houses are members of this family and are found throughout India, as practically throughout the world. Annandale has recorded *Lepisma* (*Acrotelsa*) *collaris*, Fabr., as a fish insect of Calcutta (Journ. Asiat. Soc., Bengal, 1906, Vol. II, p. 346), and mentions this as the only recorded Indian species. The Himalayan species is apparently *L. saccharina* (Fig. 4).

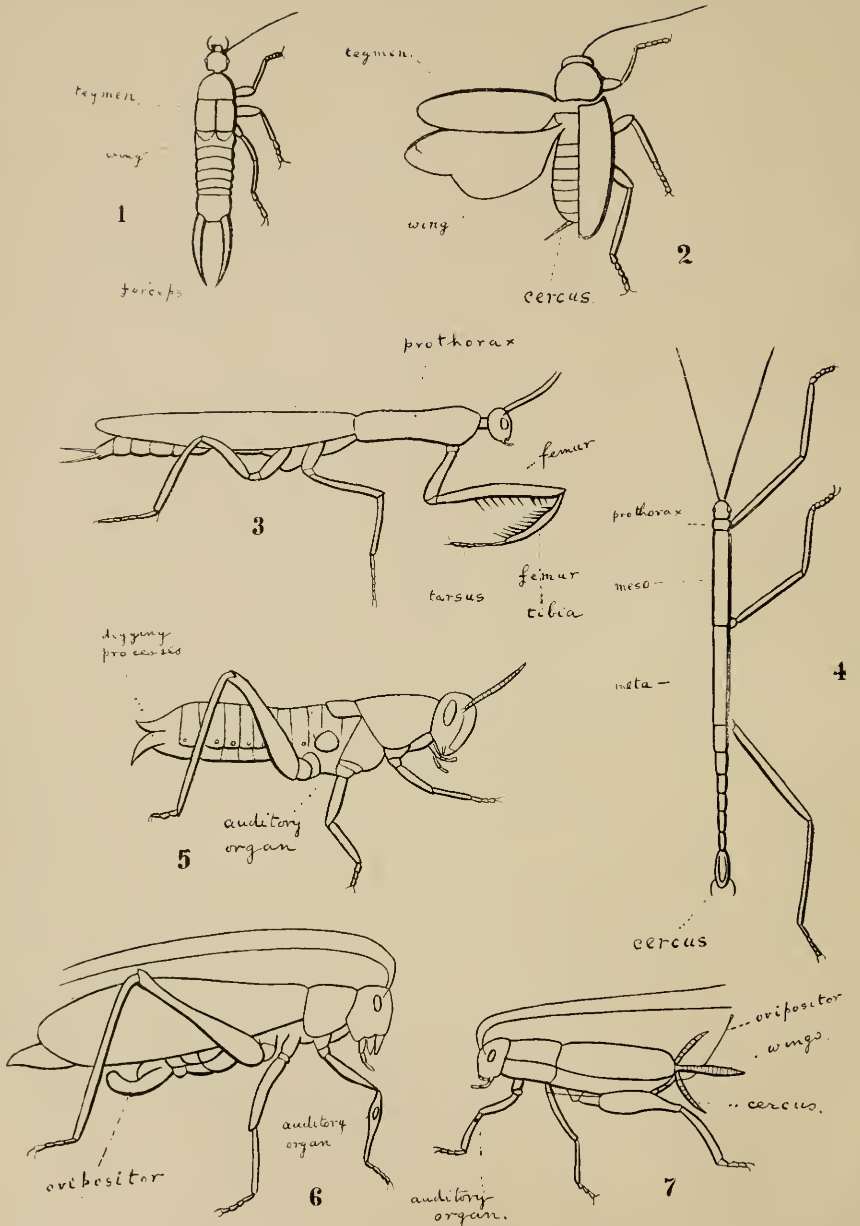
Lepismids are common enough, though all may belong to the above species; they shun light, live behind books among paper and in dark corners and are supposed to feed on starchy and sugary matter. Their body is clothed with flat scales which give them a greasy feel and the shiny appearance that characterises them. The surface of paper is commonly eaten by these insects probably because of the material used in glazing it and they can be in this way destructive.

Collembola.

We are not aware of any described Indian species and only a few have been collected or observed. Species of the first two families appear to be common in damp situations as in decaying vegetable matter and wet moss, under stones by streams, where water drips and under bark. In general one finds such conditions for so brief a time in the plains that these delicate insects are probably not abundant, though they are so in the hills.

Collecting.—Though of no economic importance, this order is well worth studying. The best method of collecting is to use a camel-hair brush, which is dipped into a mixture of glacial acetic acid and strong alcohol and with which the little insects can be caught and put in a tube of this mixture. They are afterwards transferred to 70% spirit. Berlese's funnel trap is a good method of separating these insects from leaves, moss, etc.

PLATE I.



tegmen
wing
1
forceps
tegmen.
wing
cercus.
2
prothorax
femur
3
tarsus
femur
tibia
prothorax
meso
meta
4
cercus
digging processes
auditory organ
5
ovibesitor
auditory organ
6
ovipositor
wings.
cercus.
auditory organ.
7

PLATE I.—ORTHOPTERA

Fig. 1. Forficulid.
,, 2. Blattid
,, 3. Mantid
,, 4. Phasmid
,, 5. Acridiid.
,, 6. Locustid.
,, 7. Gryllid.

ORTHOPTERA.

The antennæ filiform or setaceous, of variable length. The mouthparts mandibulate, of the herbivorous type. The first pair of wings (tegmina) thickened, coloured or ornamented, narrow with nearly parallel sides. The second pair of wings large, membranous, with many fine nervures, hyaline and often coloured, folded below the first pair in repose. The forelegs formed for running or for capturing prey. The hind legs formed for running or leaping, in the latter case long and powerful Cerci are usually present. There is no perfect metamorphosis, the young differing from the adult chiefly in size, colour and the absence of functional wings and reproductive organs. A small proportion never become winged. The imaginal life is often longer than the nymphal life and occupies the greater part of active life. The order includes moderate to large sized insects, the majority scavengers or herbivores, a part predaceous on other insects. None are aquatic, social, or parasitic in living plants or insects.

The order is divided into seven clearly defined families, four of which form one series in which the hind legs are normal, three of which form a second series in which the hind legs are long and formed for leaping.

HIND LEGS NORMAL.	*Forficulidæ.*	Abdomen terminates in forceps. Tegmina shortened. (Plate 1, fig. 1).
	Blattidæ.	Flattened, head deflexed, coxæ large. (Plate 1, fig. 2).
	Mantidæ.	Forelegs raptorial. Prothorax long. (Plate 1, fig. 3).
	Phasmidæ.	Mesothorax long. (Plate 1, fig. 4).
HIND LEGS FORMED FOR LEAPING.	*Acridiidæ.*	Antennæ short. Auditory organ on abdomen. (Plate 1, fig. 5).
	Locustidæ.	Antennæ long. Auditory organ on fore-tibia. Tarsi four-jointed. (Plate 1, fig. 6).
	Gryllidæ.	Antennæ long.* Auditory organ on fore-tibia. Tarsi three-jointed. Tegmina angled. (Plate 1, fig. 7).

* Except *Tridactylina* recognisable by the absence of hind tarsi and *Gryllotalpa*.

Whilst these families are in the main clearly distinct, their relationships are by no means clear. Many entomologists regard the *Forficulidæ* as a separate order (*Euplexoptera*). *Blattidæ* are a geologically ancient family whose connection with present day insects is not clear. *Phasmidæ* are also an ancient family from which may have branched the *Mantidæ* on one side, the *Acridiidæ* as well as the *Locustidæ* and *Gryllidæ* on the other. The last two are undoubtedly closely allied and such aberrant forms as *Schizodactylus* may well be placed in either.

Gryllidæ is much more an aggregation of divergent tribes which may or may not have a common ancestor and so be included in one family, than is for instance *Acridiidæ* which is a homogenous family. Until further evidence is available, a reasonable view is to regard *Blattidæ* and *Phasmidæ* as two archaic families still existing in a slightly modified form, from the latter of which descended the carnivorous *Mantidæ* on one side, the common ancestor of the *Acridiidæ* and the herbivorous *Locustidæ* on the other, from which we have the carnivorous *Locustidæ*, the burrowing crickets (from some such form as *Schizodactylus*), the various other tribes of *Gryllidæ* from other forms of primitive *Locustidæ*. The *Forficulidæ* are possibly an off-shoot from a primitive form of a Blattid ancestor and although retaining the characters of the primitive Orthopterous ancestor, are now distinct; it is equally probable that they are a distinct family more closely related to the primitive ancestor of the Coleoptera. Whatever view may be held by science when more information is available, these seven families are usefully aggregated in one order and the separate families are, as a rule, easy to distinguish. It is unfortunate that the name *Locusta* should have been applied by Linnæus to an insect that is not sufficiently close to the "locusts" to be in the same family; the result is that taking the family name from the oldest named member, *Locustidæ* does not include "locusts" which are *Acridiidæ*. Entomologists sometimes evade the difficulty by naming the Locustid family *Phasgonuridæ* or by transposing the names and applying the name *Locustidæ* to the *Acridiidæ*. Mr. Kirby calls our Acridiids, *Locustidæ*, our Locustids, *Phasgonuridæ*, and our Gryllids, *Achetidæ*.

The more important papers are the following :—

Stal, Recensio Orthopterorum (1873), Brunner, Revision du Systeme des Orthopteres (1893). Walker—Catalogue of Dermaptera Saltatoria (1869-1871). Bolivar—Orthopteres de St. Joseph's College (Ann. Soc. Ent. France, 1897, p. 282; 1899, p. 761; 1901, p. 580).

FORFICULIDÆ.—*Earwigs.*

Slender insects, the forewings short and covering the hindwings, which are large and radially folded; the abdomen terminates in a pair of processes formed like forceps.

Fig. 5—AN EARWIG WITH EXPANDED WINGS.

The earwigs are medium-sized insects, rarely exceeding half an inch in length, rarely less than one quarter of an inch. The forceps at the extremity of the abdomen is characteristic of the family and while very diverse in form, is at once recognizable. There is a superficial resemblance to the Staphylinid beetles but the latter never have forceps. The colours are sombre, black, brown and chestnut predominating; none are brightly coloured but all have the dull colour of insects that live in concealment or on the surface of the soil.

The head and body are somewhat flattened, the legs of moderate length, adapted to running swiftly on the surface of the soil. The antennæ are about half the length of the body, composed of a number of almost moniliform joints. The mouthparts are of the mandibulate type, the mandibles formed for crushing the food, the labium and maxillæ for further mastication of the crushed food. The labial and maxillary pulps are apparently tactile organs, used to determine the nature of the food. The compound eyes are large with many facets; the thorax is of moderate size, its parts little coadapted; the upper wings (*tegmina*) are short and thickened, rarely covering more than the base of the abdomen. The lower wings fold into small compass, but are large, round, with short radial ribs, the outer part folding back on the basal, the basal folding radially as a fan does; this wing is a beautiful structure, which can be opened with care and in which the method of closing is more complex than in the wings of any other insect. The abdomen is often broader than the rest of the body, the segments imbricate, terminating in the forceps which are in some species half the length of the whole body. These forceps vary immensely in size and structure in different species and are not constant in length even in the same sex of some species. Those of the male are commonly larger; bilateral symmetry is not always preserved, and in a few, one limb crosses the other. The sexes are similar in general appearance; the male, however, having a greater number (nine) of visible ventral segments, the female having only seven. There are wingless forms, also some in which the tegmina are reduced to functionless lobes. These species resemble the young of winged species, but the latter have a softer integument, less developed forceps and a smaller number of joints in the antennæ.

Little is known of the life history and habits of Indian earwigs, though that little agrees with what is known of the family elsewhere. Of these insects, as a whole, it may be said that the round white eggs are laid in a mass in the ground or in shelter, the female in some cases remaining with them until they hatch. The young are white at first and while similar in general form to the adults are likely to be mistaken for Thysanura. The transformation is a gradual one, the number of moults not being known. The following account from Cuvier's Natural History relates to *Forficula auricularia*, Linn. the European Earwig:—

"This curious insect," observes Mr. Kirby, "so unjustly traduced by vulgar prejudice—as if the Creator had willed that the insect world should combine within itself examples of all that is most remarkable in every other department in nature—still more nearly approaches the habits of the hen in the care of her family—she absolutely sets upon her eggs, as if to hatch them—a fact which Frisch appears first to have noticed—and guards them with the greatest care. Degeer, having found an earwig thus occupied, removed her into a box where there was some earth, and scattered the eggs in all directions. She soon, however, collected them, one by one, with her jaws, into a heap, and assiduously sat upon them as before. The young ones which resemble the parent, except in wanting elytra and wings, and, strange to say, are, as soon as born, larger than the eggs which contained them, immediately upon being hatched, creep like a brood of chickens under the belly of the mother who very quietly suffers them to push between her feet and will often, as Degeer found, sit over them in this posture for some hours. This remarkable fact I have myself witnessed, having found an earwig under a stone which accidentally turned over, setting upon a cluster of young ones, just as this celebrated naturalist has described.''

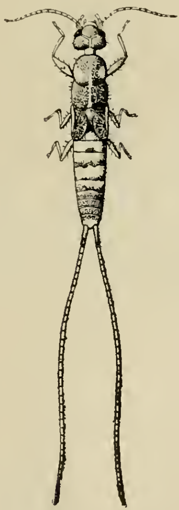


Fig. 6—DIPLATYS LONGISETOSA, NYMPH. (*After Green*).

Diplatys longisetosa, Westw. has a remarkable nymph (fig. 6), in which the abdomen terminates in a pair of long many-jointed processes, of which the basal joint, at the final moult, is transformed into the forceps (Green, Trans. Ent. Soc., London, 1898, p. 381 [Dyscritina]).

Equally little is recorded or known of the food of earwigs. Apparently it consists of decaying vegetable matter, of pollen, of the sap of plants and possibly often of small insects or other small forms of animal life. Earwigs are found in decaying trees, under bark, among rotting vegetation and the deposit of leaves under trees, under stones, in flowers, in the tangled roots of plants (*e.g.*, sugarcane), and in other similar situations; they hide away and live principally under shelter in damp places. Their form is adapted to running quickly and easily among leaves, grass, roots, etc., and flight is but rarely utilised.

Labidura lividipes and *L. riparia*, fly at night and come frequently to light, the only Forficulids observed to have this habit. They are not formed for actual burrowing, but are part of the Fauna of the surface of the ground, as are the *Carabidæ, Blattidæ, Tenebrionidæ, Lygæidæ,* etc.; less is known of this "surface fauna" than of any other, from the great difficulty of observation. The function of the forceps is a mystery that will be cleared up only when their food-habits and general life are better understood. It has been suggested that the forceps, though not actual weapons of defence, appear as such and give the insect a more formidable appearance which protects them against the enemies that occur in their habitat; a few species can actually use their forceps as feeble pinching organs and the power to do so may have been more fully developed in the more primitive species; there is also some reason to believe that the forceps are useful in carrying out the rather complex folding of the hind wing; neither explanation is a satisfactory one.

Earwigs are most active in the rains and damp weather, being dependent upon moderately damp conditions; in irrigated lands they are active throughout the year except when cold drives them to hibernation in shelter, as happens in colder parts of the plains. There appear to be no definite seasons for reproduction, and individuals of different ages may be found at any time. None are recorded as pests in India, though they are often believed to be injurious owing to their habit of coming to wounded tissues of plants to obtain sap; they are thus found under very compromising conditions, but investigation has shown that the injury was caused by other insects, and there is no reason to believe that any can be regarded as pests. A few are constant frequenters of the sea-shore and are found almost throughout the world among the seaweed and debris thrown up on the beach.

Earwigs are found throughout the temperate and tropical parts of the globe; they are less common in India than in other countries, but a fair number of species are already known from India. They do not fall into well-marked sub-families and may be regarded as a distinct and fairly homogeneous family. Bormans and Krauss describe 76 species from India including Burmah, the majority being Burmese species. Kirby's catalogue gives only 48 as Indian, and more have been described from India by Burr; this does not include species found in Ceylon only. The number of known species will be increased when more attention is paid to this group in India, and some of the commonest species have been found to be undescribed. The student should consult Burr's paper on Ceylon Forficulidæ (Jour. Bombay Nat. Hist. Soc., XIV, 59), his papers on Indian species (Jour. Asiat. Soc. Bengal, 1905, p. 27; and 1906, p. 387); and his revision of part of the family (Trans. Ent. Soc., London, 1907, p. 91).

Diplatys is represented by several sub-tropical species; *D. longisetosa*, Westw. is marked by the long multi-articulate setæ of the nymph, the basal joint of which is stated to become the forceps of the adult. *Forcipula* has three species in India; *Labidura* is represented by several species. *L. riparia*, Pall. *L. bengalensis*, Dohrn. (fig. 7), and *L. lividipes* Duf. are common in grass and are obtainable in numbers when a grass lawn is flooded with water. *Anisolabis maritima*, Gene. is a world-wide species, found in sea-weed on the beach. *A. annulipes*, Luc. is a wingless species, found abundantly in the plains on the soil. *Labia minor*, L., is a common insect not only in Asia but in Europe, Africa and America, found in flowers and on plants, rarely seen on the wing by day. *Chelisoches* is represented by nine species, *C. morio*, Fabr. being spread over the coasts of the South Pacific and Indian Oceans. *C. melanocephalus*, Dohrn. has been found commonly in sugarcane roots and also in the tunnels of the borer caterpillars in the cane. *Apterygida gravidula*, Gerst. is widespread and there are other species of this genus. Several species of *Forficula* are recorded, though the widespread *F. auricularia*, L., the common earwig of Europe, has not been found.

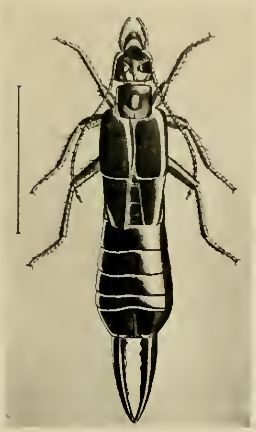


Fig. 7—Labidura bengalensis.

Collecting.—Earwigs will be found only by patient search if they are to be specially collected. In the course of general collecting one finds them in flowers, under stones, among decaying vegetation and fallen leaves, among debris on the beach. Some are found in houses, especially in damp places, such as bathrooms in the hot weather; others will be found at the roots of plants in the cold weather. Many come to sap, or are found in bored canes or in other situations where the sap of a plant is exposed. A few come to light, but this is rarely a useful method of collecting them. When caught, they should be killed in a cyanide or B. C. bottle and pinned through the right wingcase. Care is needed to open the left lower wing, though this is not usually necessary.

WHERE INSECTS LIVE.

INSECTS are small creatures and very abundant; where are they all? At some times in the year one can easily gather at least one hundred thousand insects within one day over a space of, say a few acres; at another time there would not appear to be an insect obtainable in that space and yet the insects must be somewhere. It is when one comes to try to answer this question that one realizes the absolute truth of the statement that insects are to be found everywhere on the surface of the earth within a narrow zone which includes 20 feet of the solid soil, the vegetation that stretches up from the soil for some 100 feet, and to a slight extent the air above. Excepting for the moment the artificial erections of man, we are not far from the truth in saying that this zone is very completely occupied by insect life in some form or other. It may be hoped that light will be thrown on this point some day by the very careful investigation of the fauna of, say one square mile of the earth's surface, including this zone we speak of, covering average areas of fallow, crop, grass land, bush, jungle and forest. The number of actual living insects in some form or other will be surprising. Commencing, say 20 feet down, there are the deeply burrowing insects, the termites, the dung beetles, the Cicadid nymphs, and the crickets; within six feet of the surface we come to the insects that burrow, but do not go so deep; the ants are conspicuous examples, as are all the above-mentioned insects which cannot go deep in some soils; Scarabaeid grubs are near the surface, as are Tipulid maggots, Cicindelid grubs; nearer still to the surface are the surface crickets which only make tunnels as shelters, the many digger wasps and other boring Aculeates, the burrows of some Carabids, such as Anthia; quite near the surface our fauna might be immense if we dug in winter, as we should find the countless pupæ of the hibernating beetles, of moths, of Diptera; we should also find the many adults which seek shelter there, as well as abundant egg masses and many half-grown larvæ not yet ready to pupate. At any season there would be many such, not hibernating, but pupating or feeding or in the egg stage. The fauna of these few inches would be of great interest, and we venture to assert that, in India at least, much light would be thrown on many insects' life-histories were it better known. Coming to the actual surface a large fauna would reward us where any fallen leaves and the like offered shelter and food; we have referred often to this fauna, a very extensive medley of black and dark brown insects, such as Earwigs, Cockchafers, Embiids, Carabids, Staphylinids, Clavicornia of many families, Tenebrionid and other beetles, as well as the Cydnine division of the Pentatomidæ, the Lygæidæ, the Reduviids and the Capsids; besides these there are the abundant larvæ of beetles, of Diptera a few of Lepidoptera, probably outnumbering all the remainder and teeming in favourite places. A square foot of good soil covered in leaf mould offers a great variety anywhere, and it is only on very dry or hard soil that one can anywhere find a square foot unoccupied and usually no square inch. This little part of our zone is one centre, the home of the light-shunning surface fauna which works at night and which makes up so large and so unknown a portion of the fauna. It may be noted that this part of our fauna is probably far less important in sub-tropical India than it is in tropical India, the surface fauna in the former being comparatively small. Above that we are on surer ground and the variety is not so confusing; for each part of our plants will have their own fauna; the stems contain borers, the Buprestids, Cerambycids, Pyralids, Cossids and the like; the bark shelters multitudes if it is at all loose or decomposing and here again is a centre of activity, nor rivalling our chief centre but very important and crowded; even the outside of our stems and trunks has cocoons and such like, as well as a whole fauna of its own in the case of a large tree round which debris collects. No one has ever described the fauna of the heap of decaying leaves, bark, etc., found round the base of the trunk of a large pipal, for instance, which is the home of numberless insects, the resting place of pupæ, the place of deposition of eggs. Our low plants have their own fauna, a very large one too, of herbivorous caterpillars, of leafmining Diptera, Coleoptera and Microlepidoptera, of gall insects, of the seed-eating species of caterpillars, of the sucking bugs and aphids; apart from the plant, the two feet or so of air space round the plants teems with the active flying forms, with bees and wasps, with butterflies and beetles, with flies and grasshoppers, all the lives that lives on and round and among low plants. It is this fauna which is, in moist sub-tropical India, with its immense flora, so extensive and which is of much greater relative importance in this zone than it is in tropical India. A reduplication of this fauna is found higher up, in or among the taller forms of vegetation, such as bamboos and grasses and to a large extent this fauna is quite distinct if, as is true, human beings live wholly in the six feet of air space lying immediately over the soil, so also insects are largely restricted each to its particular zone, and we believe there is a very distinct and peculiar fauna of the air at the tree levels; the dancing insects that may be seen in such myriads on a clear still day are certainly peculiar, and it is at least probable that a number never come, in this form, within our ken, but remain at higher levels; then too no one knows what insects are found in the air above the trees or how far this zone extends; what do swallows get when they are hawking high up, far above the trees? Aitken speaks of a butterfly (*Melanitis ismene*) soaring far above into the air and no one knows what countless forms of winged insects may not go to these levels as soon as they emerge. There must be a limit to this zone, but we would hesitate where to put it unless, for the plains, we give an outside limit of, say 3,000 feet. When the day of flying machines dawns we shall certainly find insects of interesting kinds above the trees, and we should like to see "kite" nets employed to investigate the fauna.

It is perhaps not unprofitable to consider, in the light of the above remarks, how little of our insect world we probably know or attempt to know. In this country, progress beyond the stage of classifying and naming the insects most easily got has scarcely been made at all and this must come first; but it is certain that the only insects that have been found, named and placed in Museums are those which fly by day, or which live on bushes, etc., above ground, or which come to light. A great number of insects come to light, notably perhaps a part of the "surface soil fauna" and other retiring insects; but we do not know that there are not hordes which never come to light, which are never seen, and of which we are quite ignorant. This is true probably of all countries and the fauna of the soil, except as regards the large forms, is extremely little known even where naturalists and collectors abound. (The same is to some extent true of freshwater.) How much more will this not be the case with the tropics, especially with the drier parts where much of the fauna is known to go to the soil. We know from experiment that many species go to the surface soil to spend the hot weather; but there are no records that they were ever found there; put out a light trap on a still moist evening during the monsoon and see the countless insects that come and the number of kinds; very many are never found in any other way, yet they and how many more, must be hidden somewhere.

BLATTIDÆ.—*Cockroaches.*

Flattened insects, the large forewings lying flat on the abdomen, completely covering the hindwings. Coxæ large and covering the lower surface of the thorax. The head turned down and hidden from above.

Cockroaches have a very characteristic general appearance and are usually recognizable at sight; they include small fragile insects of a quarter of an inch in length to larger robust forms which measure nearly two inches. They are coloured in sombre sheds of brown and black, only a few species with conspicuous bands or spots of yellow or orange which may constitute a degree of warning coloration and are usually found in the diurnal species living to some extent exposed. The antennæ are long and filiform, functioning as delicate sense organs; the mouth-parts are of the non-predaceous biting type, the mandibles short and massive, the labial and maxillary palpi well developed. The body is generally soft, the chitinous plates of the integument not firmly united and the chitin usually less thick than in other insects. The flattened body and slippery surface enable the insect to hide in crevices and render it more difficult to capture. The abdomen terminates in a pair of short jointed cerci, whose precise function is not known. The legs are long, thickly spined and formed for quick running; the first pair are reduced in some species. (Fig. 8.) Males and females are generally similar in appearance, the former in some instances with a pair of slender styles at the genital opening. In several species the wings and tegnima are absent or only imperfectly developed, this being correlated with the general disuse of the wings throughout the family. It is difficult to distinguish the wingless adult from a nymph of a winged form; the presence of lobes at the hind angles of the mesonotum and metanotum shows the insect to be a nymph of a winged species, in most cases.

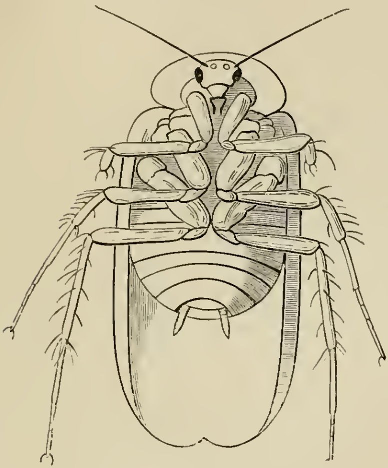


Fig. 8.—Polyphaga ægyptiaca. *From below.*

The life-history of all known species agrees in the general features.

Eggs are laid in the forms of a capsule, (fig. 9) a brown hard structure of characteristic form containing a considerable number of eggs. In *Periplaneta americana*, out of seven egg-capsules, four contained 16 eggs, two contained 18 and one only 12. Each capsule consists of a

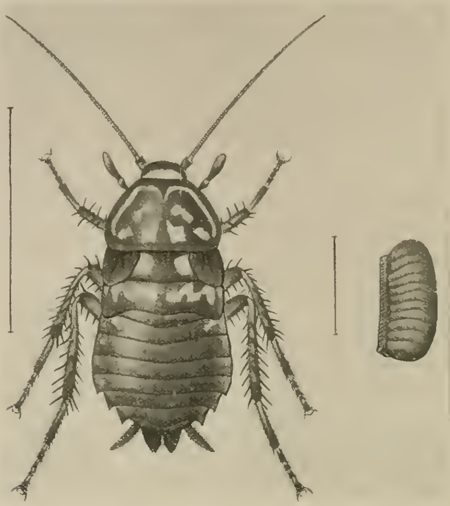


Fig. 9.—Styloygia rhombifolia.
Adult female and egg-case.

double row of cigar-shaped eggs, surrounded by a chitinous coating which is joined by a wavy line which runs along the one end of the rows of eggs; when the eggs hatch, this line opens, allowing the young emerge. It is probable that the expansion of the eggs before hatching, a common phenomenon, is the cause of the opening of the egg-capsule, but it is also stated that the cement joining the edges is softened by a fluid secreted by the embryo just before hatching. The egg-capsule is not always deposited by the female as soon as formed, but is in some species carried in the oviduct almost until hatching; in a few foreign species this habit is carried to the extreme, and the eggs are carried till the young hatch. An egg cluster of *Periplaneta americana* laid on the 2nd July, hatched on 27th July and the nymphs were only half-grown at the end of the following April. The young which emerge from the egg-capsule are in general form similar to the adult, the skin softer, the antennæ and cerci with fewer joints, the wings absent. The number of moults is not known; in captivity, development is slow, the common household species (*Periplaneta americana*), requiring several months to come to maturity. There is reason to believe this is the case also with the free-living species, and since the possession of wings is usually a matter of slight importance and the habits remain unchanged, there would not appear to be any necessity for quick nymphal development. The total length of the life history is not known, but the imaginal, like the nymphal, life is probably comparatively long.

In all stages, cockroaches are found amongst fallen leaves, on the surface of the soil, under stones, in thick grass, and on trees and plants. The majority are nocturnal, living in concealment on the surface of the soil and forming a part of the large "surface fauna." The tree and bush species are diurnal in habit. A few are household insects living in buildings and these are undoubtedly wild free-living species which have migrated into man's dwellings. The food consists of dead animal and vegetable matter; these insects are "scavengers" and none is known to feed on living plant tissue or to attack living insects. Plant sap, decaying plant tissue, dead insects and the like probably represents the food of the free-living species. The household species have the same food-habits, a great variety of animal and vegetable substances forming their food while their dead brethren are freely eaten when hunger presses. Nothing is known as to the activities of Indian species during the different seasons. Hibernation, where necessary, is apparently passed in any stage and there appear to be no special "seasons" when cockroaches breed. Excessive cold, excessive heat, drought or hunger cause a cessation of reproduction, development and activity but no definite seasons have been made out. No species is known as a pest, though those which live in houses are objectionable and destructive.

Since these insects are dependent upon crumbs, scraps, and access to human food, cleanliness and care should prevent them thriving. Where they are abundant, the simplest precaution is the use of borax, mixed with double its weight of syrup, as a poison; many ingenious traps are also useful when baited with intoxicating liquor. The principal check on cockroaches are egg-parasites; the ichneumons of the genus *Evania* lay their eggs in the egg capsules of cockroaches and the household species are not exempt from attack. Field cockroaches are attacked by fossorial wasps of the genus *Ampulex*, which sting them, deposit them in holes or crevices and lay an egg on them. The unpleasant odour of the household cockroaches is probably protective and is due to the secretion of liquid from glands placed between the 5th and 6th abdominal segments. (Minchin, Q. J. M. S., XXIX.)

It is known that cockroaches contain internal parasites belonging to the Gregarine division of the Protozoa, as well as parasitic bacteria, Nematodes (*Oxyuris*), Hair worms (*Gordius*) and a *Filaria*. It is also probable that the large centipedes which enter houses in India are seeking blattids. Rats also feed on cockroaches.

Fig. 10—PHYLLODROMIA HUMBERTIANA. × 2⅔.

The family is a comparatively large one, with many described species, occurring in all parts of the globe. The majority of the Indian species are described by Brunner and Bolivar.

Kirby's recent catalogue of the family lists 123 Indian species, which probably include the majority of the larger forms. The family is being listed by R. Shelford in Genera Insectorum; it is divided into eleven tribes by Brunner, but it is unnecessary to consider these in this place. *Phyllodromia* (Blatta) *germanica*, Linn. is one of the common small species found in houses in India and now cosmopolitan, probably introduced to India from Europe. *P. humbertiana*, Sauss. (*cognata*) (fig. 10) is a small brown species, the prothorax marked with black and light brown. It is perhaps the most common field species, found among decaying vegetation and also on trees; its eggs are laid on the leaves and bark of trees. On the soil is its wingless nymph, a small black insect with median and lateral light stripes. *Phyllodromia suppellectilium*, Serv., is the small household species, common throughout the tropics; it is winged, of a brown colour with varied dark markings.

Stylopyga (Blatta) *orientalis*, Linn. is a widespread species, believed to have been introduced to Europe from tropical Asia and now carried over the world in ships. It is a dark coloured insect of a length of a little over an inch; the tegmina do not reach to the apex of the abdomen and cover only the basal five segments. The males alone are winged. The development in Europe is stated to occupy as much as four years, the duration of each instar being very long. *Stylopyga rhombifolia*, Stoll. (fig. 9) is a larger wingless form, brown, with varied yellow markings, found also in houses. This is the most common household species next to the large winged *Periplaneta australasiæ*, F.

Fig. 11—Periplaneta australasiæ.

Periplaneta includes the two large cockroaches so common in houses and on board ships. Both are winged, red brown with lighter markings on the prothorax. *P. australasiæ*, Fabr. (fig. 11) is smaller than *P. americana*, Linn. the prothorax more wholly dark. The latter has the startling habit of flying about in the house before rain falls and is accounted a reliable weather prophet. This habit is possibly a relic of the instinct of its original free-living ancestor, which flew up into safety before the fall of heavy rain. *Rhyparobia maderæ*, Fabr. is a cosmopolitan species, carried over the world by commerce. *Leucophæa surinamensis*, Linn. is a smaller thickset insect, the prothorax black, the tegmina brown; it is common in the open and is widespread over the tropics. *Panesthia regalis*, Wlk. is a peculiarly striking species, black with a broad band of orange across the tegmina. It is one of the rarer plains' species. *Corydia petiveriana*, Linn. is a beautiful cockroach of South India, the tegmina having large white spots. *Heterogamia* (Polyphaga) *indica*, Wlk. resembles a large round woodlouse, wingless and nearly circular in outline.

Collecting.—Cockroaches are found by searching under stones, among fallen leaves, on herbage and bushes, on the bark of trees, and among the debris that accumulates at the foot of the trunk of a large tree. The smaller ones are found also in thick (doab) grass in the hot weather. Syrup or fruit juice smeared on the bark of trees is a good bait but unless this is alcoholised, it must be examined soon after dark; if strongly alcoholised the insects get drunk and may be found at any time in the night till dawn. A few species are attracted by light. When caught and killed, they should be pinned through the right tegmen near the base, the legs and antennæ set. Rearing is slow and difficult; the right conditions of moisture and food must be given with plenty of shelter and space.

COSMOPOLITAN INSECTS.

A CONSIDERABLE number of insects have been carried by man from one country to another and have succeeded in establishing themselves not in one country only but in a large number of countries; the spread of these insects is continuing and they will in time be world wide. These species are to a large extent those which can live in houses, or which infest grain and other merchandise, or which have been carried on living animals and plants. Naturally the household and grain insects predominate, since commerce is carried on between large cities in which these insects thrive, whereas those infesting plants have not the same chance of surviving in all cases. Many of our common household insects are cosmopolitan; the common silver fish of houses is now widespread and will become more so; the Cockroaches, *Stylopyga orientalis*, *Periplaneta americana* and *P. australasiæ*, *Rhyparobia maderæ and Leucophæa surinamensis*, are common in India as elsewhere; with them have gone their parasite *Evania appendigaster*, now a common insect and met with on board ship. It is probable that our household *Psocids* are also the same as the European though we are not aware that this has yet been substantiated. Ants, (*e.g.*, *Monomorium*) as is well known, constantly come with shipments of goods and establish themselves successfully in new cities.

A host of beetles are cosmopolites. Hamilton gives a list of 100 beetles which he styles cosmopolite or nearly so; this refers more especially to Europe and North America and indicates how large a number of insects have been carried by commerce and have succeeded in establishing themselves in new countries. Only a small number of these appear to originate in the East.

The following are Cosmopolitan beetles apparently found in India, some possibly originating there (indicated by*).

Silvanus surinamensis.	* *Sitodrepa panicea.*
Lœmophlœus ferrugineus.	*Dinoderus pusillus.*
,, *pusillus.*	*Bruchus chinensis.*
Dermestes vulpinus.	,, *emarginatus.*
Carpophilus hemipterus.	* *Tenebrio molitor Linn.*
Trogosita mauritanica.	* *Tribolium ferrugineum.*
Necrobia rufipes.	* ,, *confusum.*
Necrobia ruficollis.	* *Calandra oryzœ.*
Necrobia violacea.	* ,, *granaria.*
Gibbium scotias.	*Arœcerus fasciculatus.*

Among Lepidoptera some of the genus *Ephestia* are constantly carried and are now almost universal; so also are such forms as *Tinea pellionella*, *Setomorpha rutella*, and other clothes moths. Of the flies, we know of few ; *Eristalis tenax* is widespread and the common houseflies such as *Musca domestica* are world wide, as are some of the fleas ; the cheese maggot, *Piophila casei* is also carried in its food and establishes itself successfully.

Finally the malodorous bug *Cimex lectularius* is sufficiently familiar. The above are all household or grain pests and would naturally be readily spread. Amongst animal pests it is sufficient to mention the fly *Stomoxys calcitrans* established throughout India, as well as the three bot flies of the horse, cow and sheep, (ticks also are carried). When we turn to plant parasites, there are fewer true cosmopolites since the vegetation varies so much, and since climatic conditions affect the insects more. (See Agric. Journ., India, III, No. 3. "Introduced Insect Pests.") Many scale insects are extremely widespread and numerous species are known to have been carried, some reaching India. In fact, the introduction of living plants is practically certain to mean the introduction of scale insects if precautions are not taken. We can enumerate 25 species probably introduced to or from India, and we have seen more than one on consignment of plants from abroad. How our Aphids reached India is not clear but our worst are all cosmopolites and have probably come on plants. Of other insects, it is extremely hard to speak; a few are cosmopolitan, such as *Chloridea obsoleta*, *Danais plexippus*, *Vanessa cardui*, *Hellula undalis*, *Nomophila noctuella*, *Plutella maculipennis*, but there is no evidence that they are spread by man and this cosmopolitanism possibly antedates man. *Phthorimœa operculella* is a widespread insect introduced to India probably in recent years and is the sole instance of its class we know of.

We have barely touched the fringe of this subject as alone is possible in this place. Enough has been said to show that insects are carried by man and though India has not suffered from this cause, as for instance, America and the West Indies have, yet when more is known it may be found that India has got nearly as much as she has given.

MANTIDÆ.—*Preying Mantises.*

The forelegs raptorial, long, the femora and tibiæ spiny. The head deflexed. The prothorax elongate.

A moderately large family, recognizable by the raptorial forelegs, in which the tibia works in opposition to the femur like the blades of a

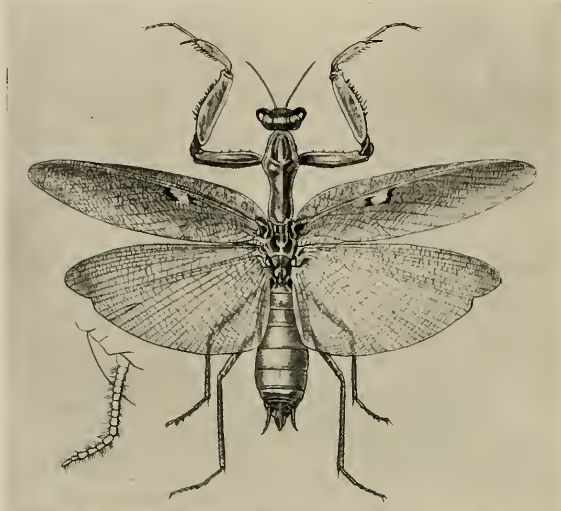


Fig. 12—HIERODULA COARCTATA.
And left cercus.

scissors, and both are wholly or partially spined. Where this character is insufficient to separate from *Phasmidæ*, the length of the prothorax is sufficient, this being short in the latter family. Mantises are commonly of large size and include no insects of less length than half an inch while some attain to four and even six inches. In appearance, these insects are extremely striking, including some of the most picturesque and bizarre forms of insect life. The form and colour is cryptic, designed to produce a resemblance to natural objects in their surroundings which is extremely marked. Many are stick-like, elongate, coloured in tones of brown and black as is a dry twig; in these, the attitude assists the deception, the creature poising itself on its posterior legs and swaying lightly from side to side as if moved by the breeze. Others that live in grass are slender and grass coloured, either "dry grass colour," green or green with the antennæ and cerci coloured like the dry tips of withered grass. Others are leaf green, living among the leaves of bushes or are the colour of bark and are found on tree trunks. The most striking instance is the Orchid mantis, *Gongylus gongyloides*, which is a floral simulator, the body and wings so formed as to suggest a flower when a particular attitude is assumed. In this attitude, the lower surface suggests a blue flower, and insects coming to it are destroyed by the forelegs. Williams (Trans. Ent. Soc. Lond., 1904, p. 125) states that the upper surface can be so arranged as to simulate an orchid flower, this being primarily as a means of defence (cryptic), the blue flower resemblance alone being used to obtain food. In general the cryptic form and colour serves the double object of protecting the insect from foes and allowing it to be invisible to other insects which it captures when they come within reach.

The antennæ are filiform, in some short and inconspicuous, in others long. The head is elongate, sometimes produced at the apex, the compound eyes are large, the head very mobile and the insect has a curious habit of turning the head to look intelligently even at a human being as if it really saw it. The mouthparts are similar to those of the rest of the order, short biting mouthparts, the mandibles not elongate as in other predaceous insects, since the prey is captured by the forelegs and the jaws are solely for mastication. The prothorax is long, sometimes nearly half the length of the body, and this is apparently an adaptation to secure great mobility for the forelegs and head. The forewings are of moderate size, thickened, coloured and covering the large folded hindwings, which are hyaline and often coloured. Wingless species occur but rarely, one or both sexes being without either tegmina or wings. Wood-Mason describes stridulatory structures in certain *Mantidæ*, but there appears to be no direct evidence that sounds are actually produced (Trans. Ent. Soc. London, 1878, p. 263). The abdomen is often expanded in a leaf-like manner and is cárried in striking attitudes to aid the cryptic resemblance. The abdomen terminates in a pair of short cerci. The forelegs are beautifully formed, the tibia closing on to the femur; as both are set with spines, an insect caught in them is firmly held and can be brought up to the mouth to be eaten. The tibia is sometimes as long as the femur, sometimes very short and only closing on the apex of the femur, this portion of the femur alone being spined, the remainder smooth. Wood-Mason describes femoral brushes used to keep the eyes and ocelli clean and found, he says, in the nymphs just hatched and in all later stages (Proc. Asiat. Soc. Bengal, 1876, p. 123). The posterior legs are long and enable the insect to run actively, as well as to balance itself ready to turn or to dart forward. There are few more striking insects than a mantis in its natural habitat on a plant waiting for food ; balanced on the two pairs of legs, it looks from side to side, turning the head with quick motions and seeming to look intently from the large eyes ; the antennæ are active, moving constantly, the forelegs drawn up under the head but ready to dart out ; the creature is so intent, the attitude so expectant and yet suggestive of cunning ; in an instant it stiffens, becomes rigid, every part still, the long forelegs extended ; should its prey alight near, it moves stealthily, stalking it as a cat does a bird, gradually drawing near

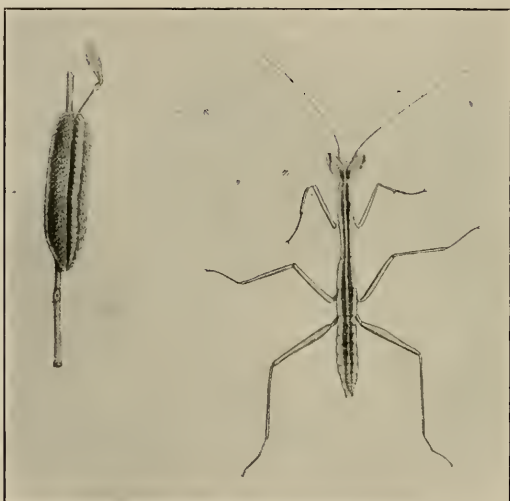


Fig. 13—Mantid egg-mass and newly emerged nymph, the latter much enlarged.

till its forelegs strike and the insect is held securely, drawn up to the mouth and devoured.

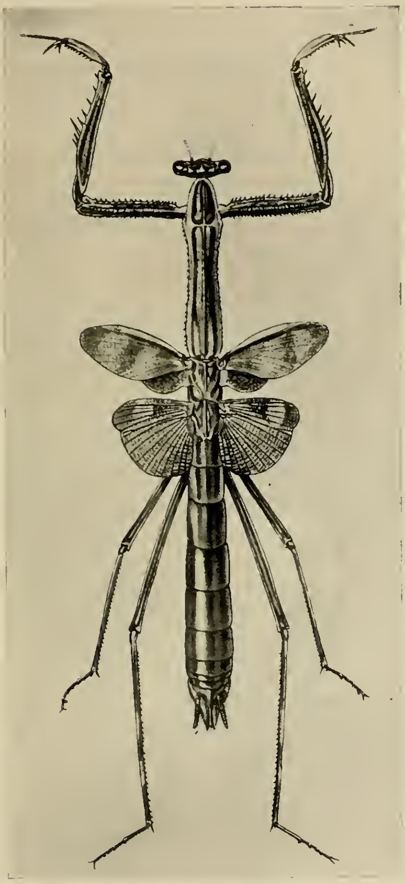


Fig. 14—Deiphobe ocellata.

The female deposits her eggs in a characteristic large egg case, (fig. 13) fixed to a plant. The egg case is made of gummy matter secreted by the female, which comes out as a frothy mass, and sets hard in a short time; taking a firm position on the plant, with head down and the tip of the abdomen touching the plant, she extrudes a mass of frothy gum and with the end of the abdomen works it into the shape characteristic; as soon as the base is formed and some amount of gum used, eggs are deposited in the midst of the gum. The emission of eggs and gum continues, the eggs in the middle, the gum round, until the whole egg mass is built up, layer by layer, when she finishes it off with gum and the whole hardens to a watertight object firmly secured to the plant. The eggs are in regular rows inside the egg case and the whole mass will last through the winter on the plant. The young mantids emerge from the egg almost simultaneously and are small active insects often dark coloured and with a general resemblance to an ant (fig. 13). Shelford records the mimicry of the nymph of *Hymenopus bicornus* for the nymph of a Reduviid bug, *Eulyes amoena* (Proc. Zool. Soc. London, 1902, p. 230). They are active and lead an active life until they are full grown. In general their habits are not those of the parents, the young seeking small insects on plants or on the soil, and only adopting the peculiar habits of their parents as they progress towards maturity. The form and attitude of the young is frequently very striking, though different to that of the adult, and there is a large field for investigation into the habits and resemblances of these nymphs. All are predaceous at all times of their life ; the food of the full grown insect is large living insects, which are caught when they come within reach of the waiting mantis. None are vegetarian, none are injurious, but the group comes into the class we may denominate as "General Predators," feeding on such insects as come to them and not being specially adapted to special insects. The length of the life history is not known. Hibernation appears to take place chiefly in the egg stage ; eggmasses are laid in early November in the plains, and hatch in early March. This is not the only time that eggs are laid, as they may be found during the rains. Wood-Mason found eggs laid by *Mantis* sp. to hatch in 18 days (July 17th to August 4th), while those of *Schizocephala bicornis* took 30 days (July 17th to August 16th). Nymphs and adults of bark-infesting species have been found in winter under the bark of trees, and this appears to be the normal hibernation of such as can find shelter. Throughout the remaining months these insects are active and there appear to be no special periods when they breed or multiply extensively. They are distributed throughout India, more abundantly in the jungle but still commonly in the cultivated plains. They are essentially tropical insects, and are rare or non-existent in temperate climates. The eggmasses are the habitat of parasitic *Chalcidæ*, the females of which have long ovipositors with which they pierce the eggmass and reach the eggs within. Apparently a large proportion of the eggmasses are parasitised. Other enemies are not known.

Mantidæ are far less numerous than some other groups of Orthoptera and fewer species occur.

Wood-Mason catalogued the *Mantidæ* and more recently Mr. Kirby's catalogue has been issued by the British Museum (Cat. of Orth., pt. 1). In this 82 species are listed as Indian divided as follows :—

Amorphoscelinæ 1, Hemiaphilinæ 7, Chaeradodinæ 1, Mantinæ 43, Miopteryginæ 0, Creobotinæ 17, Vatinæ 10, Empusiinæ 3.

The majority of Indian Mantidæ belong to genera widespread over the Indo-Malayan region. Five genera are purely Indian, accepting India in the broad sense, these being *Sphendale, Phyllothelys, Heterochaetula, Aethalochroa* and *Gongylus*. *Empusa* is widespread, having but one Indian species, but occurring also in Africa, South Europe and Western Asia.

Creoboter urbana, Fabr. is a common small green form, each tegmen with a yellow black-ringed eye-spot ; it is an active species found upon bushes. *Hierodula Westwoodi*, Sss. and *H. coarctata*, Westw. (fig. 12) are the robuster green insect seen upon bushes and in crops, which are the most familiar "Mantis" in India. The former has been seen eating *Scutellera nobilis*. *Eremoplana microptera*, Wlk. is a long slender species of a dull brown colour with a narrow green costal stripe, found upon low bushes in the plains. It comes freely to light. *Humbertiella indica*, Sss. is a smaller dull grey species found upon the bark of trees, where its colouring renders it very inconspicuous. *Schizocephalus bicornis*, L. is one of the most delightful of the insects one can find commonly in the plains. It is a very long, attenuated insect, with long slender legs, and with short wings folding tightly round the body. Its colouring is green and the antennæ and anal cerci are both the colour of a dry grass blade. Sitting among the grass, the insect is indistinguishable from the grass blades round it ; its antennæ or anal cerci give the idea of grass just drying at the tip and one may search for these insects and not find one when they are abundant under one's eyes at the time. They are slow in movement and the femur is armed only at the tip, the tibia very short.

Two species of *Gongylus* occur in India, of which we figure one. *G. gongyloides*, Linn. (fig. 15) is a notorious insect of which much has been written. *G. trachelophyllus*, Burm. is the commoner Indian insect, a graceful creature coloured in tints of yellow and brown and commonly found in jungles and woods.

Fig. 15—GONGYLUS GONGYLOIDES.

Collecting.—The great number of mantids are found upon bushes, in grass, on the bark of trees. They are most abundant upon bushes, rare upon small crops. A number will be found in the bag when it is used to sweep insects on grass. These insects should never be included with others in a box or bottle while alive, but should be confined separately or at once killed. They are best pinned through the right wing case or prothorax, the left wings being set. Rearing is exceedingly difficult in most cases, though the eggs hatch readily, as the special food of the young cannot be ascertained or easily procured. What is now specially required is careful observation of the food of these insects; we are not aware of any definite observations on the food of individual Indian species and no proper estimate of their economic value can be made until we have such facts.

PHASMIDÆ.—*Stick and leaf insects.*

The prothorax small, mesothorax large. Tegmina small or absent; wings often absent. Cerci of one joint only.

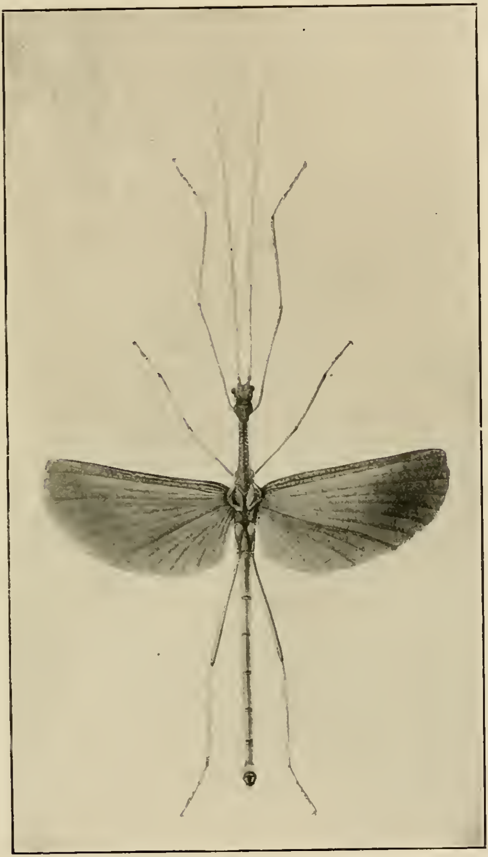


Fig. 16—NECROSCIA PHOLIDOTUS, WESTW., MALE.

A smaller group of insects, distinct from *Mantidæ* by the small prothorax and by the forelegs which are not formed for the capture of prey; they are distinct from the jumping Orthoptera by the hind legs, which are not formed for leaping. None of these insects are small, whilst some are of great length, four to six inches being the usual size for the full grown ones. They present a great variety of form and colour, some being stick-like, others leaf-like or resembling a blade of grass, while others closely resemble other natural objects. The colour schemes bear out this cryptic form and their whole appearance is designed to give them so close a resemblance to their habitat that they will escape the observation of their foes.

The antennæ are commonly many jointed and long. The head is small, and not deflexed. The mesothorax is long, as is usually the metathorax in the elongated species. The legs are long, formed for walking and without special structures. The tegmina are small or wholly absent, even in forms which have large hindwings. In many species the wings are wholly absent either in both sexes, or in the female only. The male has claspers at the end of the abdomen, the female a ventral process which directs the eggs as they are extruded. The differences between the sexes are often very great, the male small, active and winged; the female large, clumsy and unwinged.

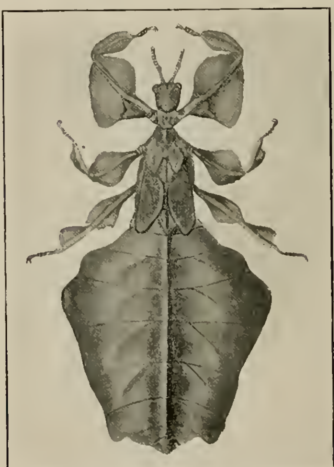


Fig. 17—PHYLLIUM SCYTHE, NYMPH.

The eggs are laid singly, dropped like seeds upon the ground. They are often of peculiar form, with very thick covering, and closely resembling hard seeds. Little is known of the life history of Indian species. The young are similar to the adult and are stated to develop slowly. There is a line of weakness (suture) between the trochanter and femur, which enables the insect to throw off a leg with ease, this leg being later formed anew. It has been observed that not only is this useful as a protection from enemies but also in moulting, as few Phasmids can moult successfully without remaining attached to the cast skin by a leg, and this adaptation enables the moult to be completed, though with the loss of a limb. (Bordage.) The food is apparently wholly vegetable and no cases are recorded of these insects being carnivorous; they eat the leaves of plants and some possibly feed upon lichens. None are injurious in India and their habitat is practically confined to the forest and jungle areas of the warmer parts of India. Not much is known of

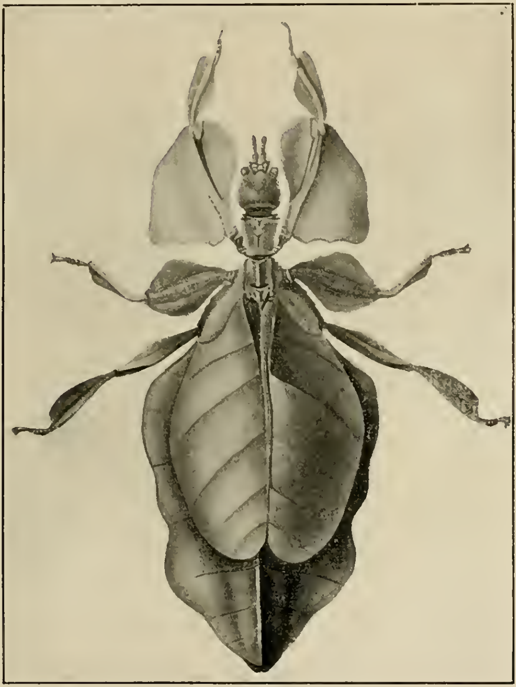


Fig. 18—PHYLLIUM SCYTHE.

Indian species and none are likely to be found in the cultivated areas. Westwood figures a number of Indian species (Cab. Or. Entom., 1847). Brunner listed 19 from Burma, and Bolivar 26 from South India. Kirby's Catalogue enumerates 65 Indian species.

Pulchriphyllium (*Phyllium*) *scythe* Gr. (figs. 17, 18) is a large leaf-like insect, whose life history is described by Murray and quoted in Sharp's Insects. It occurs in forest areas in Assam.

ACRIDIIDÆ.—*Short-horned Grasshoppers.*

The antennæ short ; the auditory organ on the first abdominal segment ; the ovipositor composed of short valves formed for digging ; tarsi three-jointed. Hind legs long, and saltatorial.

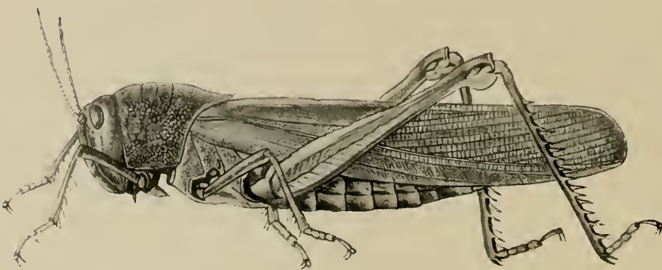


Fig. 19—ACRIDIUM MELANOCORNE.

A family which can scarcely ever be confused in the field; the short antennæ and leaping hind legs mark a true grasshopper at once. The size varies from a length of a quarter and a wing span of nearly half an inch to a length of over two inches and a wing span of three to four. The majority are less than one inch long, the smallest among the Tetriginæ, the largest among the Acridiinæ. Size is usually sufficiently constant to be valuable as an indication of species. With few exceptions the colour is cryptic ; the colour schemes harmonize so closely with the natural surroundings that the insects are difficult to see. Since the life is a long one and the surroundings vary with the change of season, it is common to find that, while the nymph is also cryptically coloured, the colour may not be the same as that of the imago. There may be two or more actual colour schemes in the whole life, both cryptic and adapted

PLATE II.—The Bombay Locust.

Acridium Succinctum.

Fig. 4. Hopper after third moult (in fourth stage), magnified five times.

,, 5. Hopper after fourth moult (in fifth stage), magnified three times.

,, 6. Hopper after fifth moult (in sixth stage), magnified twice. The wing lobes are turned up.

,, 7. Hopper after sixth moult (in seventh stage), magnified twice.

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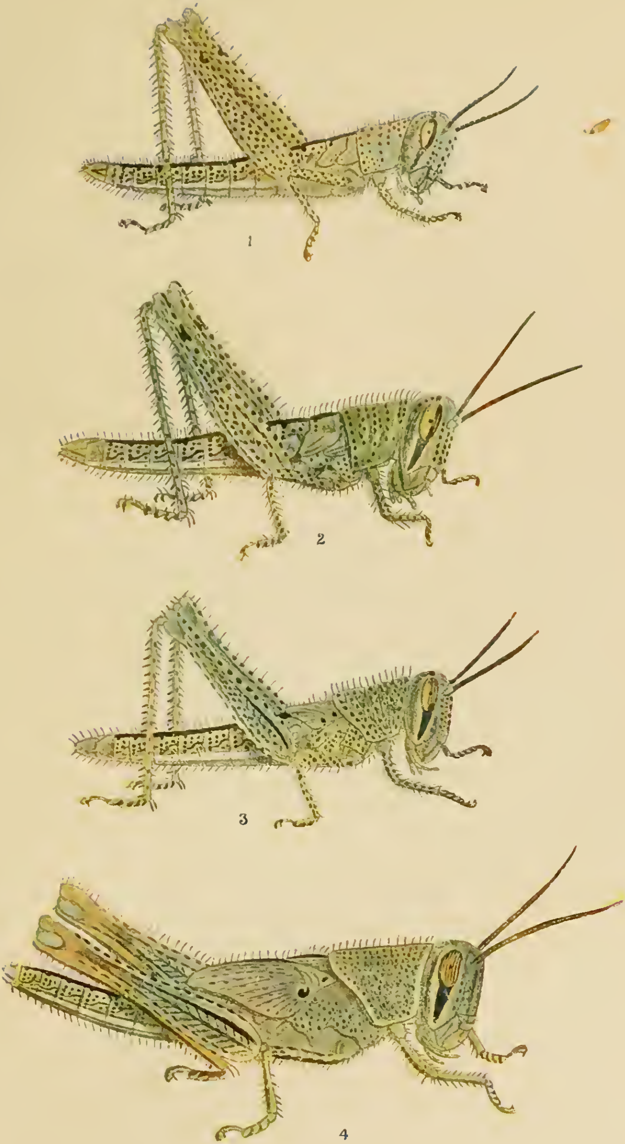

THE BOMBAY LOCUST.

to changes of season. Young grasshoppers hatching in the rains are frequently green to harmonize with the growing vegetation; this often gives place to "dry grass colour" in the adult which is found in October. Others which live on dry soil, on rocks, on moors, on sand dunes are coloured in shades of grey and brown with lighter markings and spots; in nearly all the colours are dull, and though varied, evidently cryptic. In the true locusts further and more striking colour changes take place, one of which is the "swarming colour," a vivid red, that probably facilitates migration by rendering the swarm visible at a distance and enabling all to join it. A very few are vividly coloured and undoubtedly exhibit warning colouring; this is correlated with the habit of living exposed on the plant and the young are also warningly coloured, though not always in the same tints as the adult. In a large number of cryptically coloured forms, we find that the lower wings are brightly coloured; in flight this colour is very conspicuous and it is not difficult to follow the jerky zigzag flight with the eye; but as the wings close on the insect settling, all trace of the colour is lost, the tints of the upper wings and body blend with the surroundings, the insect sits still and vanishes before one's eyes. There is no doubt that the bright colours of the lower wings, which sometimes extend to the sides of the abdomen, are "deceptive" and materially assist in the escape of the grasshopper

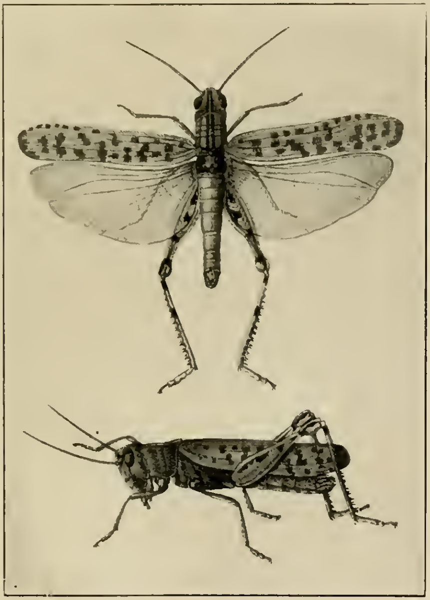

Fig. 20—Tylotropidius didymus.

from birds or other enemies. Although the general form of the body is usually uniform throughout the family, a few are modified in connection with their habits. Thus the surface grasshoppers (*Chrotogonus*) which live on the soil are very much flattened, the prothorax and tegmina roughened. Some of the species that live among long grass are elongated, the body cylindrical, admirably adapted to cling to and resemble the long grass stems.

As in other Orthoptera, the chitinous integument preserves the primitive form of the lower insects, the segments being easily distinguishable, the plates little differentiated. The head is of moderate size, distinct from the thorax, with large compound eyes and three ocelli. The antennæ are filiform, with less than thirty joints, flattened in some species. The mouthparts are of the herbivorous type, the upper lip (labrum) well developed, the mandibles large with cutting teeth, the maxillæ and labium distinct, fitted for mastication and bearing sensory palpi. The hypopharynx is well developed as a blunt tongue-like organ on the floor of the mouth. The prothorax is large, its form and markings useful in the discrimination of genera. In one sub-family (*Tetriginæ*) the pronotum is produced backwards as a long process between and over the wings (fig. 21). In some sub-families there is a tubercle or tooth-like

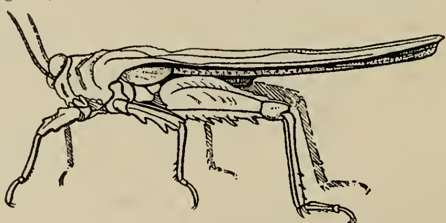

Fig. 21—SCELIMENA LOGANI.
(*After Hancock.*)

projection on the prosternum between the base of the forelegs. The meso- and meta-thorax are distinct, covered by the tegmina, which are long and narrow, opaque and variously coloured or ornamented. In many species they project beyond the abdomen, in others they are shorter. In the *Tetriginæ* they are reduced to tiny lobes and the wings are covered by the prolongation of the pronotum (fig. 21). In some species

PLATE III.—THE BOMBAY LOCUST.

ACRIDIUM SUCCINCTUM.

Fig 13. } The Bombay Locust as ordinarily found when it does not
,, 14. } swarm and change colour.

(Reprinted from *The Agricultural Journal of India.*)

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THE BOMBAY LOCUST.

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wings are short or reduced, the tegmina reduced to lobes or only partially developed. In the majority the wings are large, hyaline and many-veined, folding under the tegmina ; they are frequently coloured at the base with red, yellow or black. The tegmina and wings in flight function as one. The abdomen is long, the segments distinct ; it contracts and expands telescopically to a great extent in the female, in copulation being excessively retracted, in oviposition extremely elongated. The external genital organs are well marked ; the principal features of the female are the upper and lower chitinous valves, which are used for digging, the anus being above, the genital aperture below. In the male, the genital aperture is on the upper surface of the usually conspicuous ventral shield, which often ends in a point. There is a small pair of cerci on the apex of the abdomen at each side of the anus. Males and females are frequently of different sizes and also of different colours. The anterior legs are short, fitted for slow walking and clinging ; the hind legs are conspicuous by the great development of the femur and tibia ; the tibia bends back on to the femur, the apex of the former reaching the base of the latter and from this attitude the tibia kicks back, giving the impetus of the leaping motion. The tibia is outwardly set with thick spines. The femur may be specially modified to produce vibration when rubbed against the tegmen. The inner face of the femur bears a row of knobs ; the femur is rubbed up and down against a projecting vein of the tegmen, causing the latter to vibrate. Under the tegmen, on the side of the basal abdominal segment, may be seen the auditory organ, visible as a round depression in the integument, and containing the tightly stretched tympanal membrane. Spiracles are situated on the thorax and on the membrane connecting the notum and sternum of the first eight abdominal segments. The tracheal system is characterised by having bladder-like dilatations of some of the vessels, which are inflated previous to flight and while increasing the bulk of the insect, diminish its specific gravity and facilitate flight.

The life history of the known Indian grasshoppers is uniform in the main outlines but only a small proportion have been worked out. Eggs are, so far as known, universally deposited in the soil in a compact cluster, with gummy matter which hardens and compacts the mass (fig. 22). The number varies with the species, and all are not necessarily laid in one mass. About sixty eggs are laid by Hieroglyphus about 100-120 by Acridium. The eggs remain in the soil for a considerable period, and loosen slightly owing to their expansion before hatching. The young hoppers have the general form of the adult, the antennæ with fewer joints, the wings and internal genital system absent. The number of moults is generally from five to seven, the wings appearing as lobes at the third or fourth moult. The nymphs are active from the first; the colouring, as stated above, may change during nymphal life or may change slowly until with the penultimate moult the colour approximates to that of the imago. The duration of the nymphal stage varies with individual species but is usually long.

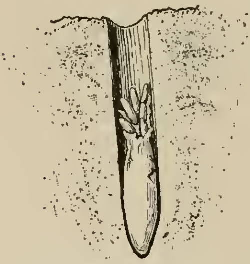

Fig. 22—CHROTOGONUS TRACHYPTERUS, EGGS IN SOIL. xl.

It is at present impossible to generalise as to the duration of each stage of the life of these insects. Apparently most have definite seasons for reproduction, governed by climatic conditions and which are rigorously adhered to. Thus some have but one brood in a year, the three stages occupying the whole twelve months; the Bombay Locust lays eggs in June, which hatch in July (after six weeks), the nymphal development is completed in late September and the imago lives until the following June: the Rice Grasshopper on the other hand remains in the egg stage from October to June and the nymphal and imaginal life occupy about four and a half months. There are probably many grasshoppers having only one brood yearly. Others have two, as does the Migratory Locust, the imaginal life being longest, but the two broods of about equal length. Others appear to have two broods during the rains, but the eggs laid by the second brood in November remain dormant until the following rains; in this case the two broods are of unequal length. A number probably will be found to agree with these, having two or more broods from June to November, or from March to November, but always one hibernation brood which passes the cold weather, and generally the hot dry weather in the egg stage. A number have several broods a year

PLATE IV.—The Migratory Locust.

Acridium (Schistocerca) Peregrinum.

Fig. 15. Migratory Locust Hopper, in first stage, magnified five times.

,, 16. Migratory Locust Hopper, in second stage, magnified four times.

,, 17. Migratory Locust Hopper, in third stage, magnified three times.

18. Migratory Locust Hopper, in fourth stage, magnified 2½ times.

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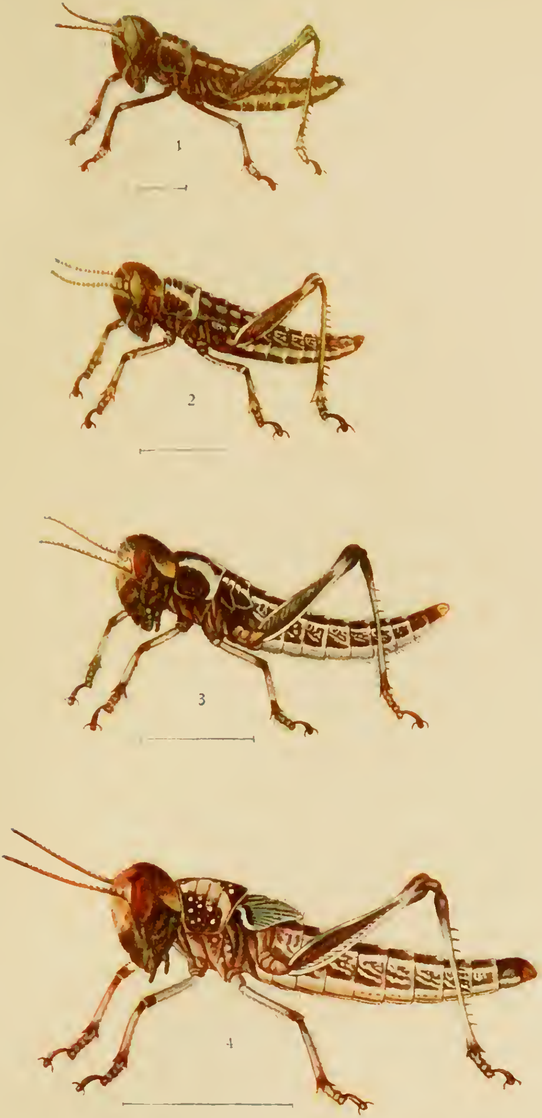


THE NORTH-WEST LOCUST.

but apparently have no regular seasons. They breed throughout the year except in the very cold weather and probably not when food is scarce. The Black Spotted Grasshopper (*Cyrtacanthacris ranacea* stoll) is an example, as are the species of *Chrotogonus* and *Atractomorpha crenulata*. Hibernation and æstivation appear to be passed almost wholly in the egg in the plains, only a small proportion as imagines; this varies however with different degrees of cold and dryness in different localities. A few hibernate as imagines or nymphs in the colder parts of the plains. Apparently there is a great variety in this respect and a far larger number of species require to be worked out before one can generalise on this point. So far as known no Acridiid is anything but herbivorous, feeding on green plants; some have a single food plant, others several and many appear to be to some extent omnivorous. Grasses and gramineous crops are the principal food plants but flowering plants, shrubs and bushes are not exempt. Locusts have a very wide range of food plants.

Nymphs and adults live free lives, and are found wherever there is vegetation. The greater number are to be found in grasslands, in open waste lands, among low herbage. Others live among shrubs, a few on trees. Open moors, sand dunes, fallow land also contain other species and they range from the plains to considerable altitudes in the hills, with their maximum development in the grasslands of the plains. This is one of the few families in which the number of purely "plains species" is as great as the number found in submontane forest and jungle areas.

This family, being wholly herbivorous and very abundant, is one of the most injurious to Agriculture. Besides the two locusts, there are grasshoppers which attack special crops and the many species, which when abundant, attack gramineous crops. Few of these are specific pests of particular crops, they occur spasmodically and irregularly and, since grasshoppers are of universal occurrence, nothing is done to check them until they are already abundantly destructive. A distinct class of pest are the Surface Grasshoppers, species belonging to the genera *Chrotogonus, Epacromia, Atractomorpha,* which live on the soil and attack young crops. Little is known of which species of grasshopper are destructive since the actually destructive species is not always the one sent in as destructive and there is here a large field for research. The student may be cautioned against accepting the reports of injury by Acridiids in Indian Museum Notes; often an entirely harmless species is sent in, being the first one to come to hand. Not more than two locusts and six grasshoppers are actually and positively known to be injurious in India.

Whilst there is some information available as to the enemies of the two locusts, little is known of the checks on the increase of the family as a whole. The eggs of the locusts are attacked by Hymenopterous parasites, the young by ground beetles (*Carabidæ*), the adults by parasitic insects and the young of a mite (*Trombidium grandissimum*, Koch.). An Oligochæt worm (*Henleya Lefroyi*, Bedd.) has been found destroying the eggs of one locust and probably attacks those of other Acridiids. Birds, monkeys and squirrels feed on locusts and the larger grasshoppers; mynas, hoopooes and other birds eat hoppers and fossorial wasps store their nests with small hoppers. Certain fly and beetle grubs attack the eggs, but while these are probably insects of the families *Bombyliidæ* and *Cantharidæ*, respectively, the species concerned are not known.

The family is a very large one, the largest of the Orthoptera, but no complete list exists. It is universally distributed through the tropical and temperate zones, with a large number of species. Indian forms are largely Indo-Malayan, or have a wide distribution over Southern and Eastern Asia; a few are European and African. In India, the species are, so far as known, widely spread and not local, though Burmah appears to have many species not found in India. No catalogue of Indian species has been compiled and the information is buried in the literature of the past century. (See page 48.) Bolivar records 100 species from a small area of South India, Brunner records 157 from Burmah. There are probably 500 recorded Indian species and at least 1,000 now existing in India. Brunner divides the family into nine subfamilies, which are on the whole well marked. Indian species fall mainly into five of these, the characters of which are as follows :—

Tetriginæ. The pronotum produced backwards over the abdomen, the tegmina lobelike, no pulvillus.

Pneumorinæ (African).

Mastacinæ. Antennæ shorter than the anterior femora. Head short.

PLATE V.—Migratory Locust.

Acridium (Schistocerca) Peregrinum.

Fig 19. Migratory Locust in swarming colouration.

,, 20. The same in egg-laying colouration.

(Reprinted from *The Agricultural Journal of India*.)

THE NORTH-WEST LOCUST.

Proscopiinæ (American).

Tryxalinæ.—The face looking down, the vertex of the head produced forward forming an angle. Prosternum unarmed.

Oedipodinæ.—The face looking forward, vertex rounded. Prosternum unarmed.

Pyrgomorphinæ.—Face looking downwards, prosternum with an elevated lamina.

Pamphaginæ.—(Europe, Africa and E. Asia).

Acridiinæ.—Face looking forwards, prosternum with a tooth-like process.

The classification is best studied in the works of Brunner, de Saussure and Bolivar. The *Tetriginæ* are recognizable at sight; the *Acridiinæ* and *Pyrgomorphinæ* are clearly distinct, the *Tryxalinæ* and *Oedipodinæ* are not always easily distinguished as the characters are not universal in both sub-families.

Tetriginæ (*Tettigides*).—Small insects, of a dark-brown colour, found upon the soil and in grasslands. There are a considerable number of species which are not easy to distinguish. The sub-family as a whole are sharply marked off from the remainder of the family. Most are roughened and warty above, as are the *Chrotogoni*, and this with their colouring renders them difficult to see on the soil. Some are leaf-like and live among dead leaves; all are bizarre in appearance and superficially resemble Membracids. They are most abundant on damp soil and near water; some are aquatic and have the hind tarsi more or less expanded to serve for swimming; at least one species in India is aquatic, feeding on vegetation at or below the surface.

Hancock lists a total of 434 species from all parts of the world, with 34 Indian species. *Scelimena* (fig. 21) is a semi-aquatic genus with three Indian species, *S. producta*, Serv.; *S. harpago*, Serv. and *S. uncinata*, Serv. *Criotettix* has five Indian species; in this genus the insertion of the antennæ is on a level with the lower part of the eye, in the former below the eye. *Acanthalobus* has three species. *Mazarredia* is an Oriental genus with four species in India. *Paratettix* has two Indian, two Burmese species; *Coptotettix* has four Burmah species, and *Saussu-*

rella two, one also from India. The student should consult Hancock (Genera Insectorum) for the genera, Brunner and Bolivar for most of the species.

Eumastacinæ.—The species of this sub-family are not found commonly in the plains and are confined to the moister forest areas. Burr lists 23 Indian species (Genera Insectorum) including the aberrant *Choroetypus fenestratus*, Serv.

Tryxalinæ.—The genus *Tryxalis* (*Acrida*) includes a small number of very variably coloured insects, distinguished by their slender form, produced head and flattened antennæ. One species (fig. 23) is common

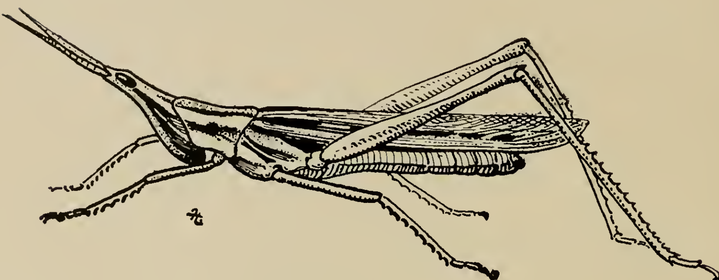


Fig. 23—Tryxalis turrita.
(F. M. H.)

throughout the plains, formerly known as *Tryxalis turrita*, L.; there is confusion in the present nomenclature and it is also referred to as *Acrida turrita*, L. and as *A. exaltata*, Wlk. This species varies in colour from green to "dry grass" colour, some with bright markings, others without; the males are smaller (36-46 m.m.) than the females (52-64 m.m.). *Tryxalis lugubris*, Burr is a second large species separated by Mr. Burr in his revision of the genus (Trans. Ent. Soc. London, 1902, p. 149). *T. brevicollis*, Bol. and *T. variabilis*, Klug. are also Indian. *Acridella* is represented by *A. indica*, Bol. and *Gelastorrhinus* by two species from Burmah and Sikkim, respectively.

PLATE VI.—THE BLACK-SPOTTED GRASSHOPPER.

CYRTACANTHACRIS RANACEA (ACRIDIUM AERUGINOSUM).

(Reprinted from *The Agricultural Journal of India.*)

1

2

THE BLACK SPOTTED GRASSHOPPER.

Engraved and P

Epacromia.—A genus of small grasshoppers, common throughout India. *E. dorsalis*, Thunb. (fig. 24) is the most abundant species, found as a surface grasshopper destructive to young crops. It has the unusual habit of coming to light. There appear to be two broods yearly during the rains and hibernation takes place in the egg stage.

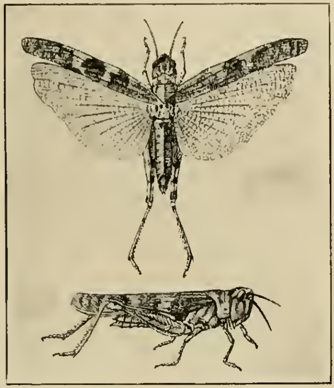


Fig. 24—Epacromia dorsalis. (I. M. N.)

Oedipodinæ.—This is a large sub-family including a large number of species difficult to distinguish. *Oedaleus* (Gastromargus) *marmoratus*, Thunb. is universal in the plains, marked by its brilliant orange and black lower wing. *Sphingonotus, Trilophidia, Acrotylus, Heteropternis, Chloeobora* and *Dittopternis* are also represented. *Pachytylus* (Locusta) *cinerascens*, Fabr. (danicus, L.) is a large insect of a dull grey colour sometimes marked with brilliant green with a median keel on the pronotum. It has a wide distribution over Southern Europe and Asia and though known to form swarms and migrate in Europe, has not been recorded as a locust in India, where it is a somewhat uncommon insect. It has been found in numbers in grasslands and there is some reason to believe that, becoming abundant in extensive tracts of grasslands in the less cultivated districts, it migrates in swarms over the country. Such swarms are apparently rare and they remain in uncultivated areas, but it will probably be definitely ascertained that the swarms of green locusts occasionally seen are of this species.

Pyrgomorphinæ.—*Aularches miliaris*, Fabr. (Phymateus punctatus, F.) is the brightly coloured grasshopper found in the lower hill slopes; it is black or dark green, with roughened tegmina and thorax, with yellow spots on the tegmina, the abdomen with red bands, the prothorax and head with a broad continuous yellow band. This insect when seized emits from pores in the thorax a liquid that froths up and diffuses an unpleasant odour. The habit is a very striking one and is apt to disconcert the unwary person who does not expect it. The warning colouration of this insect is very striking and this emission of evil smelling froth is probably a good protection. A chirping sound is produced in this species by a method unusual in the family; at the base of each tegmen and distinct from it is a small chitinous plate, the convex curved edge of which meets the concave curved edge of the median chitinous plate at the base of the tegmina (the Scutellum); the former moves in an arc so that the curved edge which is striated, rubs against the striate fixed edge of the Scutellum, producing a vibration which is probably intensified by the tegmina. The sound is distinct but not loud and is probably protective as it is produced by the female.

This is the so-called "Coffee Locust" since it occurs plentifully on coffee estates but it is practically harmless. It is recorded as destructive to coffee in Ceylon and E. E. Green has published a circular on it (Circ. Roy. Bot. Garden, Ceylon, 111, 18). There is, in Ceylon, one brood yearly, eggs being laid in October-November and hatching in March, the nymphs being full grown by September. Several species have been made of the varieties of this species.

Poecilocera picta, Fabr. is the conspicuous Painted Grasshopper so common on the ak plant (*Calotropis* spp.). It is brightly coloured in blue and yellow, living openly on its food plants and evidently protected by its bad taste from birds. There are at least two broods a year, the last (in November) laying eggs that pass through the winter. The nymph is coloured in yellow with black stipples and red spots, this colouring gradually giving place to that of the adult in the last two instars before the final moult. The distribution of this species is peculiar and follows that of its food plant which thrives in the drier portions of India from the north of the Punjab to the Southern extremity of Madras. *Atractomorpha crenulata*, Fabr. (fig. 25) is extremely common throughout the plains, and is a serious pest to young plants. The males are smaller than the females and often brown, while the female is commonly green. Tobacco is a favourite food plant of the insect in all stages and the round holes eaten in the leaves of this plant are frequently the work of this species. It is reported as injurious to cane in Java.

Chrotogonus (fig. 26) includes the common surface grasshoppers, flattened, the upper surface of a dark earth colour, roughened. with spots of white or yellow, the lower surface white. These insects are found in fallow fields, on newly-sown land, in grass and low crops. The male is smaller than the female. The latter lays about 60 eggs in a mass in the soil and there appear to be no regular seasons for breeding. They are among the most common of insects in the cultivated plains and are often seriously destructive. The number of species concerned is very uncertain. *Chrotogonus trachypterus*, Bl. appears to be the common plains' species but it is either a variable species or several are confused. *C. lugubris*, Bl. is a smaller insect of similar appearance. (See Ann. Soc. Ent., France, V, 607, where Blanchard describes *Ommexecha trachypterus*, *lugubris*, etc., from India.)

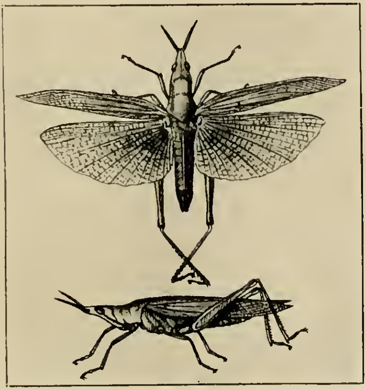


Fig. 25—ATRACTOMORPHA CRENULATA.

Acridiinæ.—A large sub-family which includes the locusts and large grasshoppers. They are readily recognised by the tooth between the base of the forelegs.

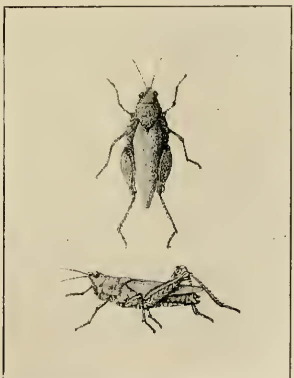


Fig. 26—CHROTOGONUS LUGUBRIS. (I. M. N.)

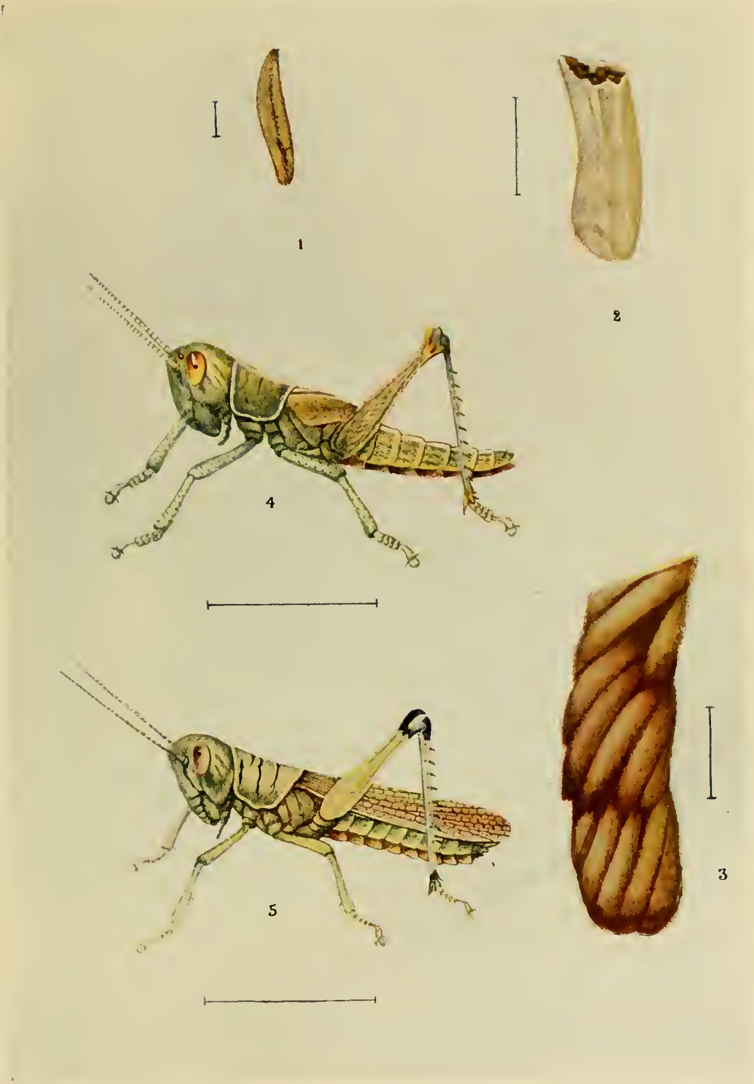
Catantops is a large genus of moderate sized insects found commonly in grass lands. *C. indicus*, Bol., *C. humeralis*, Thunb. and *C. axillaris*, Thunb. are the species of general occurrence. *Cyrtacanthacris ranacea*, Stoll. (*Acridium aeruginosum*, Burm.) is the very common large grasshopper found in the fields especially on cotton. There is no record of its migrating. It breeds apparently at all times, the eggs as usual in the ground, the nymphs being green, a pinkish line developing on the posterior edge of the pronotum as development proceeds. In the insectary eggs were laid in November, hatched in January, and, after six moults the nymphs became full grown in May, the total nymphal life being 113 to 138 days. They were fed wholly on cotton. Males are smaller than females. The adult is distinctly more markedly black and white in colouring than any common Indian *Acridium* (Plate VI). *Schistocerca* (*Acridium*) *peregrinum*, Ol. is the North-West or Migratory Locust of greatest notoriety (Plate V). It occurs now over North India, Afghanistan, Arabia, Persia, Northern Africa and Cyprus ; it has been found far out in the Atlantic Ocean and is believed to have actually originated in South America and spread thence to Africa; it is known to have spread so far West as England and constantly reaches the Assam valley and the most Eastern Hills of Northern India. It has been much discussed and written about, but we are not aware of any one really good account of its life history, depredations and movements. In India it is destructive only in the dry areas of the Punjab, since only in these does it breed; the swarms of adults can be frightened away, but it is the hoppers (Plate IV) which are really destructive. The student should see the article on "Locusts in India" in the Agricultural Journal of India, Vol. II, p. 238, and consult the voluminous literature on the subject. *Acridium succinctum*, Linn. (Plates II and III) has been the subject of investigation recently and while we require to know more of its enemies, its movements and life history are well known (Mem. Agric. Dept. India, Ent. I, "The Bombay Locust"). The most interesting point is the very curious colour changes which are more complex than in the Migratory Locust. The following extract is interesting as it almost certainly refers to this species :—

"A friend of Mr. Kirby informed him, that at Poona an immense cloud of locusts ravaged all the Mahratta territory, and was thought to have come from Arabia. This, indeed, was a most astonishing swarm,

PLATE VII.—Hieroglyphus Furcifer.

The Rice Grasshopper.

Fig. 1. A single egg.
,, 2. Egg-mass.
,, 3. ,, divested of the outer covering.
,, 4. Nymph, last instar.
,, 5. Imago, male.



RICE GRASSHOPPER.

if Mr. Kirby's friend was correctly informed. The column extended five hundred miles, and was so dense as thoroughly to hide the sun, and prevent any object from casting a shadow. This horde was not composed of the migratory locust, but of a red species, which imparted a sanguine colour to the trees on which they settled.'' (Cuvier's Natural History, 1832, Vol. II, p. 207.) *Acridium* is also represented in the plains by rarer forms, large robust insects found chiefly on trees and bushes.

Demodocus (*Heteracris*) includes large grasshoppers distinct from *Acridium* in having the pronotum more flattened with two dorsal light stripes enclosing a central dark fascia. *D. robustus* and *D. capensis*, Thunb. are common species.

Hieroglyphus banian, Fabr. (furcifer, Serv.), is known as the Rice Grasshopper and breeds freely in rice land and wet grassland (Plate

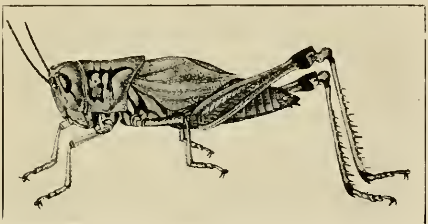


Fig. 27—HIEROGLYPHUS FURCIFER, MICROPTEROUS FORM.

VII). There is but one brood yearly, the eggs remaining in the soil from November to June. The tendency to abbreviation of the wings is very marked and in the same place can be found macropterous forms with intermediates to micropterous ones. There is a considerable amount of variation in size and a species (*H. cotesii*) was described which is probably not valid. The common species can be found over a wide area of the moister parts of India. Amongst the most delightful of Indian insects is the large *Teratodus monticollis*, Gr. (fig. 28); it is dull green or "dry grass" colour, with brighser colouring under the wings; the pro-

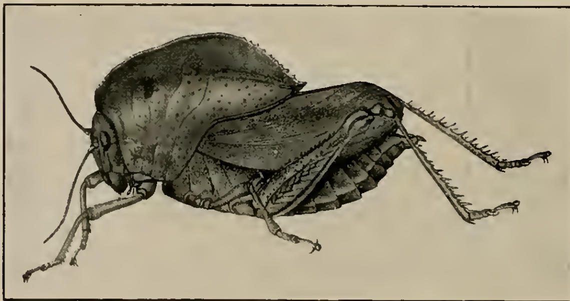


Fig. 28—TERATODUS MONTICOLLIS.

notum is produced up as a sharp hood over the body, giving it a most striking appearance; in flight (fig. 29) it is extremely beautiful, the bright colours showing out. While it is common in Western and Southern India, it does not appear to occur East of the Deccan and the dry parts of Central India. The young forms have the hood well developed and are extremely striking in appearance, the lateral compression being very marked. They look like green leaves.

In thick vegetation and in green crops, one sees numbers of little active green grasshoppers, feeding on leaves and often very destructive; these are *Oxya*, the common species known as *O. velox*, Thunb. predominating; these are of small size, and have a dark streak along each side and on to the tegmen. They are found commonly in the rains and appear to emerge only at that time.

Collecting, etc.—Grasshoppers are easily collected, either with a net or by hand. Many forms are got by sweeping in vegetation and this is perhaps the best method. Few come to lights (*Epacromia, Chrotogonus*, etc.) or to any bait that can be put down. When killed in a cyanide bottle they make good specimens; benzene, chloroform and other fluids are not good, the hindlegs being often shed or broken. They are easily stored in paper cylinders and travel well through the post in this way: if pinned, the left wings should be spread, the pin through the right wing or thorax. Large specimens may be stuffed, but this is not necessary if the specimen is properly dried. Rearing from the egg is sometimes difficult unless done on a really large scale and even then the right conditions must be maintained, especially an adequate amount of moisture in the air. Adults mate in large cages and lay eggs freely if not disturbed and given suitable conditions.

Fig. 29—TERATODUS MONTICOLLIS.
(From Curier.)

DECEPTIVE COLOURING.

The *Acridiidæ* more than any other group of insects exhibit that combination of colours which is designated under the above term, a scheme of colouring designed to deceive birds and other predators which pursue these insects. The essential features are a cryptic scheme of colouring functional when the insect is at rest, with bright and conspicuous colouring revealed only when the insect is in flight and concealed by the forewings or by the attitude when the insect alights. If one goes into a grass field, intent on observing large grasshoppers, one will suddenly see a brightly coloured insect jump up, fly a little distance and disappear. One sees it by the bright colours and one can, as a rule, easily follow its flight by them. These bright colours are in the lower wing and perhaps part of the abdomen ; they are visible only when the forewings are expanded in flight revealing the large expanse of lower wing and the abdomen. The insect in flight is easily visible owing to these bright colours and the *Acridiids* fly with a swift jerky motion, at the end of the flight suddenly wheeling down and settling motionless with closed wings. The eye has followed the bright colours and loses the insect as these disappear with the closing of the wings at the completion of the flight. One's eye is not seeking the cryptically coloured grasshopper, which thus escapes attention, even if one could easily see the motionless insect coloured in shades approximating to its surroundings and marked with darker colours to suggest the light and shade in the vegetation. With the exception of the warningly coloured grasshoppers and the vividly coloured locusts, deceptive colouration of this kind, depending upon bands of yellow, red or other vivid tints, is very common among *Acridiids*. Exceptionally beautiful examples are found in *Gastromargus* (*Oedaleus*) and in the extremely striking *Teratodus monticollis*, the colouring in the latter being on the body under the wings rather than on the wings. An instance is also found in the Leaf butterflies (*Kallima inachis*, and *K. Horsfieldi*) in which the upper surface of the wing has a bright orange blotch, visible in flight, whilst the form of the wings, the colouration and the resting attitude are extraordinarily like a leaf; at rest the insect is invisible, in flight it is conspicuous and the transition from the latter to the former at the close of a brief zigzag flight is extraordinarily deceptive.

Another group with conspicuous examples is the *Sphingidæ*, the body and forewing of the large species being commonly coloured in dull cryptic tints which harmonize with bark, while the lower wings are banded in bright colours which extend often to the sides of the basal abdominal segments. The same colouring is found, for instance, in Noctuid Moths of the genera *Ophideres*, *Ophiusa*, *Hyblaa* and *Catocala*, as well as in the *Mantidæ*, a few of the *Arctiinæ*, and an exceptional *Pyralid*. Some *Coreidae* also exhibit it and it is probably commoner in cryptically coloured insects than is generally supposed. The commoner *Cicadas* exhibit it in exceptional beauty, the cryptic colouring being very marked and the lower wing very vivid, the flight jerky and in zigzags. We are probably correct in concluding that in all these, the insect relies on its protective colouring first, but if disturbed, the deceptive colouring is brought into play in the sudden quick flight to another tree, when cryptic colouring is again predominant. This colouring gives us a glimpse into the inner life of insects which is, in its way, instructive. There are so many adaptations of this kind in insects that one can realize dimly that, always and at all times, they are in danger from birds, from lizards, from Asilid flies, from Dragon flies, from Locustids, from Mantids and so on. To enable them to escape they have various forms of colouring but the mere fact that they are in constant danger of being destroyed shows how far their mentality must differ from ours and how constant is the working of that balance of life that prevents the undue increase of any one species above its fellows.

LOCUSTIDÆ.—*Long-horned Grasshoppers.*

The antennæ long, many-jointed. The auditory organ on the fore tibia. Tarsi four-jointed. The female with a conspicuous ovipositor.

This family is at once distinguishable from the *Acridiids* by the long antennæ and the position of the auditory organ; it is less clearly dis-

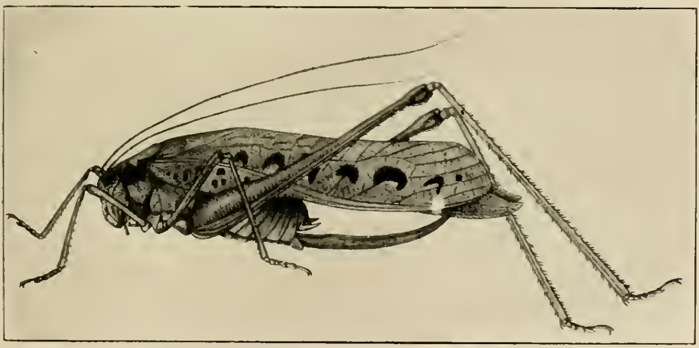


Fig. 30—MECOPODA ELONGATA.

tinct from *Gryllids* in the wings and tarsi. These insects are usually of large size, none of less than half an inch in length, a few exceeding two inches. They are less robustly built than the *Acridiids* and include a greater variety of forms. Many are elongate, the body narrow, the general colour green variegated with darker tints, their form and colour blending with the grass or vegetation among which they live. Others are larger, the tegmina broader and leaf-like; (fig. 31) the colour is green

Fig. 31—HOLOCHLORA ALBIDA.

and the veins of the tegmina suggest the veins on a green leaf. These live upon bushy plants and are well concealed. Others living upon bark are grey, the tegmina roughened, and so closely adapted are they to their habitat that they can scarcely be seen until they are in motion.

The antennæ are very long and fine, with many joints, functioning as delicate organs of touch. The mouthparts are of the herbivorous type, the mandibles short and powerful, the palpi well developed. The prothorax is large and distinct; the tegmina are thickened and coloured, usually sloping over the abdomen, with a small basal flat area. In the males, this flat area is modified to form a sound producing organ ; the right tegmen overlaps the left and has on its lower surface a sharp point: the left on its upper surface a file ; by the movement of the tegmina, vibration is produced, the sound being intensified by the stiff tegmina. In some species this organ occurs in both sexes. The hind wings are large and folded below the tegmina. A number of species are wingless or have wings reduced in size. The foreleg has a swelling on the tibia, in which is situated the auditory organ, closed externally by a tympanal membrane situated in a small depression. This organ is not present in all species. The hind leg is similar to that of the *Acridiids*, the femur dilated near the base, the tibia long and reaching to the base of the femur. The female is characterised by the ovipositor, a conspicuous external structure, often of large size and shaped like a sword. The male has external clasping organs. The abdomen is soft and fleshy, not extensible.

The life history of no Indian species appears to have been worked out, though the eggs and nymphs are common. Eggs are laid in the edges of leaves, in the stems of grasses, in the bark of trees and in the soil. As a rule these eggs are flattened ; the female makes a slit with the ovipositor and deposits her eggs in the slit. Nymphs are found in the habitat of the adults and pass through an unknown number of moults, the wings appearing gradually.

Locustids are, as a rule, nocturnal in habit, remaining quietly in concealment during the day ; this is not an invariable rule. While many are herbivorous, some are predaceous on insects, probably only in part and with the power of becoming herbivorous if food is scarce. The holes eaten in the blades of leaves of ornamental shrubs in the plains are probably the work wholly of *Locustidæ* and a large proportion appear to feed in this way. Diurnal species have been seen to capture butterflies, but as most are nocturnal their food is not known. Many are conspicuous songsters, the sounds produced varying from a deep harsh note to a sustained high shrill one. Some come to light, as do so many winged nocturnal insects. *Locustidæ* are most abundant in the rainy months and are practically never captured during the cold weather where this is well marked. Hibernation appears to take place in the egg stage but this is not certain and if it occurs, the eggs must presumably be laid in some situation more permanent than a grass stem or a leaf.

In India none are recorded as pests except the aberrant burrowing *Schizodactylus* whose habits place it among *Gryllids* rather than *Locustids*. Elsewhere are few which become sufficiently abundant to be destructive to cultivated plants. These insects are rarely found in numbers in India and appear to increase slowly. The *Conocephali* that live in grass are perhaps the most abundant.

The most recent catalogue of the family is Kirby's in Volume II of "Synonymic Catalogue of the Orthoptera" (1907). Following Brunner he divides the family into 24 sub-families half of which are unknown in "India" or known from single genera only, while four only contain the majority of our species. A total of 205 species is enumerated from India, Burmah and Ceylon, though the family is extremely little known in India and many species remain to be found. In this as in other Orthopterous families, the number of tropical forms far exceeds the Himalayan and palæarctic, though in this family more than others the vast majority are forest species and are found but rarely in the cultivated plains. The literature of Indian forms is given by Kirby ; the works of Brunner, Bolivar, Redtenbacher, Saussure are the most important. The distribution of species is as follows :—*Stenopelmatinæ* 5, *Rhaphidophorinæ* 3, *Gryllacrinæ* 40, *Decticinæ* 1, *Scyinæ* 1, *Conocephalinæ* 13, *Agræciinæ* 10, *Xiphidiinæ* 8, *Listroccbinæ* 6, *Eumegalodontinæ* 1, *Prophalangopsinæ* 1, *Pseudophyllinæ* 45, *Mecophodinæ* 2, *Phyllophorinæ* 7, *Phaneropterinæ* 57.

Stenopelmatinæ. *Oryctopus* includes two species found in burrows in a river bank near Trichinopoly by the Professors of St. Joseph's College. The male has rudiments of tegmina and wings, well developed eyes and tarsal claws; the female has quite small eye spots, the antennæ are very small or absent, the tarsal claws rudimentary, the ovipositor absent and the insect is wholly apterous. Both sexes were found together in the burrow. Two species are described, *O. Bolivari*, Brunn. and *O. prodigiosus*, Bol. (fig. 32). We figure the female from Bolivar (Ann. Soc. Ent. France, 1899, 784).

Fig. 32—ORYCTOPUS PRODIGIOSUS, FEMALE. × 2. (*After Bolivar.*)

Gryllacrinæ. Schizodactylus monstruosus, Don. (fig. 33) (the bherwa of Behar) is an extraordinary insect, rather doubtfully placed in

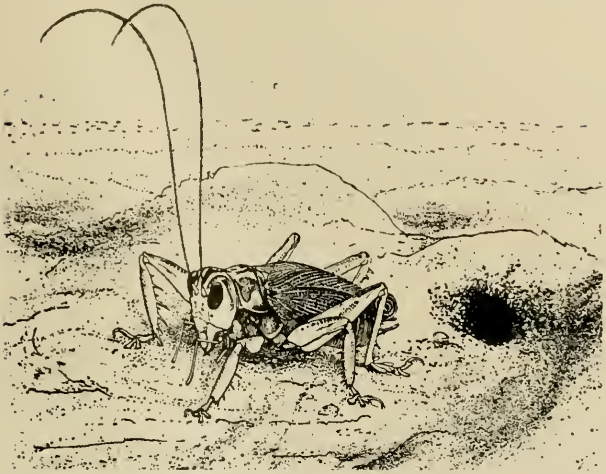


Fig. 33—SCHIZODACTYLUS MONSTRUOSUS.
(F. M. H.)

this family. It is a large insect, robustly built, with long tegmina which roll up into a spiral; the sides of the tegmina turn down abruptly as in the *Gryllidæ* and the tarsi have curious flat expansions. The appearance of the insect is extremely striking and its large jaws make it appear ferocious. It is wholly a burrowing insect, living in sandy soil and often near rivers, making deep burrows in which it lives. The eggs are laid in the burrow, the female having no ovipositor and behaving much like a cricket. It is believed to be carnivorous, and is destructive to crops only when its borrows are so abundant that it cuts the roots of plants. Its distribution in India is a curious one including Tirhoot, parts of Assam, Bellary, parts of Sind and Multan. Apparently it is dependent upon peculiar conditions of soil and moisture.

Conocephalinae.—*Conocephalus* includes narrow grasshopper-like forms which live in grass. Their eggs are laid in the stems of grasses

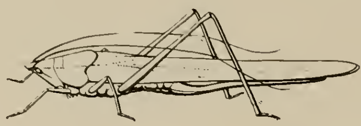


Fig. 34—Conocephalus indicus Redt.

and the insects of all ages are found in waste lands and long grass. The males produce a sustained shrill note which is exceedingly difficult to locate and the shrill music heard in long grass is mainly produced by these species. *C. indicus*, Redt. and *C. pallidus*, Redt. are the common species.

Mecopodinae.—*Mecopoda elongata* (fig. 30) is a very large form, of a dark brown colour, of the "dead-leaf" tint, the tegmina often with markings such as are found on decaying leaves; it is found sparsely over the plains, among trees and not in the open.

Pseudophyllinae.—*Sathrophyllia* includes the large flattened forms coloured like bark, which are found sitting motionless on the bark of trees by day and are active by night. Their roughened upper surface, their colouring in dull shades of brown and grey, their flattened form and motionless attitude pressed against the bark renders them a very notable case of cryptic form and colouring and they are extremely difficult to see.

Collecting.—Locustids are best collected by careful search among grass, on bushes, on the bark of trees, under the loose sheets of bark that are found on some trees and between the sheathing leaf-stalks of palms. Rearing is apparently possible only when the food habits of the young are first ascertained. When killed (in a cyanide or B. C. bottle), they should be pinned through the right tegmen, the left tegmen and wings set. Drying must be very thorough as the abdomen is very fleshy, but if properly done, stuffing the abdomen with carbolised cotton or other similar treatment is not required.

GRYLLIDÆ.—*Crickets.*

Leaping insects, with usually long filiform antennæ. The auditory organ is on the fore tibia. The wings are turned over at right angles from the dorsal to the lateral surface of the body. Tarsi three-jointed; female with a long ovipositor.

Gryllidæ are distinct from *Locustidæ* in the tarsi and the wings; they are, however, a group which contain many different types of insects which hardly fall into one family and which, with further knowledge, will probably be split up. All do not have long antennæ; some have no ovipositor,* and in others the wings are not deflexed. If we remember *Schizodactylus* which may be a Gryllid, and are familiar with *Gryllotalpa* and *Tridactylus*, it is easy to realise that *Locustidæ* and *Gryllidæ* are hard to separate and that peculiar environment has produced such changes in some forms that they scarcely come within the definition of the family. The *Gryllidæ* as a whole are a large family not of great importance economically and not interesting to the ordinary student of nature. The Indian species are probably very imperfectly known. Brunner lists 43 species from Burmah of which he describes 20 as new to science; Bolivar lists 35 from South India of which 14 were new. Kirby's Catalogue lists 130 species from India, Burmah and Ceylon of which 80 occur in India. There are probably many new species to be found and there is much interesting work to be done in the biology of all of them. The works of Saussure, Brunner van Wattenwyl and Bolivar include the most important literature of the family as a whole.

Fig. 35—LIOGRYLLUS BIMACULATUS. (I. M. N.)

Allowing them to be a group which will eventually be split up and are now maintained for convenience rather than logical fact we can discuss them individually and need make no general statements about the family as a whole. The family is by de Saussure divided into seven tribes, regarded by Kirby as six sub-families. The following key follows de Saussure's arrangement and is given in Sharp's Insects :—

1. Antennæ ten-jointed ; posterior tarsi aborted. Tribe 1. *Tridactylides.*

1'. Antennæ many jointed ; posterior tarsi normal.

2. Tarsi compressed, the second joint minute.

3. Anterior legs fossorial ; anterior tibiæ at the apex with two to four divisions. Pronotum elongate, ovate, rounded behind. Female without ovipositor. Tribe 2. *Gryllotalpides.*

3'. Anterior legs formed for walking. Ovipositor of the female visible (either elongate or rudimentary).

4. Posterior tibiæ biseriately serrate. Tribe 3. *Myrmecophilides.*

4'. Posterior tibiæ biseriately spinose. Ovipositor straight.

5. Antennæ short, thickish, almost thread-like. Facial scutellum exserted between antennæ. Posterior tibiæ dilated. Gen. *Myrmecophila.**

5'. Antennæ elongate, setaceous. Facial scutellum transverse. visible below the antennæ. Tibiæ slender.

6. Posterior tibiæ armed with two strong spines, not serrate between the spines. Tribe 4. *Gryllides.*

6'. Posterior tibiæ slender, armed with slender spines, and serrate between them. Tribe 5. *Oecanthides.*

2'. Second joint of the tarsi depressed, heart-shaped.

3. Posterior tibiæ not serrate, but biseriately spinose.

4. The spines on each side three and mobile ; apical spurs on the inner side only two in number. Ovipositor short, curved. Tribe 6. *Trigonidiides.*

4'. The spines numerous, fixed. Ovipositor elongate, straight. Gen. *Stenogryllus.*

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* The genus *Myrmecophila*, being exceptional in several respects, is treated separately.

3'. Posterior tibiæ serrate and spinose on each side, the apical spurs, as usual, three on each side. Ovipositor straight or curved. Tribe 7. *Eneopterides.*

We may here discuss the group under divisions including the *Tridactylinæ* (small surface crickets), *Gryllotalpinæ* (mole crickets), *Gryllinæ* (house and field crickets, burrowing crickets), *Oecanthinæ* (plant crickets).

Tridactylinæ are small insects, measuring about one-quarter of an inch in length ; the antennæ are short with about ten joints, the wings

Fig. 36—TRIDACTYLUS SP. × 8.

in some are imperfectly developed, in some fully developed ; the abdomen terminates in six processes like cerci, which are hairy and strongly suggest the hairy processes used by some aquatic larvæ to support themselves on the surface film of water while they get air. The hind legs terminate in two straight processes, the tarsus not being formed, and the tibia also bears lateral processes, which apparently are spread out upon the wet soil on which the insect lives and act as supports ; these lateral processes are also capable of being closed up. These little insects live upon damp soil ; they are common on the banks of tanks, in irrigated fields, in watered gardens ; they prepare small galleries by burrowing along the surface of the soil and live in these burrows. They form a very large part of the tiny "flies" which crowd in hordes round lamps in such places as Calcutta and are enormously abundant in places near large rivers. *Tridactylus variegatus*, Latr. in Europe is said to burrow in the sand of river banks. *Tridactylus thoracicus*, Guer. from the Nilgiris, *T. major*, Scudd. from "India" and *T. castetsi*, Bol. from Trichinopoly are our recorded species.

Gryllotalpinæ include large insects, which are characterised readily by the forelegs, which are profoundly modified to form powerful digging instruments. These insects grow to a length of over one inch, the head and prothorax very hard, the antennæ short, the wings tightly wrapped round the soft abdomen (fig. 37). As in other Gryllids, the hind wings are extended backwards and appear as a slender process beyond

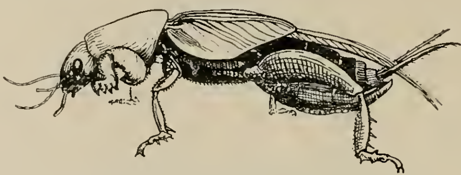


Fig. 37—Gryllotalpa africana. × 2.

the tegmina when at rest. There is a pair of cerci at the end of the abdomen. The forelegs are extremely powerful and by digging and pressing, the hard head and prothorax is forced through the soil, the soft abdomen and weaker posterior legs following. The female is destitute of an ovipositor and lays her eggs (fig. 38) in the burrow, which extends to a considerable depth below the surface. These eggs have been found in

Fig. 38—Gryllotalpa africana; eggs, reduced to $\frac{3}{4}$, and nymph.

a cluster in the moist sand of the river bank, soft white oval eggs lying loosely in a round chamber at some depth in the sand. The young nymphs thrive on a diet of fly grubs, worms and other small animal life, making small burrows in the loose sand.

Like other parts of the earth's surface, the soil for some twenty feet down contains abundant insect and other life, which forms the food of the mole cricket and in search of which it burrows through the soil. When its burrows are near the surface, damage is caused to the roots of plants and the insect is destructive to this extent.

The winged imago flies at night and comes to light very readily. In the rains they are often flooded out and in dry weather descend deeper for soil moisture. There are many ingenious ways of destroying them, none sufficiently effective to appeal to any but an economic entomologist. Two species occur in India. *Gryllotalpa africana*, Pal. B., which is widespread over the plains and lower hills (also through the warmer parts of Asia and Europe), and *G. vulgaris*, Latr., found in the Himalayas and common also in Europe, Egypt, Western Asia, etc. Throughout our area, *africana* alone appears to occur.

The *Myrmecophilinæ* are small insects chiefly interesting because they are found in ant's nests. A variety of *Myrmecophila acervorum*,

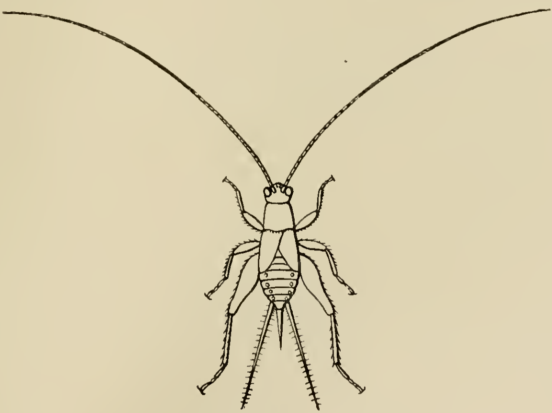


Fig. 39 PTEROPLISTUS PLATYCLEIS.
(*After Bolivar.*)

Panz., was found by Wroughton, *M. plagiolepidis* Wasm, by Assmuth, while *Ornebius Guerini*, Bol., and *O. nigripalpis*, Guer., and *Pteroplistus platycleis*, Bol., are recorded from South India and several from Burmah. (See below under *Myrmecophilous Insects* after *Paussidæ*.)

We come then to the *Gryllinæ*, the "crickets." These insects are distinguished from *Locustides* by the characters given at the head of the section. They vary in size from half an inch to over two inches in length; the colours are dull, mainly cryptic, brown predominating with black and rarely yellow-brown. None are brilliant or conspicuous, and the colouring is that of other surface-living insects. The antennæ are long and filiform; head large, the prothorax distinct. The tegmina are deflexed, the inner area lying flat on the upper surface, the outer area vertically against the side of the body. The lower wings are produced back and when at rest, give the appearance of a projecting sting or process. At the apex of the abdomen are two cerci, and as the female has a long fine ovipositor, the hind end of a female cricket bristles with formidable looking structures. Auditory organs are situate in the foreleg, as in the Locustidæ.

Gryllidæ produce loud and sustained sounds, often very shrill, by the rapid vibration of the wings, one (right) working over the other (left), the edge of the one acting on the file on the other. The males have the flat area of the tegmina modified to intensify the sound, though to a less extent than is the case in Locustidæ. The sound is peculiarly shrill and sustained, extremely difficult to locate in the field. Some of the smaller species may be seen to be vibrating their wings but the sound produced is not audible to everyone, the pitch being so high it is beyond the register of the normal human ear. Apterous forms also occur and species in which the wings are reduced in size. Almost nothing is known of the life history of Indian crickets. The young are similar in general appearance to the adults, but the number of moults is not known.

There are practically three distinct classes of crickets. Some burrow deeply in the soil, making very extensive burrows which have several openings at the surface. Others live on the surface, among fallen leaves and other debris and make short burrows into which to retire but do not habitually live concealed in them. Of these a few are household insects. Others live on plants, passing their life among bushy vegetation.

The burrowing species are vegetarian feeding upon roots and also coming up at night to cut off green vegetation. Little is known of the food of other species. The small bush crickets are to some extent predaceous on small insects and there is no reason to believe they are vegetarian. The surface-living species are possibly also predaceous but one at least is found feeding upon living plants. Crickets are universally distributed in India and are perhaps as abundant in the drier plain areas as in the moist tracts of the delta and forest districts.

The large brown cricket (*Brachytrypes achatinus*, Stoll.), is the most familiar burrowing species, found commonly in the Himalayas and the

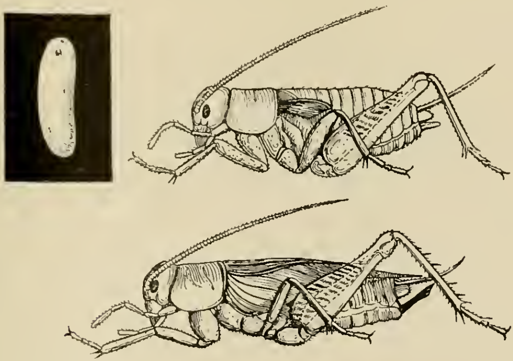


Fig. 40 BRACHYTRYPES ACHATINUS. EGG. × 4. NYMPH, FOURTH INSTAR. × $1\frac{1}{2}$. IMAGO. × 1.

adjacent plains, in Assam and Burma. It has a wide distribution in Eastern Asia and may be widely distributed in suitable localities throughout the plains. It grows to a large size and is rarely seen on the surface save when the heavy rains flood it out from its burrows. At dusk, the male comes to the surface, and pours forth its strident note, the sustained shrill vibration being very piercing and, as one approaches, beating in the ears with extraordinary intensity; even a *Cicada* hardly produces such intensity of sound. At night the cricket seeks its food, the leaves and shoots of plants which it eats or draws into its burrow. The life history occupies one year, the winged adults being found from late April to September, only nymphs being found in the cold weather. It has been successfully reared in the Pusa insectary on a diet of green lucerne and other plants. This species is the prey of *Sphex lobatus* the metallic green digger wasp (see *Sphegidæ*). *Liogryllus bimaculatus*, deG. is black, with an orange spot at the base of each tegmen. It appears to occur throughout India, and is stated to be found throughout the East. It has been found in Khandesh to cut through the stems of potato plants at soil level. (Ind. Mus. Notes, Vol. III, p. 97.)

Gryllodes melanocephalus, Serv. (fig. 41) is reported as injurious to crops and has been found in some number in parts of the Punjab. It is a

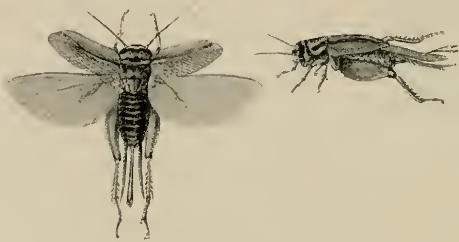


Fig. 41—GRYLLODES MELANOCEPHALUS.
(I. M. N.)

surface-burrowing species, living in the fields and not making deep burrows. There are a large number of species to be found in the plains and an investigation of the Indian species is much to be desired.

Kirby (Synonymic Catalogue of Orthoptera, Vol. II, 1906), records *Paranemobius* 1, *Nemobius* 4, *Brachytrypes* 3, *Gymnogryllus* 3, *Gryllus* 12, *Gryllodes* 6, *Cophogryllus* 2, *Scapsipedus* 2, *Homaloblemmus* 1, *Loxoblemmus* 1, *Landrena* 1, as genera represented in India, apart from Himalaya, Ceylon and Burmah.

The *Oecanthinæ* are represented by *Oecanthus indicus* Sauss., a delicate whitish insect with a tinge of pellucid green. It has the general characters of *Gryllids* but is easily recognisable. This insect is found upon plants, in rice fields and in dense moist vegetation. Its life history does not appear to have been worked out in India. It is, to some extent at least, predaceous and has been observed eating insects it has captured in the field. Other recorded Indian species are *Arachnomimus picticeps*, Wlk., *A. dubius*, Bol., and *Oecanthus rufescens*, Serv.

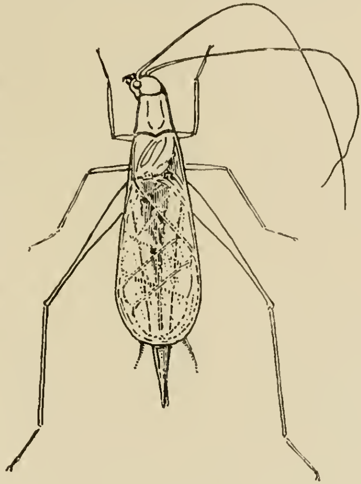


Fig. 42—OECANTHUS INDICUS. × 3.

The *Trigonidiinæ* are but little known and only five species are recorded from India proper: these are *Trigonidium cicindeloides*, Ramb., *T. gigas*, Bol., *Cyrtoxipha* (Eneoptera) *fascipes*, Wlk., *C. concolor*, Wlk., and *C. alboatra*, Wlk.

The *Eneopterinæ* include *Madasumma* (7 spp.) as well as *Patiscus quadripunctatus*, Bol., *Corixogryllus abbreviatus*, Bol., and *Meloimorpha cincticornis*, Wlk.

Collecting.—A knowledge of their habitat is the surest guide to the methods of obtaining crickets of all kinds. Tridactylides are readily found in moist places, and also at light; Gryllotalpa comes to light and may be dug out; the Gryllides can be dug out, found among fallen vegetation, or caught in the evening when they emerge; some come to light and some are flooded out in the rains. Oecanthides are found upon plants and are best looked for when sweeping pests in rice.

The lesser forms are very little known, on account of their fragility, and the number of undescribed forms is probably very large; equally little is known of their habits or life-histories and there is room here for a very extended investigation by an observer situated in the plains, where these little insects abound.

ATTRACTION TO LIGHT.

Among the many methods adopted by Entomologists to obtain insects in number, the light trap is one of the simplest and most efficacious. In India, the attraction of insects to light is so disagreeably and abundantly proved, that it is familiar to every one, though there is little exact information as to which insects come to light. The real difficulty is not to get the insects to come to light but to catch them in good condition when they come.

Generally speaking, a little is known as to the groups that are attracted by light and some careful collecting at light for a few years would soon furnish the data necessary to list the light-loving species.

A curious point is the kind of light; the intense white of an arc light brings insects in hordes as can be seen on Howrah bridge or on a river steamer; the same is true of the acetylene light, a very white intense light; the yellower oil light may attract fewer insects because of its less range but this is by no means certain. Whether coloured lights exert the same influence, and which colours are best would appear to be a promising line of research, especially in relation to injurious insects as one might then be able to discriminate the harmful and not destroy the harmless. Actually no experiments on this point seen to have been made in this country and our data refer to white light entirely.

A consideration of the insects that are known to come to light in any country, has not, so far as we are aware, led to any facts concerning the nature of the attraction light exerts; Crepuscular or Nocturnal insects are not attracted as a body, though naturally nearly all that are attracted to light are insects that are active after daylight. Only flying insects are known to be attracted, but so far as we are aware all experiments have been made with a light elevated above the ground and without means of trapping walking insects. A considerable proportion that come are ground insects, such as the Ground beetles, but the proportion is only what one would expect when one considers how large is this part of the fauna. The principal families found at white light in India are mentioned below but this account is a very incomplete one.

Blattids are rarely caught but some species have found their way to light traps. Of *Acridiidæ*, *Epacromia dorsalis* is a very notable example, coming abundantly to lights even into houses. A small number of other *Acridiidæ* have the same habit. *Conocephalus* among *Locustidæ*, as well as *Schizodactylus* and a few green species, are found at light. Of *Gryllidæ*, the burrowing mole crickets, *Brachytrypes*, *Gryllus*, *Nemobius* and other *Gryllinæ*, are attracted ; the little *Tridactylinæ* come in hordes to lamps and are extraordinarily abundant at some seasons even at a feeble railway station lamp. *Embiids*, winged termites and Myrmeleonids come readily ; Phryganeids are conspicuous by their presence, as are *Ephemerids*, *Mantispides*, *Ascalaphides* and *Chrysopides*. Nearly all *Hymenoptera* are diurnal, but the flying ants are often caught in very large numbers at light traps and some few Parasitica. Of *Coleoptera* the nocturnal *Scarabæids*, principally *Melolonthids* and *Dynastids* with some of the *Coprids* (*Geotrupids*) are attracted, as are the *Carabidæ* (especially *Scaritides*), *Paussidæ*, *Cantharidæ*, some Malacodermids and an occasional weevil (*Asemus*).

Moths come freely, especially the *Noctuids* and *Pyralids*, with some *Sphingids* but not every species is attracted and the fact has to be ascertained for each species. *Cydninæ* are the only *Pentatomids* known to me to be freely attracted to light and this is possibly due to their habits; the Ganges ferry steamers are sometimes swarming with *Stibaropus*, and, as all know, the "Gundi" (*Cydnus*) is only too fond of coming to the lamp at dinner time. *Nezara viridula*, Linn., is exceptional as being attracted to light, and there are others. Aquatic *Rhynchota* are not uncommon at light and the little *Corixa hieroglyphica* is occasionally very abundant. *Cicadids* are caught at light occasionally, the giant water bug (*Belostoma*) constantly.

Of the *Fulgoridæ*, the small *Delphacinæ* come in swarms, as do the *Jassidæ* ; I am not aware of other *Homoptera* though there are very likely others, and I am not acquainted with any *Diptera*, except *Chironomidæ* and *Psychodidæ*. The reader can see from the above how diverse are the insects that are attracted and what a curious selection of the nocturnal insects it is ; whether there is a real physiological explanation, whether some are more curious than others, or whether some have more leisure to investigate strange phenomena, we must leave to others to decide.

The use of lights and light traps has been a favourite method with agriculturists in dealing with certain classes of pests, but it is a method of very uncertain value and it is not a method generally useful ; it is essential to be certain that the pest to be captured does really come to light freely and this is a point usually neglected.

NEUROPTERA.

An assemblage of heterogeneous families, united in one order rather for convenience than scientific accuracy. There are two pairs of wings, with many veins, both functional in flight and often of equal or nearly equal size. The mouthparts are mandibulate, usually of the predaceous type. The metamorphosis is incomplete in a part, complete in the remainder, the pupa usually active at the emergence of the imago.

In a large number the nymphal or larval life is the only period of long duration and activity: in the remainder the imaginal is as long as the nymphal and of equal importance. The order includes predaceous and scavenging, land and aquatic insects. None are parasitic, and none herbivorous.

The order is here divided into ten families; grouped in series:—

No Metamorphosis.

I.—Wingless and Semiparasitic.

Mallophaga.—On warm-blooded animals.

II.—Land Insects. *Pseudoneuroptera.*

- *Embiidæ.*—Two pairs of narrow equal wings, few veins. Prothorax small.
- *Termitidæ.*—Two pairs of narrow equal wings, many veined. Prothorax large. Social.
- *Psocidæ.*—Forewing larger than hindwing, with few cross veins. Prothorax small. Gregarious.

III.—Aquatic Insects. *Neuroptera amphibiotica.*

- *Perlidæ.*—Hindwings larger than forewings, folded. Coxæ small, wide apart. Antennæ long. Cerci in some forms. Tarsi 3-jointed.
- *Odonata.*—Antennæ short. Two pairs of subequal wings, not folded over abdomen.
- *Ephemeridæ.*—Antennæ short. Two or three cerci. Hindwings small or absent. Wings held upwards.

A Metamorphosis.

IV.—Mandibles in adult. *Neuroptera Planipennia.*	*Sialidæ.* *Sialinæ.*—Antennæ long, wings not reticulate. No cerci. *Raphidiinæ.*—Prothorax long. *Panorpidæ.*—Head rostrate. *Hemerobiidæ.*—Antennæ long, wings equal, much reticulate, no cerci. Tarsi 5-jointed. *Myrmeleoninæ.*—Antennæ knobbed, short. *Ascalaphinæ.*—Antennæ knobbed, long. *Nemopterinæ.*—Hindwings long and very narrow. *Mantispinæ.*—Forelegs as in Mantidæ. *Hemerobiinæ.*—Antennæ moniliform. *Chrysopinæ.*—Antennae setiform. *Coniopteryginæ.*—Wings powdery.
V.—No Mandibles in adult. *Neuroptera Trichoptera.*	*Phryganeidæ.*—Wings hairy, an anal area to hindwing, which is longer than forewing. Coxæ long, contiguous. Tarsi 5-jointed.

The relationships of these families are obscure, and it is probably useless to attempt to derive them from any common stock. The problem is complicated by the number of aquatic families, which we may take to have been derived from terrestrial air-breathing forms. Equally the semi-parasitic *Mallophaga* are probably derived from free-living forms. It is reasonable to accept present-day *Termitidæ* as a separate branch, derived possibly from forms which were connected with the Blattid ancestors: *Embiidæ* and *Psocidæ* are off-shoots from some primitive form of Neuropteron possibly related to *Forficulidæ*. *Ephemeridæ* and *Odonata* are derived from insects found far back in geological times, which had probably a common ancestral race, which was terrestrial: the *Perlidae* are related to the *Ephemeridæ* and probably are a recent branch. *Sialidæ* and *Panorpidæ* may be branches from one stock, in which metamorphosis was developed, and from which came, far back, the *Hemerobiidæ*. *Trichoptera* also remain and in the absence of data, it may perhaps be placed as an offshoot of the ancestral race in which metamorphosis had been developed, emerging therefore from the terrestrial ancestor of the *Planipennia.* Quite possibly this branch leads on from an ancestor of the present *Trichoptera* to the *Lepidoptera*, the ancestor of *Micropteryx* and of *Trichoptera* being the same and thus giving the point of contact.

MALLOPHAGA.—*Biting Lice.*

Small wingless insects, nearly all parasitic on birds. They have biting mouthparts and the body is flattened, the head often large and broad.

The Mallophaga or Bird-lice are sometimes confused with the *Pediculidæ* (Head-lice and body-lice). Although both are parasitic on warm-blooded animals and have somewhat the same appearance, they are quite distinct, the *Pediculidæ* being sucking insects, allied to Hemiptera, while the *Mallophaga* have well-developed biting mouthparts and never suck, living on the dry skin, scurf, and feathers of their hosts. Their relationship to other insects is doubtful, and Kellogg, who has monographed the group (Genera Insectorum Fasc. 66) reckons them as a distinct Order. Mallophaga spend their whole life on the host, and soon die when removed or when the body of the host becomes cold in death. Observations on their life-histories are for this reason difficult, and little is known except that the metamorphosis is incomplete. Kellogg puts the known species at over a thousand, and a large number of these are restricted to one definite species of bird ; others are found on several different birds, but usually these birds either are accustomed to associate one with another in flocks, or belong to closely related species, though these related species may occur only in widely separated parts of the world.

Kellogg explains this curious fact by reference to the sedentary mode of life of the insects, which prevents their spreading from bird to bird except by actual contact. He supposes that the species of *Mallophaga* have remained unchanged since the remote periods when many different species of birds, (now settled in different parts of the globe and separated from their near relations,) had not yet diverged or evolved from their common ancestral species. Those ancient bird-lice which infested the ancestral bird continued to infest the ancestral bird's descendants: even though these descendants in time diverged into several distinct species, the conditions of life remained so much like what they had always been that the bird-lice have to this day retained the same specific characters which they possessed in those far-off times.

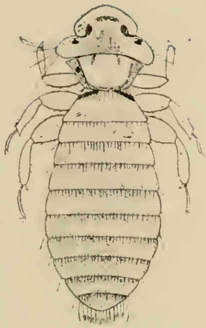


Fig. 43—Colpocephalum guiraensis (*After Kellogg*).

A few *Mallophaga* (about 50 known species) are found on Mammals, and they are distinguished from the bird-infesting species by having single-clawed feet; the species on birds have two claws. The mammalian hosts include most of the domestic animals, as well as others of very various kinds. Kellogg's classification into families is as follows:—I have included the names of the principal genera in each family.

Antennæ visible, 3 or 5-segmented; no maxillary palpi; mandibles vertical; meso- and meta-thorax usually fused. Sub-order *Ischnocera*.

Antennæ 3-segmented; tarsi with 1 claw; infesting mammals. Family *Trichodectidæ*. Genus *Trichodectes* 45 sp.

Antennæ 5-segmented; tarsi with 2 claws; infesting birds. Family *Philopteridæ*. Chief genera *Docophorus* 215 sp. *Nirmus* 228 sp. *Lipeurus* 181 sp.

Antennæ concealed 4-segmented; with 4-jointed maxillary palpi; mandibles horizontal; meso-meta-thoracic suture usually visible. Sub-order *Amblycera*.

Tarsi with 1 claw; infesting mammals. Family *Gyropidæ*. Genus *Gyropus* 7 sp.

Tarsi with 2 claws; practically all infesting birds. Family *Liotheidæ*. Chief genera *Colpocephalum*, *Menopon* 211 sp.

Kellogg's list does not record any species as coming from India. (Perhaps *Trichodectes tigris*, taken from a tiger is from this country.) If, however, one takes the trouble to examine a few birds, especially at the roots of the feathers about the neck and base of the wings, it will not be long before these insects are discovered, and evidently there must be a large number of Indian species. Those named by Kellogg as having been obtained from birds belonging to species which occur in India are fourteen in number, and belong to the nine genera *Docophorus*, *Nirmus*, *Goniocotes*, *Akidoproctus*, *Goniodes*, *Ornithobius*, *Lipeurus*, *Colpocephalum*, *Menopon* and *Trinotum*.

Fig. 44 shows the egg, a young stage, and the adult of the louse of one of the big Indian buzzards (*Pernis cristatus*), and indicates how

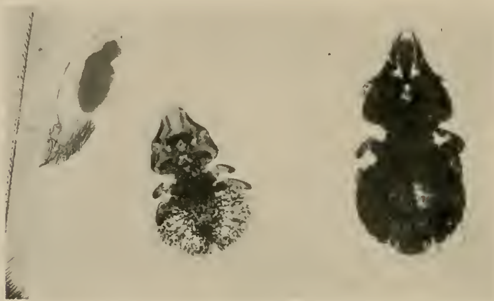


Fig. 44—Egg, nymph and adult of a biting louse on an Indian buzzard (Pernis cristatus). Magnified.

slight is the difference between the young and the full-grown parasite. The eggs are found firmly attached to the feathers of the bird. Fowls or other domesticated birds, if infested with lice, can be rid of them by carefully brushing any non-irritant vegetable oil (not paraffin or crude oil) on the skin and about the roots of the feathers. The oil stops up the breathing-spiracles and suffocates the insects. This treatment is also effective for clearing fowls or other animals of ticks. (F. M. H.)

Embiidæ.

Narrow delicate insects, the prothorax small, the wings, when present, with few veins.

These little insects have an extremely characteristic appearance due to the elongate body, the short legs, the small abdominal cerci, and (in the males) especially the narrow, usually dark coloured, wings. They are black or dull-coloured, small and very delicate. The antennæ are well developed, the mouthparts are of the biting type ; the prothorax is small, the tarsi three-jointed, and there is, in the male, an asymmetry of the cerci. The insects are suggestive of a primitive condition, especially in the thorax, the wings attached to segments that are in no way fused or adapted to the purposes of flight.

Very little is known of such fragile insects. The males are common at lights and are often found in houses. In the field, they are found on the surface of the ground, usually under stones or in some damp sheltered locality. They have been seen to prepare webs from threads which are produced by glands in the forefeet. This is a remarkable circumstance and very different from the methods of silk production general in the insect world.

The nature of the food is unknown, but as the insects are rare and very few, they are not of economic importance, and while of interest to the naturalist, are not likely to be found except at a lamp indoors by any but a skilled observer in the field.

One species (*Oligotoma michaeli* Macl.) has been found in London and is believed to have been imported with orchids from India. Another species (*O. saundersi*, Westw.) (fig. 45) is described from Bengal (Trans. Linn. Soc., XVII, 337).

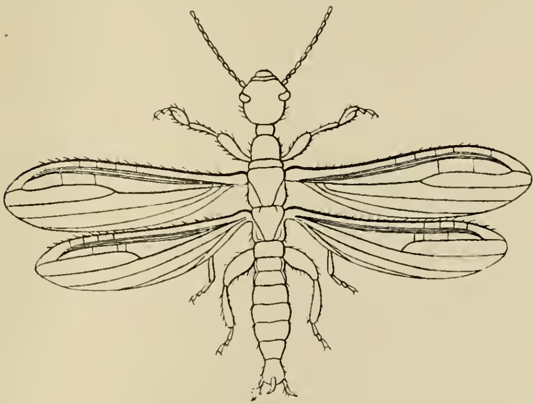


Fig. 45—OLIGOTOMA SAUNDERSI.
(*After Westwood.*)

J. Wood-Mason in 1883 (Proc. Zool. Soc., 1883, p. 328) described and figured Indian Embiides and recounts the capture of nymphs and females. The female he describes as wingless, shining black and more firmly chitinized than are the males. Males, as he remarks, are common at light, *Oligotoma saundersi*, Westw., being the common species. The nymphs he found gregarious under bricks and he figures the asymmetric male appendages.

We have found colonies of these delicate little insects in the shelter of the long dry culm-sheaths of the Giant Bamboo (*Bambusa arundinacea*), as also under bricks on the soil and in decaying leaves. They live in tubes of fine white silken material, which ramify over the sheath; we were unable to find any except where the sheath had been extensively bored by a minute Scolytid and in captivity they refused to make tubes or to remain alive except on such sheaths; whether they fed on the dust produced by the Scolytid or on some other material could not be ascertained; the quite small insects are white, and very active, running quickly along the tunnels and with equal facility backwards or forwards; on seeing them scurrying backwards along the tube one is led to think that the anal cerci serve as the antennæ do when the insect is running forwards. The half-grown nymph has a reddish head, the body whitish and soft. The student should consult Hagen's monograph of the group published in the Canadian Entomologist, Vol. XVIII (1885), wherein 17 species are discussed. *Embia Brahmina*, Sss., was described in 1896 from Bombay (Mt. Schweiz. Ent. Ges., IX, p. 352), and *E. Latreillei*, Ramb., in 1842 from Bombay, Mauritius and Madagascar (Neuroptéres, p. 312).

Fig. 46—OLIGOTOMA SAUNDERSI, MALE (LEFT). OLIGOTOMA SP., FEMALE (RIGHT). × 4.

TERMITIDÆ.—*Termites.*

Four large wings, in repose lying flat on the dorsum; three free thoracic segments. Anal cerci are present. Social, with marked polymorphism of asexual individuals.

These little insects are familiar chiefly from their depredations and are practically never seen except in the winged form, unless looked for. They are clearly distinct from all other *Neuroptera* by their habits, and from social *Hymenoptera* by their structure. The antennæ are short and straight. The segments of the thorax are distinct, the abdomen moderately large with a pair of cerci. The legs are formed for running, the mouthparts for biting. The colour of nearly all is the dull white of insects which live always in concealment, and the integument is correspondingly soft; only in those winged individuals which emerge to the air is the skin hardened and the usual colour of such insects is a deep chestnut brown.

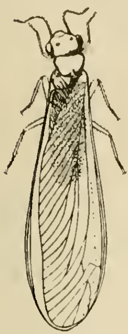


Fig. 47—TERMES OBESUS, WINGED FORM. × 2.

The most striking feature of the termites is the great development of the social system. The nest is peopled and managed by the tiny workers, small insects, sexually immature, which are active and do the necessary work of the nest; there are also a number of similarly sexless individuals, usually with larger heads and more prominent jaws, whose function apparently is the defence of the nest and the overseeing of the work of the nest carried on by the workers. As neither of these castes can usually reproduce, a limited number of sexual individuals are maintained, namely a wingless mature and fertilised queen, a wingless mature male, reserve immature queens and males. These suffice for the peopling of the nest and the establishment of new nests is provided for by the production of large numbers of winged males and females at a special season of the year.

The conduct of the nest apparently rests with the workers, who feed the whole community and who regulate the supply of each class of

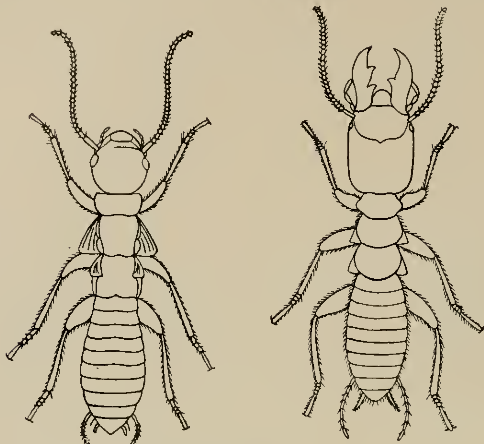


Fig. 48—Termopsis wroughtoni male and soldier; × 8. (*From Desneux.*)

individuals. The queen is a helpless individual, whose sole function is the production of eggs; she lives in the nest and is usually an immensely developed creature with great egg-producing capacities; to provide for fertilised eggs a male is kept. In reserve are immature males and females which can be brought on when desired. The perplexing problem is how so many individuals are produced from one kind of egg. We meet with the same problem in ants and bees, and undoubtedly there is significance in the fact that in both cases the food is "artificial," it is food prepared by the workers and whose composition can be varied; probably they administer different kinds of food to the larvæ according as they want a particular kind of individual. The food of the whole nest consists of vegetable fibre, chewed up by the workers and partially digested; in one species it is stated to be regurgitated from the anterior part of the alimentary canal or excreted from the posterior part and is apparently in both cases used for food, which probably has very different degrees of nutritive value.

It is a most striking thing to consider that the control of the whole system of development is in the hands of the lowest of all, the workers, and to the philosopher, the social system compares favourably with the pitch of development reached by the human race. New nests are provided for very simply. At certain seasons, immense numbers of winged males and females emerge. They are clumsy insects, and fly badly. They rise in a cloud and are at once attacked by innumerable birds and enemies. Those that escape shed their wings at the suture and couple. They then get into shelter and start a new nest if possible; the female lays eggs, the eggs hatch to workers and the new nest starts. In spite of the immense numbers produced, few such females escape to found nests. The emergence of these sexual winged individuals is constantly observed during the rainy months, and appears to occur after heavy rain when the air is still. A small opening is made in the surface of the soil and immense numbers of the winged insects pour out, crowding one after the other. As they emerge they attempt to fly and flutter upwards in a cloud, a phenomenon very quickly observed and one which attracts the attention of birds. Many cannot fly on emergence but run on the soil first and these are the prey of ants which at once carry them off living. The phenomenon strikes one as curiously interesting, the immense number of individuals pouring out, their feeble upward flight into the air where they become the food of birds, the hasty death of those that do not at once fly, carried off living to the nests of ants and there devoured; there is an immense waste of life, and the appearance of these winged termites is the signal for so great a gathering of ants and birds that one imagines it to be a well-known thing for which they are on the look-out at this season. Very few have a chance of surviving and even those which shed their wings do not escape, being the more readily carried off by ants.

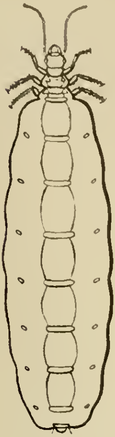


Fig. 49—Termes obesus, queen.

The nest is a most remarkable structure, consisting of numberless chambers and galleries, the walls of a moderately hard substance which is apparently a product derived from the chewed fibre the workers bring in. These nests are often two and three feet in diameter. The situation of the nest varies with the species; the nests of some Indian species are deep in the soil, of others near or at the surface or in banks. Apparently this varies with the nature of the soil, the same species building its nest at different depths in different localities.

The student should consult Petch's paper on the fungi of certain termite nests in Ceylon (Ann. Roy. Bot. Garden, Peradeniya III, p. 185, 1906). Though dealing with species not occurring in our fauna, the account of the fungi is of special interest. The "small white, stalked or almost sessile spheres" observed by him on the spongy masses are probably similar to those observed in the nests of *Termes obesus* in India. The origin and nature of these spheres or their connection with other fungus forms connected with the nests is not clear. The author states that the spongy masses are wholly formed of the excrement of the workers; that this material is probably sterilised by its passage through the alimentary canal, and that not only are special fungi cultivated on it but that other fungi, not desired by the termites, grow which are weeded by the workers; when a nest is abandoned these 'weeds' grow unchecked. He also states that it is probable but not proved that these white spheres form the food of the termites, and that it is not clear if a difference of food causes the differentiation of the forms seen in a termite's nest. The hills are formed wholly of material removed from the nest in excavating and covered with saliva, which the workers take out of the nest and build up into masses; there is no definite object in these chimneys which would probably blow away were the material not covered with saliva and of such a nature as to compact firmly.

Termites are extremely destructive in houses, owing to their fondness for woody matter. On obtaining entry to a house, they will destroy wooden beams and rafters, door frames, window frames and other wooden portions, without such a fact being at all evident at first. Having obtained access to wood at the soil or having taken a tunnel up to it, they work wholly within and remove the woody fibre. No estimate is possible of the amount of damage thus caused in India, and the prevalence of termites varies immensely from place to place. It is on record that in 1814 Government House, Calcutta, was seriously attacked and there seems no reason why any building in which wood was used should not be destroyed in time. Termite communities are so immense and their industry so great that their combined efforts are very effective. In other parts of the world, eatable objects are said to disappear in a night; the only parallel case of recent occurrence in India that can be quoted is a prison in Bengal, in which the bedding of the prisoners was destroyed in the night while the prisoners were sleeping on it. Their efforts are not confined to dead vegetables tissue, but they are particularly destructive to wheat, to sunflower, groundnut and sugarcane. These little insects excrete an acid liquid capable of attacking metal and it has been found that where their galleries cross metal, the metal corrodes.

In reviewing the Termites in *Genera Insectorum*, Desneux regards them as distinct from all families of Neuroptera and as an offshoot of a simpler form of *Blattidæ*. According to this view, the family should follow the *Blattidæ*, but owing to their degree of specialisation he regards them as a separate order under the term *Isoptera*. This is possibly a correct view, and it is undoubtedly misleading, if convenient, to group Termites and the other miscellaneous families in *Neuroptera*; the time has as yet hardly come to separate *Neuroptera* into orders as homogenous and natural as others, and we have preferred to keep them as a family, the order *Neuroptera* being regarded as a convenient group of miscellaneous insects whose position is not quite clear, just as the large series *Polymorpha* includes many very diverse families of *Coleoptera*.

There are nearly 400 species listed by Desneux, of which 15 are recorded from India exclusive of Ceylon.

The following species are known from India:—

Termopsis wroughtoni, Desn., is from Kashmir (Jo. Bo. Nat. Hist. Soc., 1904, p. 445, 1906, p. 293). The only known Himalayan termite (fig. 48).

Termes (Leucotermes) *indicola*, Wasm., from "India."

Termes (Arrhinotermes) *Heimi*, Wasm., from "India."

Termes (Coptotermes) *gestroi*, Wasm., from Burma, and Malaysia.

Termes brunneus, Hagen., from Bengal.

Termes fatalis, Kon., from Ceylon and India.
Termes feæ, Wasm., from Burmah.
Termes Horni, Wasm., from India and Ceylon.
Termes obesus, Ramb., from "India" (figs. 47 & 49).
Termes taprobanes, Wlk., from India and Ceylon.
Termes ferruginosus, Latr., from "India."
Termes (Eutermes) *Assmuthi*, Wasm., from "India."
Termes (Eutermes) *cyclops*, Wasm., from "India."
Termes (Eutermes) *Heimi*, Wasm., from "India."
Termes (Eutermes) *longicornis*, Wasm., from "India and Ceylon."
Termes (Eutermes) *quadriceps*, Wasm., from "India."
Termes (Eutermes) *xenotermitis*, Wasm., from "Burmah."

In a recent paper, Desneux has described a further number of Indian species from Sind (Ann. Soc. Ent. Belg. XLIX, 1905, p. 343). These were found by T. R. Bell who adds notes of the habits. *Hodotermes macrocephalus*, Desn., is described as the common termite of Sind, building underground nests and cutting pieces of grass stems and *Heliotropum* which it stored in the nest. *Termes mycophagus*, Desn., is described as a fungus-growing species, filling chambers underground with masses of soft yellow globules, on which it is supposed fungi grow. *Termes Belli*, Desn., was found nesting in the same spot as the *Hodotermes* above. *Termes Sindensis*, Desn., was also found in Sind.

The termite of the plains of India is *Termes obesus* Ramb., specimens having been obtained from widely scattered places in India. This species nests either deep in the ground, or near the surface, depending probably upon the nature of the soil, but this is not certain. Nests have been found and examined, as also have the small outlying fungus chambers that they make. In some parts of India the nests begin near the surface of the soil and stretch upwards in the form of conical mounds; in other places they are at the surface but not above it ; elsewhere they are deep in the soil. This termite never shows above ground unless in a tunnel or gallery : the insects are seen only when they emerge in the winged state ; their tunnels were found in Pusa 11 feet below the soil level and were occupied by workers. Where they tunnel so deeply nests are never found; small fungus chambers have been found but no nests;

PLATE VIII.—Termes Obesus.

Main and subsidiary fungus chambers, shown from below and from the side. Reduced three times

PLATE VIII.

and though the insects appear for instance in every part of the Pusa estate (1,300 acres), no nest can be found; excavations made at the spot whence the winged forms emerged in a great swarm revealed nothing. Usually the queen is found in a cell deep in the nest, with fungus chambers round; her eggs are found in masses in cells in the fungus bodies, small soft white eggs from which the tiny white nymph hatches.

The fungus bodies are found, flattened and concave below, resting on the floors of the cells in the soil but not touching the walls or the roof; they are sponge-like, with ramifying cavities on the walls of which the fungus fruits grow in the shape of small round white knobs. (Plate VIII.)

The forms this termite takes are shown in the figures. We believe this to be the termite responsible for all the damage done to crops, trees and buildings in India, and it is to be hoped that a really thorough investigation may some day be made into its economy and habits.

For a list of insects found in its nests see below under Myrmecophilous Insects (after Paussidæ).

PSOCIDÆ.—*Book Lice.*

Soft insects, of small size, with two pairs of wings, the hind pair smaller; prothorax very small, except in the wingless forms. Tarsi of two or three joints.

The Psocids are a small group of inconspicuous insects, easily recognised by their general appearance and most similar to the smaller forms

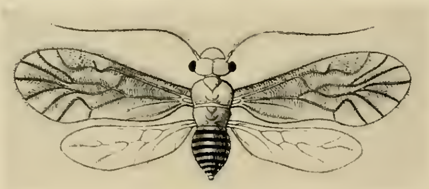


Fig. 50—KOLBEA SOLAX.
(*After Enderlein.*)

of Termites. The colouring is generally dull, the wings occasionally banded and the body bright. The smaller forms are all less than one-fifth of an inch long, the largest never exceeding one-third of an inch. The antennæ are slender, moderately long; there are simple and compound eyes. The mouthparts are peculiar, and are apparently very greatly modified biting mouthparts, small and inconspicuous. The wings and legs are well developed, the former with comparatively few veins. Males and females are similar in general appearance.

The life history is very imperfectly known. Eggs, often covered with excrementitious matter, are laid under webs produced by the parents from silk excreted from the mouth. The young are nymphs similar to the adults in general features and found gregariously with them. One species seems to be common in the plains, its eggs being laid on the leaf under webbing. A far larger and brighter species is found in the moister parts of India on tree trunks; this appears to be *Psocus lemniscatus*. Endl., found also in Java. The species live in the open on bark, under leaves, in damp places under shelter, on leaves: their food consists of animal or vegetable matter in the form of fungi, moulds, bark, etc. Others (*Atropides*) live in houses in damp close situations, a damp wall being a favourite place. The commonest species lives thus in houses, in damp paper, in damp corners, and this attacks and destroys dried insects. New insect store-boxes, if damp, breed them in great abundance, the little insects apparently finding food upon the damp paper: when insects specimens are put in, they feed within these and in time destroy them.

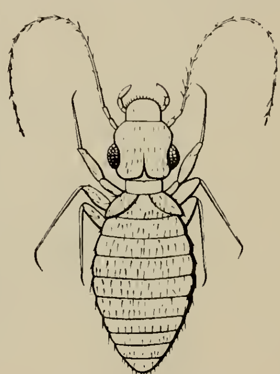


Fig. 51 ATROPOS SP. (*After Smith.*)

The number of species of Psocids is apparently a large one, but as little attention is paid to them, few are described. Two sub-families are recognised, the winged *Psocinæ* with ocelli, the *Atropinæ* which have rudimentary or no wings and no ocelli.

Dr. Enderleins' paper (Die Copeognathen des Indo-australischen Gebiet) enumerates ten species of the former from the Indian region, chiefly collected by Biro. One European species has been found in the

Himalayas, the remaining species are local. Scarcely anything can be said to be known of the family in India, their minute size and extreme delicacy being unfavourable to collection and preservation.

The recorded species are :—

Psocus longicornis.—F.

Psocus nebulosus.—St.

Psocus taprobanes.—Hag. var. *bengalensis.* Kolbe.

Psocus cinereus.—Enderl.

Copostigma indicum.—Enderl.

Caecilius himalayanus.—Enderl.

Amphipsocus pilosus.—Macl.

Ectopsocus denudatus.—Enderl.

Myopsocus fraternus.—Hagen.

Perientomum morosum.—Hagen.

Lepium chrysochlorum End.—(Spol. Zeyl. 1906, p. 81).

None are of the smallest economic importance though the insect eating one (*Atropos sp.*) is a great nuisance in the rains when specimens cannot be kept dry. The study of these insects, especially in the moister parts of India, would very greatly increase our knowledge of the group and yield valuable results from the biological, as from the systematic aspect.

GREGARIOUSNESS

If we exclude the purely social insects, in which for the good of the community there is a well marked division of labour accompanied by polymorphism, we find that the great mass of insects are, as far as we know, wholly solitary. Consider the commonest insects there are about us, and watch their ways ; all live for themselves individually and appear to take no notice of each other, except when impelled by the mating instinct. It is perhaps safe to say "apparently" because for all we know there may be modes of inter-communication not revealed by external movements, as there must be certainly in some species of ants. There are, however, a small number of insects constantly gregarious, as apart from "Social" and it is these forms we propose now to mention. The student will think of insects that migrate but these are gregarious only when this migrating instinct overtakes them and at other times are wholly solitary.

Perhaps the commonest instance of truly gregarious insects are the free-living *Psocidæ* which live under a common web in little colonies on the leaves and bark of trees and other plants. Possibly the common link is the shelter that the web provides, possibly there is some faint approximation to the truly social condition. Another instance are the *Embiidæ*. One finds numbers of these delicate insects together using the same silken runs and living in a little colony together. It is doubtful if they ever live in any other way but why they should do so is not clear ; the reason that suggests itself is that there are few spots suitable to them and that here they naturally gather and make common runs and shelters. A better and more striking instance is the *Pyrrhocorid* bug *Iphita limbata* ; great numbers of this bug cluster together on one spot on a tree trunk, and that they remain there is shown by the heap of exuviæ below the spot. Why they do so is not at all clear ; their ally the Red Cotton Bug (*Dysdercus cingulatus*) appears to have the same habit, but this is clearly a case of food or of enhancing their warning colour and they cluster on the seeds or pods to feed or sleep only. The Coreid *Corizus rubicundus*, Westd., lives till mature in clusters which look like vivid red flowers. Some moth caterpillars and a few Pierid caterpillars are gregarious, hatching from eggs laid in clusters and remaining together for a longer or shorter time. Some remain in webbed leaves till they pupate ; others for a short time only and in these cases, which are fairly numerous, the web made as a shelter is often the reason. Thus *Caradrina exigua* larvæ remain together for a few days in the webbed leaves as do the larvæ of *Diacrisia obliqua* and many other *Noctuids* and *Arctiids*. An interesting gregarious insect is the common *Machilis* found on rocks and under leaves ; it is apparently always gregarious. Young Pentatomids are often gregarious for the first two or three instars, and the persistent way in which some remain together when newly hatched out shows that it is instinctive. Cockroaches are gregarious also and apparently often prefer being in company to being alone. *Gyrinidæ* are distinctly and markedly gregarious and apparently take delight in their combined evolutions on the surface of still water. *Opatrum* among Tenebrionids is gregarious in the sense that the beetles like to crowd together in groups and clusters instead of remaining solitary. *Haltica cyanea*, Web., is another beetle that lives and feeds in company, though such instances are very rare.

PERLIDÆ.—*Stone flies.*

Delicate insects, with the hind wings large and folded beneath the forewings. Legs widely separated, with small coxæ. Larva aquatic.

These typically Neuropterous insects are distinguished from other allied groups by the above characters, by the long antennæ, and the three-jointed tarsi; as a rule there are two long anal cerci (except in Nemoura). They are inconspicuous insects of which apparently nothing is yet known in India. In general the Perlidæ are, in the immature stages, aquatic; the eggs, laid on the surface of the water, sink to the bottom and hatch to active nymphs; these are flattened, with an elongate body, the head with biting mouthparts; air is obtained by means of tufts of gill filaments; two long many-jointed cerci terminate the abdomen. Those known elsewhere are predaceous, and are found under stones or at the bed of rapidly flowing streams. The full grown nymph is said to crawl out of the water before the emergence of the imago. The family is often classed with the order *Pseudoneuroptera* or is treated as a separate order *Plecoptera*. When more attention is paid to *Neuroptera* in India, they may prove to be abundant in species; they are of no economic importance, direct or indirect. No species appear to be recorded from India.

ODONATA. *Dragon-flies.*

Two pairs of long narrow wings of equal size; antennæ very small and terminating in a bristle. Head large and mobile. Tarsi three-jointed.

A large group of large insects, easily recognisable from nearly all other insects by their wings, (which are in repose held out horizontally and not resting over the body,) by the peculiar antennæ, the large mobile head and the active habits of the flying insect. The imagines vary in length from an inch upwards with a span across the wings up to four inches. They are, as a rule, brightly coloured, black with blue, yellow, red, metallic green and other bright colours predominating. The colour is possibly warning, probably simply beautiful, though it is difficult to generalize about insects so variously coloured.

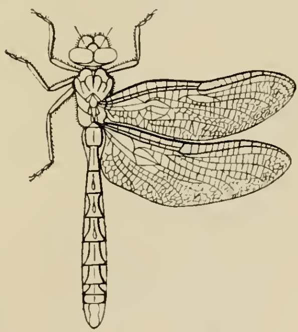


Fig. 52—HEMICORDULIA ASIATICA. (*From Martin.*)

The head is large and very mobile, with immense compound eyes. In some cases the facets on the upper surface are larger than on the lower and this difference may be an adaptation to both long and short sight. The active habits of these insects necessitates very perfect sight and the compound eyes appear to be very highly developed. The antennae are small, with few segments, and are bristle-shaped. The mouthparts are of the sharp biting type. The thorax is large and the individual segments consolidated into a single mass. The long wings are attached to the sides; the powerful muscles and well-built thorax give the insect very great powers of flight. The legs are placed very far forward on the thorax and this is apparently an adaptation to the predaceous habits of these insects. They catch their prey on the wing, hawking for flying insects; the legs extend forwards below the head in the form of a basket; as the dragon-fly rushes through the air and pounces on an insect the legs grasp the prey and hold it below the head, the dragon-fly remaining in motion throughout. The captive is then devoured. Dragon-flies are found only on the wing or resting on twigs, leaves or grass stalks. The peculiar position of the legs facilitates this method of repose but does not enable the insect to walk. The abdomen is long and thin terminated in claspers or processes. The method of fertilization is somewhat remarkable, the seminal fluid which issues from the tip of the abdomen being transferred to a pouch on the second abdominal segment, which is provided with coupling organs; the male then grasps the female by the neck and she brings the tip of her abdomen to this pouch; in some species this process takes place over the water and eggs are laid in the intervals of coupling. In others the female descends under water, carrying air with her between the wings and body and there deposits her eggs; others deposit the eggs while flying over the water, or while lying motionless on it with extended wings and a few are known to lay them in mud.

Fig. 53.—Aeschnid nymph.

The life history is, so far as known, the same throughout the family. Eggs are laid in water, a mass of eggs in a transparent mucilaginous envelope being deposited. The larvae are active, with three pairs of legs, short antennæ and biting mouthparts of a peculiar type. The lower side of the head is concealed by a development of the lower lip, in the form of a long jointed arm-like structure, which folds down over the mouth and which is armed at the tip with processes bearing strong spines. This jointed arm extends very rapidly to a considerable length, seizes the prey and withdraws it to the mouth, where are the sharp maxillæ and mandibles with which the prey is devoured. Like other aquatic larvæ, these must obtain a supply of air and as they live below the surface, this air must be obtained from the water. This is effected in the *Libellulinae* and *Aeschninae* by taking water into the rectum, the

Fig. 54.—ALIMENTARY CANAL AND TRACHEÆ OF AESCHNID NYMPH.

posterior portion of the alimentary canal, which is modified to act as a gill and to extract air from the water; this part of the alimentary canal is penetrated by tracheæ, into which the air is absorbed and which distribute it as in other insects. (Fig. 54) The nymphs can be seen to take in and eject water from the hind end, the violent ejection of water also serving to propel the nymph forward and assist it to obtain its prey. In the *Agrioninae*, the nymph is provided with three flat lamellar appendages at the apex of the abdomen, which function as gills. (Fig. 55).

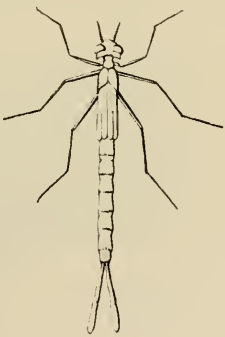


Fig. 55.—AGRIONID LARVA.

Like the adult, the nymph is predaceous, the teeming fauna of fresh water supplying it with an ample supply of food. When fullgrown, the nymphs climb up out of the water, the skin breaks along the dorsum, and the perfect insect emerges; the wings are gradually developed outside of the body in the nymphs, as in the *Orthoptera*, and the metamorphosis is thus an incomplete one. It is more complete than in the *Orthoptera*, as there is one sudden change from nymph to adult, when the insect from being a repulsive crawling creature becomes suddenly winged and aerial ; but it is incomplete in the sense that there is no resting pupal stage as in the *Hymenoptera*.

It is impossible to discuss the extremely interesting variations, which are found in the nymphs of various species, in the manner of life and respiration ; the aquatic insect fauna of this continent appears to be a sealed book and nothing is known in detail. Nymphs have been found living in dried up pools, apparently not injured by the absence of water and obtaining air directly. It is doubtful to what extent this occurs, and whether there are any species that live so habitually.

Odonata are found abundantly throughout the plains and in forest areas. The number of species is very large and an account of the family as it occurs in India is much wanted. The imagines have quite peculiar habits, and are very characteristic. They play a large part in the destruction of smaller winged insects, especially flies, their appetite being apparently insatiable. It is often observed that each individual has its own beat and it is known that when they are abundant, each confines his operations to a particular spot, returning to rest on the same twig.

The length of the life is not known but it is apparently long both in the nymph and the adult condition. A few dragon-flies are among the

Fig 56—RHYOTHEMIS VARIEGATA. FEMALE.

gregarious insects and it is not uncommon to find large numbers flying together over pools in the jungle. The bright winged species of the moister areas of Bengal are frequently seen flying in groups, and one brilliant yellow species (*Rhyothemis variegata* F.) is commonly seen in Calcutta. Migration has been known to occur elsewhere, though not recorded in India.

The *Odonata* are by some authors treated as a single family, with two divisions and seven sub-families as is done here, or as a sub-order with three families, or with seven families.

ANISOPTERIDES	1. LIBELLULIDÆ	...	Corduliinæ. Libellulinæ.
	2. AESCHNIDÆ	...	Gomphinæ. Cordulegasterinæ. Aeschninæ.
ZYGOPTERIDES ...	3. CALOPTERYGIDÆ	...	Calopteryginæ. Agrioninæ.

Anisopterides.—Hindwings broader at the base than the forewings. Wings held horizontally outwards from the body when at rest. (Figs. 57, 59.)

Zygopterides.—Wings equal or hindwing small; wings held closed together vertically above the body when at rest. (Fig. 58.)

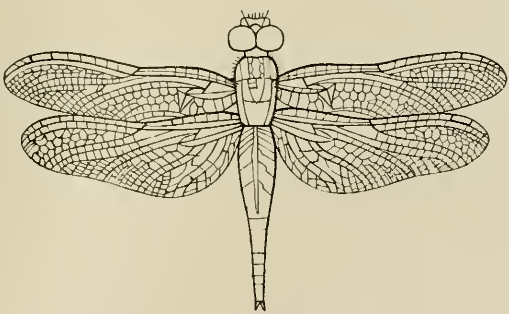


Fig. 57.—ACISOMA PANORPOIDES.
(*From Rambur.*)

Over 130 species are listed or described from India. Rambur monographs the older species (Neuroptera 1842). De Selys' many papers

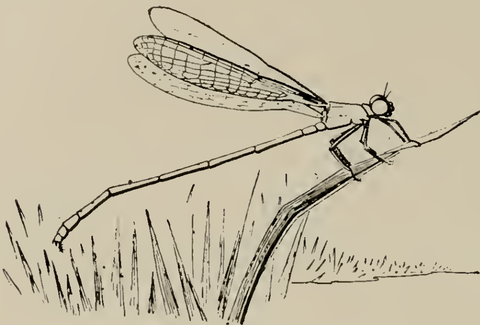


Fig. 58.—Agrionid at rest.

contain descriptions of a large number of species; Kirby has described species from Murree and Campbellpur (Proc. Zool. Soc. 1886, p. 325), the European *Sympetrum fonscolombei* de Sel. being found there; he has added descriptions of species from Ceylon and Upper Burma (Ann. Nat. Hist. VI, 14, and VII, 15); a large collection made by G. C. Nurse at Deesa and Quetta is described by Martin (Trans. Ent. Soc., London, 1907, p. 303). The species up to 1890 are catalogued in Kirby's Catalogue of Odonata and there have been stray descriptions by other authors since then.

Fig. 59.—Aeschnid at rest.

AQUATIC INSECTS.

A considerable portion of the insect world live in or on the surface of still or running water, and are more or less specially adapted to the peculiarities of this mode of life. These insects are derived from terrestrial insects and there is no hard and sharp line between terrestrial and aquatic insects. We have, for instance, the predaceous Reduviid bugs on the earth which live also on mud and in the neighbourhood of water. It is but a small transition to the *Hydrometridæ*, bugs which run on the surface of the water and which require very little modification, chiefly in the structure and motions of the legs. The aquatic carnivorous beetles are very closely allied to the land carnivorous beetles, the modifications mainly consisting of those necessary to enable the beetle to swim, to obtain air below water and to catch different prey. The *Hydrophilidæ* include both land and aquatic forms in one family, and were our knowledge of past and present day insects greater, we might be able to trace the steps by which a land insect gave rise to aquatic forms. The aquatic Diptera are excellent examples, some living in mud, some in shallow water, some in deep water. We may suppose these to have more recently acquired the aquatic habit than such a homogeneous group as *Odonata* or *Ephemeridæ* which are now wholly aquatic and were probably derived from primitive land ancestors.

Among aquatic insects, one of the most interesting features is the manner in which the air supply is obtained. Assuming that all aquatic insects are descended from terrestrial ancestors, and not from a single form which became aquatic, we would expect different groups to solve this problem in different ways and to find a great variety of devices to secure an air supply. In general mature insects obtain their air direct from the atmosphere, rising to the surface to do so, and there are among them fewer modifications in the respiratory system, possibly owing to the greater rigidity of the outer skeleton and the far smaller degree of plasticity of the adult constitution as compared with the larval. We may, therefore, consider the larval and pupal forms of aquatic insects, extremely briefly, solely from this point. Insects are commonly provided with one or two thoracic spiracles, and a series of five to eight on the abdominal segments. This, the so-called holopneustic (2 thoracic) or perineustic (1 thoracic) system obtains in adults but not, so far as we are aware, in larvæ. The first modification we find is the closure of all spiracles but the two terminal pairs, one near the head, one nearest to the tail (Amphipneustic). The closure of these spiracles is actual, but the spiracle remains, a tracheal vessel runs to it which contains no air as a rule. The larva of *Pericoma* (*Psychodidæ*) and allied larvæ are examples, and air is obtained by bringing either of the pairs of spiracles to the surface. A far commoner modification is the metapneustic one, where only the terminal abdominal spiracle persists in a functional state, being usually very large. A large number of insects exhibit this character in the larval state including *Amphizoa*, *Dysticidæ*, most *Hydrophili-*

dæ, *Helodes* (*Dascillidæ*), *Culex*, *Dixa* and *Anopheles* (*Culicidæ*), *Tipulidæ*, *Stratiomys*, *Tabanidæ*, *Syrphidæ*, and *Sciomyzidæ*; in these it obtains in the larva, and not always in the pupa, though in *Stratiomys* and *Hæmonia*, for instance, the pupa also exhibits it. In a few, we get the complementary state, in which the anterior spiracle alone is functional, as in the pupæ only of *Culicidæ*, *Chironomidæ* and *Dixidæ*.

In the above there have been in all cases at least one spiracle functional and the normal tracheal system. In those that follow, there are no functional spiracles, unless one of the above systems is combined with it; most larvæ exhibit one of the above modifications, with one or several of the following, though the latter may occur alone or in combination with each other. *Tracheal gills* alone, with no other definite system, occur in a number of larvæ; in these the skin is produced into thin-walled tubular structures in which the body-fluid circulates, in which there are tracheæ, and which function as gills since they absorb (or are supposed to absorb) oxygen but are tracheal and not true gills since the air is passed into the trachea and not, apparently, into the "blood" system. Such gills take many forms but are commonly tubular or paddle-like, in tufts, in spongy masses; they occur in larvæ which do not come to the surface but live wholly in the water at some depth usually, as in the *Perlidæ*, *Ephemeridæ*, *Sialidæ*, *Sisyra* (*Hemerobiidæ*), *Haliplidæ*, and *Calopterygides* (*Odonata*), and in the subfamilies *Phryganeides*, *Sericostomatides* and *Leptocerides* of the *Phryganeidæ*. These gills may be on the eight basal abdominal segments (*Haliplidæ*), on the seven basal abdominal segments (*Sialidæ*), on the apex of the abdomen (*Chironomidæ*), *Corethra* (*Culicidæ*), *Simulium*, and the Calopterygine division of *Odonata*, on the base of the abdomen (*Perlidæ*, some *Ephemeridæ*) or on the whole abdomen (*Gyrinidæ*, *Phryganeidæ*).

Accessory tracheal gills also occur, in combination with a spiracular or other combination, as in *Dixa*, *Culex*, *Mochlonyx* and *Helodes*. Such accessory gills are extremely common and cannot always be easily distinguished. Rectal respiration is another modification of tracheal respiration. in which water is taken into and discharged from the rectum, which is set extremely densely with tracheæ and functions as a "water-lung" or gill. *Odonata* (exc. *Calopterygidæ*) are the best examples, the very young Chloeon (*Ephemeridæ*) is another and both *Culex* and *Ceratopogon* also exhibit it.

There are finally some modifications in which tracheæ play no direct part: the skin possibly functions as a "gill" in many of the young larval forms, in which there is no other system developed; this is a matter of conjecture largely, but there is no other available explanation of the respiration of many young aquatic forms. Some *Phryganeidæ* and *Perlidæ* never exhibit any other respiration throughout larval life, and it is presumed the air is obtained through the skin.

"Blood-gills" are gills as opposed to tracheal gills, since only the body-fluid circulates in them and no tracheæ enter them, or if they do, do not contain or carry air; the gills of *Pelobius*, *Hydrocyphon* and some *Chironomus*, the rectal pouches of *Macronema*, the gills of some young *Phryganeids* and *Ephemerids* are of this class, though in the last there is little real distinction from tracheal gills.

There are a small number of insects in which air enters the body cavity and this is so extraordinary a phenomenon that though we know of it in only two insects, we mention it here. It deserves fuller investigation. Another peculiar method is found in larvæ which take air into the alimentary canal, either swallowing it as does one aquatic larva, or as Odonata do, at the hind end; this is often seen in the latter in captivity, and is simply a modification of the rectal gill.

Finally, there are the insects which contain a red pigment allied to or identical with Hæmoglobin, the constituent of man's blood that carries oxygen in weak combination from lung to tissue and Carbon Dioxide to the lung. *Chironomus* is the familiar example, found in every Indian tank, and we use this generic name in a very broad sense to include many forms allied to Chironomus but not identified.

For the benefit of the student we attach the table of modifications mentioned above.

I. Tracheal:

- 1. Stigmata:
  - *a* *Holopneustic.*
  - *b* *Peripneustic.*
  - *c* *Amphipneustic.*
  - *d* *Metapneustic.*
  - *e* *Propneustic.*
- 2. No Stigmata:
  - *f* *Tracheal gills, main.*
  - *g* *Tracheal gills, accessary.*
  - *h* *Rectal gills.*

II. Without tracheæ:

- *i* Skin, wholly or in part.
- *j* Blood-gills.
- *k* Entrance of air to body.
- *l* Entrance of air to gut.
- *m* Pigment.

Summary of aquatic families.—The following review does not pretend to mention every aquatic form or group, but contains the majority, and probably every important family.

Aptera include aquatic forms living on the surface of water. *Podurinæ* are known to have this habit and, were we to include the marine forms, the well-known *Anurida* could be cited. Aquatic *Orthoptera*, while rare, are not unknown. A description of an aquatic Gryllid (*Hydropedeticus vitiensis* Mial. and Gil.) will be found in Trans. Ent. Soc., Lond., 1902, p. 281. *Tridactylus* is found on the surface of water but usually lives on mud. (See p. 99.) Annandale has found an aquatic *Blatta* in Malaya and an aquatic *Epilampra* in India (Journ. Asiatic Soc., Bengal, 1906, p. 105). In India, one genus at least of Tetriginæ (*Scelimena*) is aquatic and an Acridiid allied to *Hieroglyphus* has the habit of diving below the surface.

Amongst *Neuroptera*, there are several important groups. The *Perlidæ* (Stone Flies) have aquatic nymphs, which have ten pairs of closed stigmata, and functional gills as a rule. A few are stated to have no gills but to have special tracheal developments at the skin. Others have gills on the first thoracic segment (*Nemoura*, *Pteronarcys*) on the sides of the thorax (*Perla*, *Pteronarcys*, *Nemoura*), on the apex of the abdomen (*Perla*, *Pteronarcys*) or on the head (*Dictyopteryx signata*). The *Odonata* are wholly aquatic with two modifications; the *Calypterygidæ* have leaf-like processes functioning as tracheal gills, the *Aeschnidæ* and *Libellulidæ*, rectal gills with anal valves to admit water, the gills in the former being *papilliform*, in the latter *lamelliform*. The *Ephemeridæ* are also aquatic with gills in the older stages. Lubbock has remarked that the skin of *Chloeon* functions till the third instar, when gills appear, but the tracheæ are functional only in the fourth instar (there are 20 instars). Gills take several forms, and may be large and exposed, flat lateral plates, tubular under a gill cover, or concealed. The long caudal setæ have a circulation and are probably also respiratory. Of the *Sialidæ*, the *Sialinæ* live in mud, the first seven abdominal segments having filaments functioning as gills. Of the *Hemerobiidæ*, the *Hemerobiinæ* contain two aquatic forms, *Osmylus* and *Sisyra*, the latter with abdominal tracheal processes. The *Trichoptera* are wholly aquatic in the larval stage, having no gills (some *Hydropsychides*, *Rhyacophilides*, *Hydroptilides*), or having gills in the form of tufts or slender processes, which may be placed all round the body.

The *Hymenoptera* include a few remarkable parasitic forms which deposit their ova in the larvæ of Trichoptera or other aquatic insects. *Prestwichia* in Europe is parasitic in the eggs of six species of aquatic insects.

The Coleoptera include eleven families aquatic wholly or in part at least in their larval stages. *Amphizoidæ* are metapneustic as larvæ. The *Pelobiidæ* are represented by *Pelobius* whose larva is said to have spiracles and blood gills. The larval *Haliplidæ* have long filaments on the abdominal segments. *Dytiscidæ* are wholly aquatic, the larva metapneustic, the imago carrying air under the wings. *Gyrinidæ* live on the surface of the water as adults, but the larvæ are provided with ten pairs of abdominal tracheal processes. The *Hydrophilidæ* are only in part aquatic; their larvæ are either metapneustic or have tracheal processes (*Berosus*). *Platypsyllidæ* are scarcely aquatic save in that their host the beaver is so. *Heteroceridæ* are semi-aquatic in mud or wet sand in all stages. *Parnidæ*, so far as known, are peripneustic or have filamentous branchiæ ; the *Elmides* have three pairs.

Dascillidæ are aquatic and while some have functional spiracles, others are said to have exsertile respiratory pouches (*Hydrocyphon*); a few forms of the *Donaciinæ* among Chrysomelidæ have aquatic larvæ, the larva being found in the roots of aquatic plants. (*Donacia*, *Hæmonia*.) We have omitted to mention the abnormal aquatic Carabid found extremely rarely in England and Annandale has recently described an aquatic weevil from Calcutta (Journ. Asiatic Soc., Bengal, 1906, p. 197) as well as an aquatic glow-worm larva (loc. cit. 1906, p. 107).

Few Lepidoptera are aquatic but some are very notably so in this country. A single Pyralid genus (*Acentropus*) has an aquatic larva (not known in India) ; the *Hydrocampinæ* include at least several aquatic forms including *Nymphula depunctalis* Guen and *N. fluctuosalis* in which the larva is set with short respiratory processes. Both these are common in India, while *Hydrocampa*, *Paraponyx* and *Cataclysta* are known elsewhere.

A single abnormal Eupterotid is aquatic, the larva of *Palustra Burmesteri* being holopneustic but having a covering of long hairs in which air is retained ; it comes to the surface to renew the supply. Of *Diptera* we are still largely ignorant but the *Culicidæ* have aquatic larvæ, variously modified, as do the *Chironomidæ*. *Corethra* is in the larval state dependent on tracheal gills ; *Culex*, *Anopheles* and others are metapneustic, but have tracheal gill processes as well ; in all, the pupæ are *propneustic*, the anterior spiracles lying within large trumpets which are brought to the surface of the water. *Chironomidæ* include the forms with *hæmoglobin* (*Chironomus*) as well as those with tracheal gills ; the pupæ are propneustic or have tufts of gills. The aquatic *Ceratopogon* larvæ appear to have no gills and to breathe through the skin. *Psychodidæ* have aquatic or semi-aquatic larvæ, living in algæ and weeds, with four ciliated processes at the hind end forming a basin round the spiracles, as well as a functional pair of anterior spiracles. *Dixidæ* have metapneustic larvæ with tracheal gills, the pupa with propneustic trumpets. Aquatic *Tipulid* larvæ are well known and are metapneustic, some with a long telescopic tail process (*Bittacomorpha*, *Ptychoptera*). One at least has long tracheal filaments (*Phalacrocera replicata*). The larvæ of *Blepharoceridæ* are known to live in torrents and near waterfalls, clinging firmly to rocks. *Simuliid* larvæ are found in swiftly running water and have five retractile gills ; the pupa has a tuft of filaments. *Stratiomyidæ* have some aquatic larval forms, the larva metapneustic with an expansible ring of hairs that hold an air bubble.

Tabanidæ have metapneustic aquatic larvæ, as do the *Syrphidæ* in some cases, the latter having in some forms (*Eristalis*, *Helophilus*), the long telescopic tail process with the spiracles at the apex ; the pupa is propneustic with the spiracle on the tubular filaments. It is known that some *Acalyptrate muscidæ* have aquatic larvæ, *Dasycerides, Ephydrides* and *Sciomyzides* being thus found.

The above includes the majority of the forms with aquatic nymphs or larvae, but we may remember that in almost any tank or stream there are abundant new forms as yet unreared, and that aquatic insects are by no means well known. We are familiar with many fresh-water larvæ which do not come into any of the above groups, and the Indian aquatic fauna is almost unknown.

The following Hemiptera are aquatic in all stages, but all are holopneustic or peripneustic. The *Hebridæ* are scarcely truly aquatic, living in damp situations, the body beneath densely pubescent. *Hydrometridæ* live on the surface of the water, being also pubescent below. The division *Cryptocerata* are aquatic, living below the surface but being holopneustic or peripneustic in all stages ; *Pelogonidæ* (*Galgulidæ*) are alone found on wet mud and near water. *Nepidæ* live in shallow water and obtain air by means of two processes which unite to form a slender tube ; the nymph obtains air by means of two ventral pubescent grooves leading to the apex of a short process. *Naucoridæ* carry air down with them in a bubble attached to the hind end and come to the surface to renew it ; *Belostomidæ* are also aquatic and obtain air from the surface. *Notonectidæ* and *Corixidæ* carry air on the lower side of the body and come to the surface to renew it.

So far as we are aware, there remains only one aquatic Hemipterous insect, an Aphid (*Rhopalosiphum nympheæ* Fabr.) found in India below the surface of fresh water on an aquatic plant.

In the above aquatic insects, we have indicated the fact that the actual habitat in the water may be very different, and it will be useful to briefly note the habitat conditions that we find. There are many forms which never or only exceptionally leave the surface, such as the Gyrinid beetles, the larvæ of *Dixa* and *Anopheles* and the various *Hydrometridæ;* they are aquatic only in the sense that they live on water and are adapted thereto.

Others live near the surface and always within reach for air-getting purposes. Of these some live in algæ or weed masses as *Palustra* larvæ, the pupæ of aquatic *Tipulids*, the larva of *Stratiomys* and the larva and pupa of *Psychodidæ ;* others are in mud at the margin, as *Ptychoptera* and *Bittacomorpha*, the Tabanid larvæ, the larva and pupa of the *Eristalis* and *Helophilus* sections of *Syrphidæ*.

A number are dependent on the surface, but go deep in search of food or shelter ; such are the predaceous beetles (*Dytiscidæ* and the like), the Hydrophilus beetles, the aquatic *Cryptocerata*, as well as the *Culicidæ* and *Dixidæ*.

When we leave the surface, we find a number that live in the middle depths; the peculiar mining larva of *Dorycera*, the red *Chironomid* larvæ found in the soft stems of aquatic plants, the larvæ of *Ephemeridæ* in the holes in the bank, the many larvæ in masses of algæ or weeds (*Ceratopogon*, *Acentropus*, *Hydrocampa*, *Cataclysta*, *Paraponyx*, *Nymphula* and *Simulium*), the few larvæ that live actually free in the water in the middle depths (*Corethra* and *Chironomid* larvæ), are examples of insects neither dependent upon the surface for air nor finding food at the bottom, and which are commonly obtained with a net in the middle depths.

There are also the insects in the depths or on the bottom; the *Perlid* larvæ are under stones; the mud-loving *Sialidæ*, the larvæ of caddis-flies and dragon-flies are found on mud; some are found only at the bottom of shallow running water, including caddis larvæ, the nymphs of *Odonata*, *Perlidæ* and *Ephemeridæ*, as well as such aquatic *Hemerobiides* as are not found in sponges.

Finally, there is the remainder, which are at all depths except near the surface, which range over the bottom and middle; these include the more active *Odonata* and *Trichoptera*, the larvæ of *Haliplidæ*, *Gyrinidæ* and *Parnidæ*, as well some of the *Hydrophilidæ* (Berosus). A far larger part of the aquatic fauna would naturally come within this last division were one to go minutely into it, which is impossible in this place.

Sufficient has been said to show that aquatic insects live in a world of their own, one as complex in its internal relations as that of the land; we find herbivorous insects, preyed on by carnivorous ones, occasionally attacked by parasitic ones; it is a teeming world of life of all kinds, of immense interest from every point of view and especially so from the aspect of the immensely ingenious contrivances by which insects obtain their air supply. But it is a subject which has been scarcely touched in this country, though there are unrivalled opportunities at almost all times; we anticipate that the investigation of how these insects pass through the time when tanks dry up will yield some extremely interesting results, and we may hope that, though there is no economic side to it, this fascinating branch of entomology will some day be attacked.

Ephemeridæ.—*May-Flies.*

Slender insects with large forewings and small hindwings. The antennæ are short. There are two or three long processes on the abdomen. Tarsi four or five jointed. Larva aquatic.

This is the last family in which the wings are formed in the active nymph outside the body as in *Orthoptera*. The wings are, in repose, held together above the body in an upright position and, with the long anal processes, are very distinctive. Some are small very delicate insects, not longer than 5 mm. with a span of nearly 10 mm.; others are larger, but none are very large. Eyes are larger in the males than in the females, the upper portion with larger facets than the lower and sometimes divided. In some cases the upper half is much larger and raised on a large projection above the head. The antennæ are short, the mouthparts feebly developed or absent. The mesothorax is well developed,

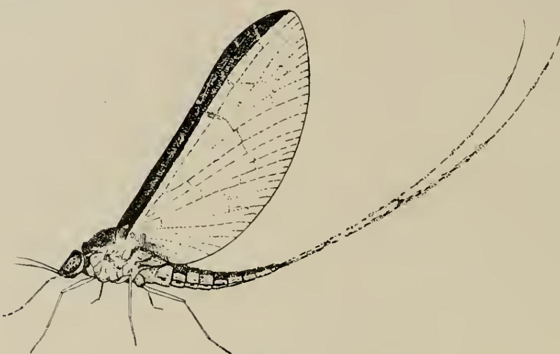


Fig. 60.—Ephemerid. (F. M. H.)

the abdomen sessile, ten-jointed and glabrous. There is no ovipositor; the male has longer forelegs (often very long) than the female, and distinct jointed claspers. The venation is complex. The colours are grey or pearly, the wings transparent, faintly tinged, or with dark markings.

The life-history is similar to that of other aquatic insects. Eggs are laid in water, either loosely or in compact masses; Eaton records seeing *Baetis* descend under water to lay her eggs under a stone and this is apparently habitual in some species. The nymphs are slender insects, usually with long abdominal processes, with long antennæ and well developed biting mouthparts. The food is said to be mud, or minute aquatic vegetation, but some are certainly predaceous. They live in various situations and beyond the fact that they are to be found in fresh water in India, not much is known. All have gills on some part of the body for the purpose of extracting air from the water: these are situated on the abdomen and consist of thin walled processes in which the body fluid circulates and in which tracheæ are found. In fact, the gills supply the tracheæ with air and are not gills in the same sense as in fishes. The form of these nymphs in general is very varied, as are their habits and there will probably be found a similar variety in Indian species. The reader will find general information in Miall's Aquatic Insects, in Sharps' Insects and in Eaton's Monograph. A curious feature of the life-history is the very sudden transformation; the full-grown nymph comes to the surface, the skin breaks along the back, the flying insect emerges; but its metamorphosis is then not really complete and the insect (now called a sub-imago) flies to a spot on which to settle, then sheds another delicate skin. This phenomenon is known only in this family. One species common in the plains flies some hundreds of yards before doing this and comes to light, settles on the wall and then emerges fully developed, leaving the delicate skin behind.

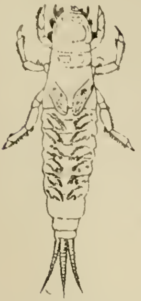


Fig. 61.—PALINGENIA LARVA, CEYLON. (*After Eaton.*)

The nymphal life is probably as long relatively as the imaginal life is short. The May-flies are types of the brevity of life, but in reality these insects have previously enjoyed a very long life (for an insect) in their aquatic form. Lubbock found that the nymph of a European species underwent twenty moults. The perfect insects apparently emerge to a brief career of enjoyment. May-fly dances are a common feature of a still warm evening, the delicate insects (males) performing intricate evolutions in companies on the wing. A dance in three dimensions may have advantages over the dance on the two dimension dance-floor and we can compare it only to a dance of flying machines. These dances take place often at a considerable distance from water, a number of the insects gathering together for the purpose and forming a very striking sight. Coupling and egg-laying closes the brief life. As the mouthparts are absent and no food is taken after emergence, an active life must soon close, and it is probably correct to say that May-flies do not live for more than one or a few days. The immense swarms of May-flies that emerge simultaneously in some countries do not seem common among

Indian species, and these insects appear during long periods in the hot weather and rains, but not in large numbersat any one time. As these insects in their feeding life live a purely aquatic life, there are none of economic importance and the group, as a whole, has attracted little attention in this country. The number of species known is small, as they are not attractive to collectors.

In his monograph, Eaton describes the known Indian and Ceylonese species (Trans. Linn. Soc., Zool. III). Eaton also mentions ten species from India (J. A. S. B., LX, p. 106) and discusses them, mentioning also that McLachlan possessed nine species from Tenasserim. The total recorded by him is twenty-two species, but our common plains species are apparently undescribed, the recorded species being from elevations above 4,000 feet in Ceylon or the Himalayas in most cases.

Collecting.—Imagines and sub-imagines are best preserved in spirit as their integuments are weak, but when plentiful, a series may also be pinned.

THE RELATIVE DURATION OF LIFE.

The actual duration of life measured in human units, is a matter of very considerable variation among the diverse forms of insect-life. From the extremely short-lived Drosophilid fly to the long-lived Cicada, there is an infinite variety; this is a matter of small importance since the passage of time has a relative value and the insect which lives for but a few days may pass through as many experiences as a human being in as many years. The point is, perhaps, interesting as popular ideas are often extremely erroneous and forget to take into account the fact that a winged insect whose life is but a day may have passed weeks or months in an immature form.

Factors which govern the duration of life are many and varied; fall of temperature suspends activity to a greater or lesser extent, and, while prolonging the actual length of life, does not add to the active living period. Abundant food by hastening maturity and the development of the reproductive system may materially shorten the life of an insect; unnutritious food or the lack of food may immensely prolong life either by preventing the immature insect from deriving sufficient nutriment from its food or by checking the development of the reproductive organs, so that life is maintained for long periods until the eggs are formed and egg-laying becomes possible. The absence of the larval food-plant is another factor which prolongs the life of the adult, since the mother insect will remain alive until eggs are laid on the food-plant unless this period is so long as to exhaust her vitality.

What terminates an insect's life? If we consider the insects which escape their foes, which do not die of injury, of parasites or of disease, but which die a natural death, what brings about the cessation of life? Speaking very broadly, the full exercise of the natural functions of reproduction brings a speedy end, perhaps from exhaustion, perhaps from a lack of vitality now that there is no further object in life. The locust dies, if a male after coupling, if a female after the deposition of all the eggs, though food may be abundant and the conditions apparently suitable for further life. The moth dies after mating or laying eggs, and the life of many moths is limited to one or two nights if reproduction is effected, though it may be much extended if mating and egg-laying be not possible; and this is true even of moths that cannot feed and in which the alimentary system is wholly undeveloped.

In estimating the natural life of an insect, we have to consider the time required to build up the tissues of the larval or nymphal as well as those of the subsequent imaginal form, the time required to reproduce. as well as the conditions of food-supply and temperature under which life is carried on. For many, the conditions of food-supply and temperature are such that a yearly period covers the whole life, there being one brood yearly. For others, one active season is not sufficient for the larval form to lay up sufficient nourishment to provide for the tissues of the imago; or this may be possible during the limits of a season or two seasons, but the processes of transformation cannot be completed in time to allow of the imago to emerge, mate and lay eggs at a favourable season and before the rigours of winter or drought prevent the imago from providing for the young. Thus we get a two-year or a three-year period, the whole life from egg to egg occupying multiples of one year. In rare cases (so far as known) this period may be peculiarly long and the Cicadas are notorious in this respect; the 17 years of *Tibicen septindecin*, and the 13 years of *Cicada tredecin*, both American insects, are notorious instances. Turning to shorter-lived insects, we find for instance the two-brooded butterflies, in which there is one quick brood in the rains, and one longer brood which persists in some form through the cold and dry weather till food is again available on the coming of the rains or perhaps at the opening of the buds in spring. From these, a large class probably, we come to those which have several broods in the limits of the hot weather and rains and which have one longer brood, with a long inactive period in the colder weather. The active periods in these cases are the same, but one brood must pass through the long inactive period.

We come finally to normally very short-lived insects such as many Diptera, in which the egg, the larval, the pupal and the imaginal life are contained within perhaps 14 days, the actually known shortest being about 7 days. For these insects life may be long, but given the optimum temperature, plentiful food, abundant flies hatching out together, and a suitable food-supply for the young, on which the parent may lay eggs, the period is reduced to the least possible, the egg hatches quickly, the larva quickly lays up food, the transformation is quickly accomplished and the flies quickly find mates. It will serve no useful purpose to attempt to summarise more closely than above, but we may indicate briefly the characteristics in this respect of some of the larger groups, with regard to Indian insects primarily, but where our knowledge fails, to the group as a whole. The known Cicadas are the longest, the known Drosophilides, Culicides and some other Diptera the shortest. Blattids appear to be long, four years or less for some species. *Mantidæ* are probably at most two-brooded in the year, many probably one-brooded. The same is probably true of Phasmids; Acridiids require one year, or have two, three or four broods yearly, probably more only in rare cases (such as *Chrotogonus* and *Atractomorpha*). *Locustidæ* are probably one-brooded in most cases and nothing is known of Gryllids, though there is reason to believe that some are many brooded, most one-brooded.

Most of the known aquatic Neuroptera seem to be two or more brooded, imagos appearing several times in the year and the period in *Ephemeridæ*, for instance, is probably normally short enough to give several broods yearly. The larger *Neuroptera Planipennia* are apparently one-brooded, but the predaceous *Hemerobiides* and *Chrysopides* are many brooded. Predaceous land Neuroptera, like many other predaceous forms, seem to have the power of enduring long fasts and the life-history may be much prolonged accordingly.

Tenthrediuidæ are many brooded so far as known, and the period for many parasitic Hymenoptera is very short, shorter than that of their hosts in many instances. Aculeata have short lives, several broods usually being produced in a year, and here we have an instance where the completion of sexual functions does not bring death, since workers have none; their life is however not long, the worker being exhausted within a comparatively short time (in the bee six weeks). A large number of *Coleoptera* require a year for complete life and many emerge as imagines only at one season yearly. This does not apply to *Coccinellidæ*, to some *Buprestidæ*, to household and grain beetles, to some *Chrysomelidæ* and *Curculionidæ* (e.g., *Apoderus*, *Hypera*, *Cionus*). On the other hand, many *Carabidæ*, *Cicindelidæ*, *Scarabæidæ*, the larger *Elateridæ* and *Buprestidæ*, *Cantharidæ* and many *Curculionidæ* have a period of at least of one year; while some *Cerambycidæ*, the large forms of *Lucanidæ* and *Scarabæidæ*, probably require more than one year. In *Lepidoptera* we have some which require but a month, and complete six to eight broods yearly, and those which require a year and emerge once only; but the majority have at least two and many, more than two broods. Our ignorance of *Diptera* is profound, but the order certainly includes some of the shortest lived and probably few really long-lived ones. Perhaps Diptera are summed up best by saying that the majority have short lives if food is plentiful but long ones if it is not, and some species normally have long lives (special parasites, such as *Bombyliids*, *Conopids*).

Few Hemiptera have been reared, and we must fall back on what is known of the periods at which the imagines appear. A few *Pentatomidæ* appear to breed often in a year, whilst some are probably two-brooded, a rains and a dry weather brood; some are probably only one-brooded. The same is probably true of *Coreidæ*. *Lygæidæ* and *Pyrhocoridæ* appear to include more species which breed several times, as do the *Tingidæ*. *Reduviidae* are probably few brooded, as well as *Capsidæ*, but the latter in some known cases breed quickly.

Cicadidæ possibly all require at least one year, while some are very long-lived, and it is quite possible that our Indian species follow the examples of the known long-lived ones. The smaller Homoptera (*Fulgoridæ*, *Membracidæ*, *Cercopidæ*) are probably two or more brooded, but it is doubtful if any have more than four broods yearly owing to the lack of food. *Aphidæ* are comparatively short lived with plenty of food, but as they are viviparous, an aphis may often live to be surrounded by several generations of children, grandchildren, and so on. Given good circumstances the number of broods in a year may be very large, without the life of the insect itself being naturally very short. *Aleurodidæ* and *Coccidæ* are, for so small insects, apparently long-lived, but they appear on the whole to have several broods a year, while some are only one-brooded.

The student will recognise that so brief a summary is of little value save as a suggestion and as an indication of the scope of the relative life. Further details are given under each family.

There are two methods of finding the length of life of insects, one the actual rearing or observation of the living insect in all stages, the other the knowledge of the seasons at which the imago appears and the length of its life; an insect that appears but once yearly may have a yearly period or one in multiples of years, but cannot have a less period than a year. The duration of life in the long-lived American Cicadas was deduced from the years in which the imagines appeared abundantly, a matter of such importance that records extending back many years gave the necessary information.

Sialidæ.

Wings of nearly equal size, hind wings not folded (cf. Perlidæ), at an angle over the abdomen when in repose. Antennæ long. The wings are not closely reticulate (cf. Hemerobiidæ). Tarsi five-jointed. Larva aquatic, with a quiescent pupa.

A small group of moderate-sized insects, distinguished by the wings and five-jointed tarsi from the *Perlidæ* which most resemble them.

There are two sub-families, *Sialinæ* with quadrangular prothorax and *Raphidiinæ* with elongate prothorax.

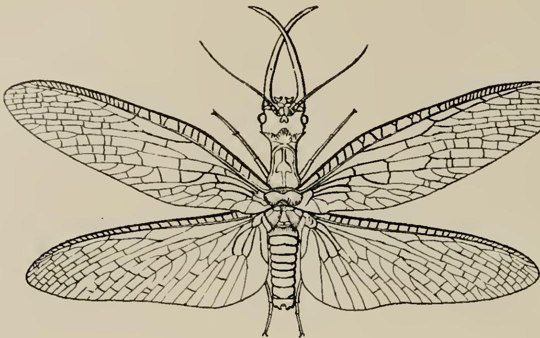


Fig. 62.—Corydalis asiatica.
(*From Wood-Mason.*)

Of the former the larvæ of the known species are aquatic, hatching from eggs laid near the water; the larva has biting mouthparts, a conspicuous head, long legs and the abdomen has a jointed gill-process on the side of each segment. They are probably predaceous and live for choice in mud. Only a small number of species are known. *Corydalis*, the very large Sialid, common in America, is recorded by Wood-Mason in India, *Corydalis asiatica*, W. M. (fig. 62), being found in the Naga Hills. (Proc. Zool. Soc., 1884, p. 110.) *Chauliodes subfasciatus* Westw. is figured in Cabinet of Oriental Entomology; *C. maculipennis* Gr. (Griffiths' Animal Kingdom, pl. 72, fig. 1) is also known from India. Three other species of *Chauliodes* are described by MacLachlan, Weele and Walker, and 8 species of *Neuromus* by MacLachlan, Weele, Walker and Rambur, all from the Himalayas or Assam.

Fig. 63.—Chauliodes maculipennis.
(*After Cuvier.*)

Of the *Raphidiinæ*, none are known in India.

PANORPIDÆ.—*Scorpion Flies.*

Head prolonged into a distinct beak with biting mouthparts. Two pairs of wings of equal size held at an angle (or wingless.) The male with the apex of the abdomen turned up, the apical joint swollen, as in a scorpion. Tarsi five-jointed.

These singular insects are at once recognizable from the peculiar head. They are of moderate size, found flying in wooded places, and easily distinguishable. The antennæ are long; the wings moderately large and held out from the body. The abdomen is long, in the male turned up as in a scorpion's tail, in the female straight and tapering.

Fig. 64.—PANORPA FURCATA. (*After Hardwicke.*)

The common Indian species are apparently similar to the European form, whose life history is known; the eggs are laid in a mass in the ground; from them hatch larvæ in the form of caterpillars, which feed upon decaying vegetable matter usually underground; the larvæ have

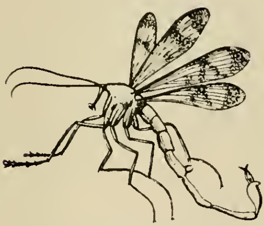


Fig. 65.—PANORPA FURCATA. (*After Hardwicke.*)

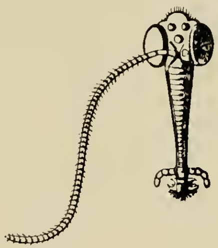


Fig. 66.—PANORPA FURCATA: HEAD. (*After Hardwicke.*)

imperfect suckerfeet as well as jointed legs and there are velvety spots or spines on the segments. Pupation takes place in the soil. The imagines of both the observed Indian species are predaceous and very active:

they haunt shady places among bushes and under trees and attack comparatively large insects. These insects are uncommon and little is recorded about them. A pretty species marked with blue is common on the Western Ghauts in the rains, and a brown species is found in the Khasi Hills. Hardwicke describes a species from Nepal, figures of which are reproduced here. (Trans. Linn. Soc., XLV, p. 132.) It is common in the E. Himalayas, and has a resemblance to a large Ichneumonid. *Bittacus latipennis* Gerst. is described from Darjeeling (M. T. Vorpomn. XVI, p. 20, 1885). Probably others will be found when the family comes to be observed, and it will be possible to see how far their life history agrees with that outlined above.

HEMEROBIIDÆ.

Wings nearly equal in size, many-veined and held at an angle over the abdomen. The hind wing not folded. Antennæ well developed. Tarsi five-jointed. Larva with suctorial mandibles, pupa in a cocoon of silk.

This is a miscellaneous assemblage of easily recognised insects, united by the life history and larval trophi. The adults differ greatly in appearance, but form a distinct family. It is possible that the family will be confused with the *Sialidæ*, unless the student is familiar with the latter. The essential differentiating character is that in *Sialidæ* the wings are not densely reticulate, whereas they are so in *Hemerobiidæ* (except *Coniopteryx*).

As a rule, the different forms of *Hemerobiidæ* are so distinct that they can be recognised at sight, but the above is apparently the only true structural distinctive character in the imago.

As the habits of the seven sub-families are distinct, we propose to discuss each in turn.

Myrmeleoninæ.	Short knobbed antennæ.
Ascalaphinæ.	Long ,, ,,
Nemopterinæ.	Hind wings almost linear.
Mantispinæ.	Forelegs raptorial.
Hemerobiinæ.	Antennæ moniliform.
Chrysopinæ.	,, setaceous.
Coniopteryginæ.	Minute. Wings powdery.

Myrmeleoninæ. Ant-lions. Recognisable by the short clubbed antennæ; the wings are usually large and of equal size, often very much marked with brown and black.

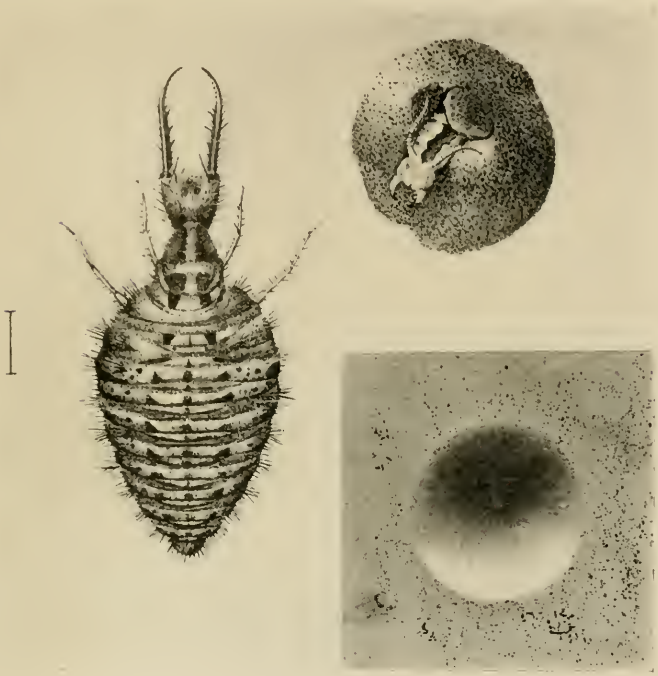


Fig. 67.—Myrmeleonid; larva, × 12; empty pupa case projecting from cocoon after emergence, × 12. Pit of the larva, × 1.

These large and somewhat ungainly insects have a wing span of three inches in the larger forms, the smaller of half that length. The colouring is sombre, brown predominating. The head is large and distinct with large compound eyes. The mouthparts are biting with long palps. The thorax is robust, often very hairy. The wings are long, of nearly equal size, with a great number of veins. The larger species have large red-brown or black blotches on the wings, the smaller have hyaline immaculate wings. The abdomen is long and slender, stretching between the long wings which are held in a sloping manner over the abdomen. The legs are comparatively short, robust and spiny, enabling the insect to cling tightly to plants. Males and females are similar in appearance, as a rule, the male sometimes distinct by the possession of two cerci.

The life history of the known species is uniform throughout the group. The eggs are laid in sand or earth; the larva that issues is flattened, the head large and flat, the thorax and abdomen stout. The head is elastically attached to the prothorax and has a large degree of motion. Projecting in front of the head are immense jaws, long and curved, which are made up of the true mandibles and maxillæ combined. The slender maxilla lies in a groove of the lower side of the mandible, and the two together form an imperfect tube, liquid ascending between the two structures into the mouth. This is an adaptation which enables the insect to suck the blood of its victims and food is taken in no other way. The larvæ live a free wandering life or live in pits in sand. The free-living ones lurk among vegetation and capture small running insects. They are a portion of the surface living insects which are so abundant in dense vegetation. Some species are common in damp localities, the imago found in long grass, the larvæ living a free life in the grass and

Fig. 68.—Myrmeleo singulare.

capturing insects. The most familiar species live in pits in sand; the larva prepares these pits in a very ingenious manner. It commences by going round in a circle, moving backwards, its body making a furrow in the soil; with its broad head it throws out sand, and by working steadily round in a spiral it gradually excavates a round pit, with sloping sides, and buries itself at the bottom. It then lies there motionless, its head at the bottom of the pit; should an unwary insect walk over the edge of the pit, the sloping sides impede its exit and the ant-lion throws sand at it by jerking its broad head. Sooner or later the insect comes within reach of the jaws and is seized, sucked out and the dried shell thrown out. Ants form a large part of its diet, as they are incessantly running over the soil, and the pits are apparently adapted to catch them; larger insects escape readily. This life is an interesting one and food appears to come only at long intervals. One might hold up this insect as a type of patience; they are able to endure long fasts and an occasional ant every week or so is apparently sufficient to keep captive specimens alive. They live only in dry sand and make new pits if occasion arises. Near houses these pits are common, and when rain comes, or when the rainy season sets in, the new pits are made under the lee of the house where rain will not wet the sand.

When the Pusa Laboratory was in course of erection, there were numerous pits in the dry sand spread over the newly floored verandahs; the reason they were there was apparently that the sand was dry, all the outside earth being soaked with the rains, but what food these insects got was not apparent as no insects were found there.

Pupation takes place in a cocoon in the sand or soil near the pit; the pupa has mandibles with which it can cut through the cocoon which consists of silk and particles of sand. It is noticeable that this silk is produced from the apex of the abdomen. The length of the life history is not known; imagos are found at all times from March to November. The imago flies clumsily but swiftly, and though nocturnal, is frequently seen flying in the day in long grass. An unpleasant odour is diffused from their bodies when they are handled, not an aromatic odour as in the *Hemiptera* but an unpleasant one, suggesting carrion. Light is an attraction and many can be caught in houses and at light. A number of species occur in India, but the usual darkness seems to shroud their nomenclature and classification. Two species of *Palpares*, seven of *Myrmeleo* and one of *Formicaleo* have been described from India by Rambur (1842) and Gerstacker (1893 and 1884). *Myrmeleon singulare*, Westw. is one of the commoner species, a very noticeable insect, figured and described in 1847 (Cab. Or. Ent., pl. XXIV, fig. 4). *M. pardalis* F. and *M. Punctatus* F. from the East Indies are figured in Donovan's Insects of India.

Ascalaphinæ—Differ from Myrmeleoninæ in having long antennæ, also clubbed.

Fig. 69.—HELICOMITUS DICAX.

This small family is at once recognisable in the winged stage. The insects are of the same general structure as the *Myrmeleoninæ*, but with long antennæ held straight out from the head, clubbed at the tip. The wings are less elongated and only with few markings. The eyes are usually divided across by a distinct line as if the upper and lower halves functioned separately.

The life history differs in detail only from that of the *Myrmeleoninæ* so far as is known. The eggs were found laid on a lucerne stem, a number of little eggs in a row; each egg is cylindrical and truncate at the ends. Small active larvæ emerged, whose appearance is best learnt from the figure. They were fed on aphides, the aphides being seized in the sharp mandibles and sucked out. These larvæ died as the right food or conditions had not been found. (Others are being reared on a greater variety of insects). Other similar larvæ are found leading a free life in the fields; the thorax is broadly joined to the abdomen, the head not movably jointed to the thorax as in the ant-lions. A larva was found on the bark of a tree; it remained motionless on the bark without food for two months and all endeavours to feed it or rear it failed. An investigation into the habits of these larvæ in the field would yield interesting results, and it is possible that they play an important part in checking some insects. The imagines are found flying under trees or in grass and are apparently principally crepuscular in habit.

Westwood describes the following species of Ascalaphus (Cat. Or. Entom., 1847), and figures the first three :—

A. tessellatus (pl. XXXIV, fig. 1), *A. segmentator* (pl. XXXIV, fig. 2), *A. canifrons* (pl. XXXIV, fig. 3), *A. dentifer*, *A. angulatus*, *A. obscurus*.

No species had been previously described from India and ten have been since added. (Weele in Selys Collection, 1908).

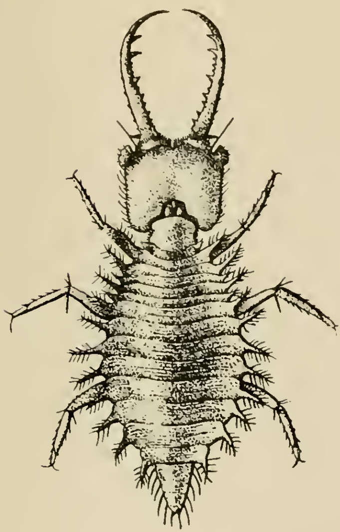


Fig. 70.—Ascalaphid larva. × 18.

Fig. 71.—Eggs of ascalaphid. × 2

Nemopterinæ.—The hind wings are long and very narrow, projecting backwards beyond the body.

A single species of this remarkable group is found abundantly in houses in India, flying about rooms in the dusk (fig. 72). We have

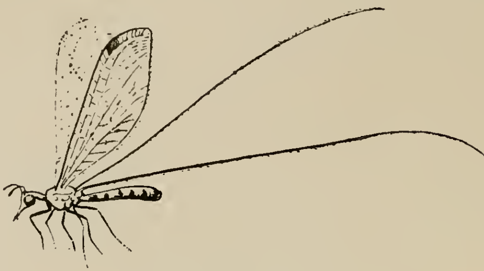


Fig. 72.—NEMOPTERID, × 3.

observed it three years in succession in April and at no other time. The insect is a very graceful one, flying with a weak fluttering motion and hovering socially much as the mosquitoes do. A single larva of the type described as Nemopterous was found in a house in India; the characteristic is the immensely long thin neck carrying the round head and formidable jaws (fig. 73).

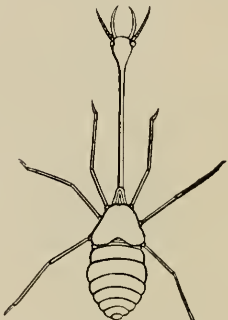


Fig. 73.—NEMOPTERID LARVA. (*After Roux.*)

There is little reason to doubt that the larva of this Nemopterid lives in our houses and is probably predaceous on small forms of life ; careful search in odd corners and dusty places will probably reveal the larva and clear up the life history of this insect. *Nemoptera filipennis*, Westw. is described and figured (Cab. Or. Entom., pl. XXXIV, fig. 6) from Central India.

Mantispinæ.—Forelegs predaceous after the manner of a Mantis. These obscure insects appear to be found but seldom in India, one species being known to occur in the plains. The imago has two pairs of hyaline wings, a rather slender body and the posterior legs fitted for walking. The forelegs have the tibia bent back upon the femur as in the *Mantidæ*.

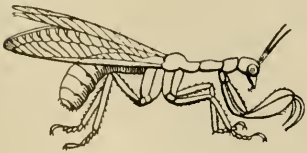


Fig. 74.—MANTISPA. × 2.

Nothing is known of the life history of our species; Brauer records that one European species lays stalked eggs, as do the *Hemerobiidæ*, and that the larva finds its way to the egg-mass of a spider and there feeds on the eggs and young spiders; it pupates in the web that contained the spider's eggs, and the pupa, when ready to transform, pierces its cocoon and the spider's web, the imago then emerging. *Glenurus pupillatus* Navas., *Mantispa rugicollis* Navas., and *M. Hamiltonella*, Westw. have been described from India, as also has *M. nodosa*, Westw. which occurs in Assam and is figured by Westwood (Cab. Or. Entom., pl. XX IV, fig. 7).

Hemerobiinæ.—The antennæ moniliform.

This sub-family includes two types of insects, of which some of each are known in India. The *Sisyrini* live as larvæ in freshwater sponges, and Annandale has recorded one as having been found in this situation in Calcutta. The student should consult Sharp's volume, where there is a good figure of the larva. *Osmylus perspicillaris*. Gerst., *O. langii* Macl., *O. lineaticollis* Macl., and *Dilar Hornei* Macl., are Indian species. The *Hemerobiini* are represented by one delicate brownish insect whose larva feeds on the cotton aphis. The life history differs only in detail from that of *Chrysopa* in the next sub-family; the eggs are laid on stalks; the larva is naked and feeds voraciously on aphides, sucking them out with its long mandibles. In this species pupation takes place under a very delicate web on a leaf. This insect is less common than its ally, the

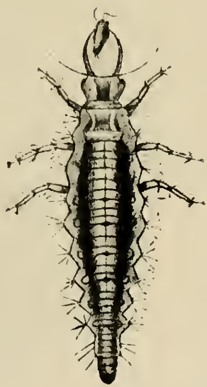


Fig. 75.—HEMEROBINS LARVA.

green Chrysopa, but may be found in cotton fields generally in the plains.

Chrysopinæ.—The antennæ filiform. One species of this group is common throughout the plains, a delicate green insect with shining

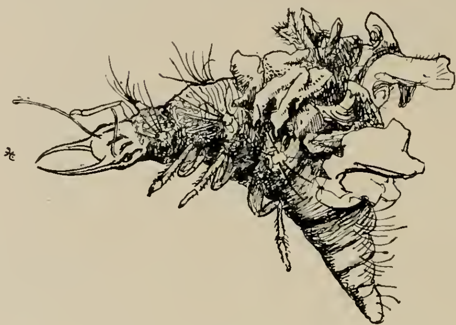


Fig. 76.—CHRYSOPA LARVA, WITH ITS COVERING OF SKINS. (F. M. H.).

eyes which diffuses an unpleasant odour on being handled. Here and there about the fields one sees little clusters of white eggs, each egg on a separate long slender stalk. (A Himalayan species lays the eggs so close together that the individual stalks coalesce and one finds a little bunch of eggs on a compound stalk). The clusters are everywhere,

Fig. 77.—EGGS OF CHRYSOPA.

on weeds, on the cotton plant, on the ground, and if one watches carefully in the dusk, one may see a long green fly laying them some fifteen to twenty in a little cluster. In a few days (a little over a week), these eggs hatch, the thin shell bursting at the tip to allow the little creature to emerge ; it sits on the egg shell on the top of the stalk till it has recovered from its cramped position in the egg and then runs off looking for aphis. It is a very active creature, with long legs, a slender body set with spines and a pair of long curved mandibles on the

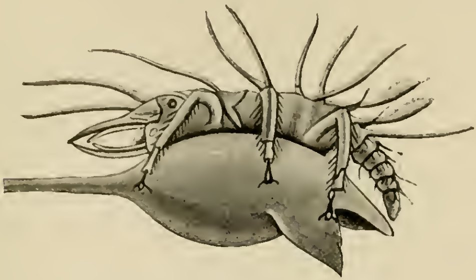


Fig. 78.—Egg and larva of chrysopa.

head. It is most voracious, catching the aphides in its hollow mandibles and sucking out the juice of their body. Having emptied the skin, it puts it on its back, where the long spines hold it, and eats the next aphis. This process continues indefinitely throughout the larval life of the little creature ; it moves about with a large heap of the skins of its victims on its back, and it is no easy matter to make out what one has got hold of when one sees this extraordinary mass running over the cotton plant. At the periodical moult it gets rid of the accumulation of skins, which by no means includes those of all its victims and starts a fresh covering. Their voraciousness is very great and in captivity the single larva required on an average some 160 aphides for one day's food. This is

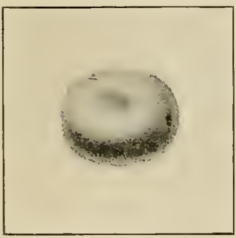


Fig. 79.—Cocoon of chrysopa.

probably not more than they eat when living freely on the plant; they feed very rapidly and voraciously and we can quite believe the number of victims in a day to be much larger. Finally, after eight days' feeding, its voraciousness is satisfied and it settles down in a quiet place to spin its cocoon and turn into the chrysalis. This is done on the plant and the chrysalis remains in it for about one month. The cocoon is a tough, white oval structure, built of silk, and when the fly is ready to come out, the top comes off as a neat little lid; there is probably a line of weakness in the cocoon when originally made, so that the top will come off neatly and allow the fly to emerge. The fly is a familiar insect with green head and body, bright golden eyes and long ungainly wings, which look much too big for it. One sees them flying about in the dusk or in the day time if disturbed, and like many other insects, the attraction of a lamp is usually too much for them. No Indian species appear to have been recorded.

Fig. 80.—CHRYSOPA. × 2.

Coniopteryginæ.—Small delicate insects, in which the wings are covered with a white powdery secretion.

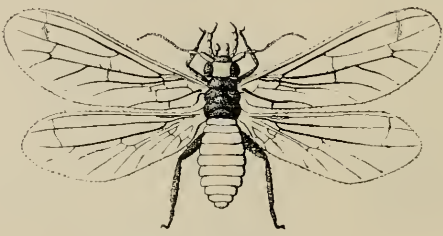


Fig. 81.—SPILOCORIS GUTTATA.
(*From Enderlein.*)

These delicate insects are just known to occur in India, a few individuals having been captured flying and on a bair tree in Surat and among pine and deodar in Simla. An account of what is known of the life history will be found in Sharp's insects. They will be confused with *Aleurodidæ* if not carefully examined; the mouthparts are well developed with prominent palpi; the wing venation is comparatively complex and the tarsi five-jointed. The wings are white, the body red in one species.

Enderlein has listed the family (Genera Insectorum, 1908); no Indian species are recorded. He states that the larvæ, after feeding on Coccids, spin a web by means of anal spinnerets and rest under it till spring, when they pupate and emerge.

Collecting.—Special methods of collecting are not required in this family, but great care must be taken to preserve the specimens from damp as in all groups of Neuroptera. Myrmeleonides and Ascalaphides are on the wing once a year and come to lights. Nemopterids come out in houses at dusk and dance; the remainder must be sought for in their haunts. Any killing bottle is good, so long as it is quite dry. Good series of all species are required, and in this group there is very much biological work to be done before we can fully estimate the value of this family.

TRICHOPTERA.—*Caddis flies.*

Wings hairy, the hind wing larger, with a folded anal area. Coxæ long and contiguous. Antennæ long, tarsi five-jointed.

The family can be distinguished by the above characters with some doubt, since the hairiness of the wings is not always noticeable. They

FIG. 82.—MACRONEMA FASTUOSUM WLK.
(*From Ulmer.*)

are rather delicate insects, moth-like in appearance, but with the wings sloped over the abdomen when at rest. The antennæ are long. We are aware of no observations on these insects in India, other than the descriptions of species. Their biology appears to be untouched. In general, the larvæ live in fresh water in cases, made of a great variety of materials, including silk, stones, vegetable matter, shells of molluscs, etc.; each species makes its special form of case, in which the larva lives. The larva is somewhat caterpillar-like, with a terminal pair of processes or hooks to fasten it to the case, with blood-gills of a variety of kinds to secure respiration. They are believed to be vegetarian, and while one at least is injurious to the "water-cress" grown in Europe, none are known to be injurious to India.

The student of this group should read the chapter in Sharp's Insects and the account in Miall's Aquatic Insects; it is to be hoped that the family will be investigated in India; the number of plain's species appears to be small, but very little is known and the group has not been studied. Wood-Mason recorded a species which produced 460 living young ones when artificially stimulated. Apparently this is the normal habit of this Caddisfly, which is provisionally named by him *Notanatolica vivipara* (Ann. Mag. Nat. Hist., 1890, 6 ser., Vol. VI, p. 189). Morton describes a *Hydroptilid* from the Khasis as *Ithytrichia violacea*, remarking that it is the largest of the sub-family with an expanse of 12-14 m.m. (E. M. M. 1902, p. 283). He also describes Khasi Rhyacophilids in Trans. Ent. Soc. London, 1900, p. 1. In all, some 61 species are recorded from India, Burma and Ceylon, the majority from the last locality, most of the remainder from the hills.

Fig. 83.—CADDIS LARVA, IN CASE. × 25. FROM BALSAM SLIDE.

The following are recorded from India by Ulmer (Zeitschr. Wiss. Insectenbiol. 1905, pp. 16, 68, 119, and Genera Insectorum, Trichoptera, 1907).

1. Phryganeidæ	1. *Neuronia maclachlani*, Wh. (India).
2. (Limnophilidæ).	
3. Sericostomatidæ	2. *Dinarthrodes armata*, Ulm. (Assam).
	3. *Dinarthrorum ferox*, Macl. (North India).
	4. *Dinarthrella destructor*, Ulm. (Darjeeling).
4. Leptoceridæ	5. *Notanatolica magna*, Wlk. (India, etc.).
	6. *Notanatolica vivipara*, W. M. (Calcutta).
	7. *Leptocerus indicus*, Wlk. (Bengal, its systematic position doubtful).
	8. *Setodes argentifera*, Macl. (North-Western India).
5. Hydropsychidæ	9. *Polymorphanismus nigricornis*, Wlk. (North India).
	10. *Aethaloptera sexpunctata*, Kol. (India).
	11. *Hydropsyche asiatica*, Ulm. (Sikkim).
	12. *Hydropsyche luctuosus*, Ulm. (Sikkim).
6. Polycentropidæ	13. *Plectronemia aurea*, Ulm. (Sikkim).
	14. *Plectronemia navasi*, Ulm. (Sikkim).
7. Philopotamidæ	15. *Dipseudopsis indica*, Macl. (India).
	16. *Stenopsyche griseipennis*, Macl. (India, etc.).
8. Rhyacophilidæ	17. *Rhyacophila anatina*, Mort. (Khasis).
	18. *Rhyacophila curvata*, Mort. (Khasis).
	19. *Rhyacophila inconspicua*, Mort. (Khasis).
	20. *Rhyacophila lanceolata*, Mort. (Khasis).
	21. *Rhyacophila scissa*, Mort. (Khasis).
	22. *Rhyacophila tecta*, Mort. (Khasis).
	23. *Rhyacophila naviculata*, Mort. (Trichinopoly).
9. Hydroptilidæ	24. *Ithytrichia violacea*, Mort. (Khasis).
	25. *Melanotrichia singularis*, Ulm. (India).

The *Trichoptera* are characteristic of moist temperate areas rather than of the moist or dry tropical areas and the student will scarcely find any species without search. None the less, it is probable that in the moister parts of India many remain to be found and this is true also of the hills. More species are recorded from Ceylon than from all India including the hills, and this is due partly to better collecting and to more attention having been paid to these insects there.

Note.—Since the above was in type, the Ascolaphid larvæ figured have been successfully kept alive and have passed through several instars; they are fed on small sluggish insects such as caterpillars, aphides and immature membracids; they are inactive by day resting pressed tightly on stones or earth, usually covered with particles of soil held by their spines.

The common hemopterid, which was obtained as usual in April, laid eggs in captivity, small oval bluish eggs, laid singly and concealed by adhering dust. They hatched to small white larvæ of the form shown in figure 73, but without the long neck which apparently develops in later instars. They cover themselves with dust and, in the absence of other food, prey upon each other. There can be no doubt that the larvæ occur in houses and other buildings and there is additional evidence that they are predaceous, probably upon Psocids (*atropos*) and other small forms of insect life, their long necks probably assisting them to obtain their prey in cracks and chinks.

HYMENOPTERA.

Two pairs of wings of almost equal size, hyaline and with few veins. The antennæ simple, straight or elbowed. The mouthparts mandibulate, the labium and maxillæ formed in some cases into a lapping tongue. The thorax complex, the parts accurately co-adapted to form a rigid whole. An extrusible ovipositor is present. Metamorphosis complex, the larva freeliving or, more usually, dependent for food on a host or on the parent and in this case a white apodous grub. In both the latter the imaginal life is the active period, usually of long duration The order includes herbivorous insects, feeding in or on plants, parasites in insects, stinging predators feeding their young on paralysed insects and spiders, and social or solitary insects deriving their food from flowers, from waste matter (scavengers) or from living insects.

The sawflies, gallflies, ichneumons, cuckoo-wasps, bees, ants and wasps which make up this order are readily recognised in the field: the order is a very large one, with a great number of known species, and perhaps a greater number of undescribed species than any order except Diptera. It includes insects of the very highest importance to agriculture, and some of great economic value but few that are destructive to crops or merchandise.

The classification of this large order is simple, and though authors do not agree as to the details, the broad lines are generally accepted. Ashmead has revised the whole classification and introduced a new nomenclature, but, while this is accepted in America, it is not that accepted in Europe and differs from that still adhered to in England. We must here follow the Fauna of India. The order is divided into *Sessiliventres*, with the abdomen broadly attached to the thorax, and *Petiolata* with the abdomen connected to the thorax by a petiole. The *Sessiliventres* include only three families of phytophagous insects, which are borers in plants or feed on leaves. The *Petiolata* includes the remaining 24 families, which fall into three series :—The *Parasitica*, with divided trochanter and extruded ovipositor, the *Tubulifera* and *Aculeata* with retrusible ovipositor and single trochanter, the former with three to five visible ventral segments and an ovipositor, the latter with the abdomen of more than five visible ventral segments and a sting.

The *Aculeata* again fall into four series, the *Anthophila* with plumose hairs and dilated hind tarsi, the *Diploptera* with forewing longitudinally folded in repose, the *Heterogyna* with the basal one or two segments formed into nodes, and the *Fossores* without any of these characters. The classification of the order falls as in the following table :—

SESSILIVENTRES.			(Cephidæ).
(PHYTOPHAGA).			Siricidæ.
			Tenthredinidæ.
PETIOLATA.	PARASITICA.		Cynipidæ.
			Proctotrypidæ.
			Chalcidæ.
			Dryinidæ.
			Ichneumonidæ.
			Braconidæ.
			Stephanidæ.
			(Megalyridæ).
			Evaniidæ.
			(Pelecinidæ).
			Trigonalidæ.
	TUBULIFERA.		Chrysidæ.
	ACULEATA	FOSSORES.	Mutillidæ.
			Thynnidæ.
			Scoliidæ.
			(Sapygidæ).
			Pompilidæ.
			Sphegidæ.
		DIPLOPTERA.	Eumenidæ.
			Vespidæ.
			(Masaridæ).
		ANTHOPHILA.	Colletidæ.
			Apidæ.
		HETEROGYNA.	Formicidæ.

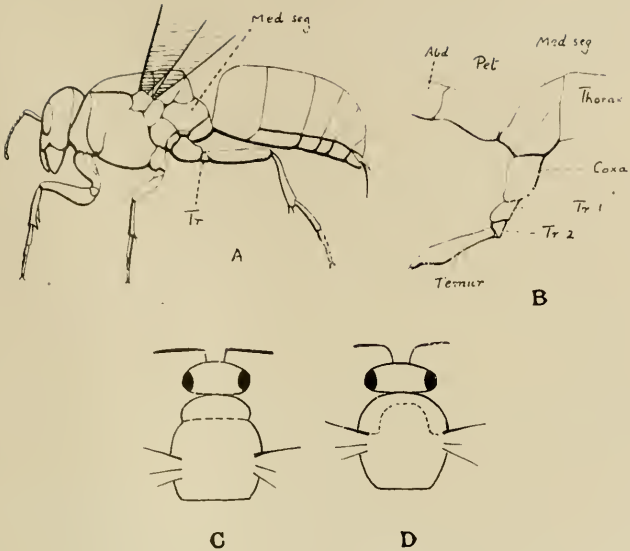


Fig. 84—A. VESPA MAGNIFICA, TO SHOW MEDIAN SEGMENT AND SINGLE TROCHANTER (TR). B. BRACONID TO SHOW JUNCTION OF THORAX AND ABDOMEN. PET.-PETIOLE, MED. SEG-MEDIAN SEGMENT. TR. 1, TR. 2, THE DOUBLE TROCHANTER. C. THORAX OF SPHEGID TO SHOW COLLAR-LIKE PROTHORAX. D. DITTO. OF POMPILID TO SHOW PROTHORAX REACHING THE TEGULÆ.

There is a very extensive literature on this group. The *Sessiliventres* and *Parasitica* have been largely listed in Genera Insectorum and the *Ichneumonidæ* and *Braconidæ* are being monographed in the Fauna of India shortly. The *Tubulifera* and *Aculeata* are already monographed in the Fauna of India but the student will find a large number of species since described by Cameron, Nurse and others.

It is at present useless to attempt to grapple with the *Parasitica*, and our account below must, in the absence of the Fauna volume, be meagre in the extreme. Collections in this group are badly wanted and there is here a very large field for collecting and research, specially in tropical India. In the *Aculeata*, the pioneer work of listing and describing species is largely done, though new species still appear, and the next step is to study the habits and life-histories. The student will note that we follow the order and nomenclature of Bingham's Fauna of India, rather than that of continental authors as is done by Nurse and Cameron, and as may be most easily seen in Genera Insectorum.

HYMENOPTERA SESSILIVENTRES

SIRICIDÆ.—(including *Oryssidæ*).

A small family distinct from other families by the characters of the thorax and venation, as well as by the larval habits. The larvæ are borers in wood, and have three pairs of stumpy legs on the thorax, a process at the end of the abdomen. The imagines are conspicuous insects, large and brightly coloured, the female with sharp ovipositor. They are wholly forest insects and confined in India to hilly forest tracts. The recorded Indian species include *Xiphydria* (3 spp.), *Sirex* (1 sp.), *Paururus* (1 sp.), and *Tremex* (3 spp.). None are likely to be found in tropical India.

TENTHREDINIDÆ.—*Sawflies.*

The pronotum small; two spurs to the tibia. The female with a saw, usually concealed. The larva leaf-eating, caterpillar-like, with more than five pairs of sucker feet.

The sawflies are easily recognizable from other *Hymenoptera*, the abdomen being broadly united with the thorax, the pronotum small and visible principally at the sides, the female without an exserted ovipositor and the anterior tarsi with two spurs. They are moderate-sized insects, of bright colours, the common plains species less than one-third of an inch long. The head is distinct, with short antennæ, simple and compound eyes and the usual biting mouthparts. The thorax and abdomen are robust, the wings short and often smoky or coloured. The most striking structure is the female ovipositor or "saw," with which she cuts leaves in which to lay her eggs. This is concealed except when in use and requires to be dissected out.

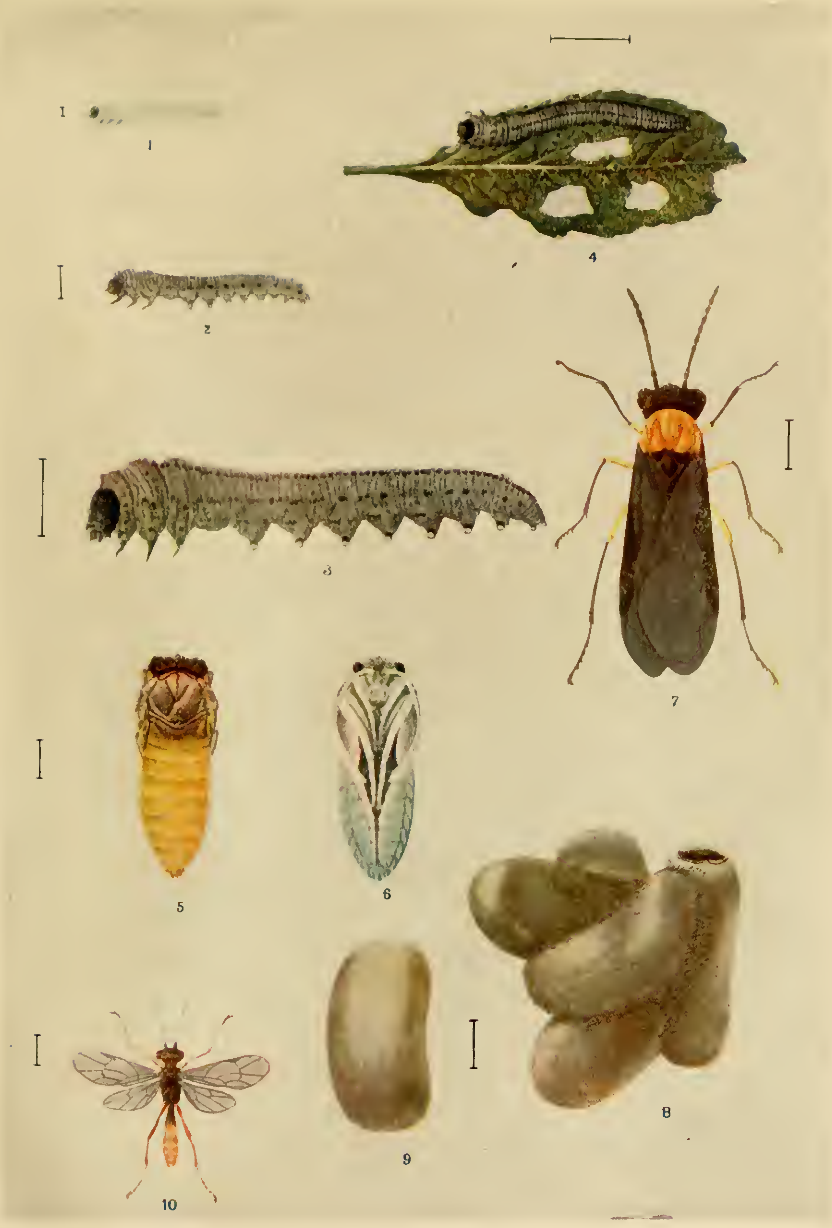
The life-history is, in general features, similar to that of the *Lepidoptera*. The larva is a caterpillar-like creature with three pairs of thoracic legs and from six to eight pairs of prolegs without hooks on the

PLATE IX.—Athalia Proxima.

The Mustard Sawfly.

Fig. 1. Young larva.
,, 2. Half-grown larva.
,, 3. Full-grown larva.
,, 4. Larva feeding on mustard leaf.
,, 5. Pupa, dorsal aspect.
,, 6. Pupa, ventral aspect.
,, 7. Imago.
,, 8. Cluster of Cocoons.
,, 9. Single Cocoon.
,, 10. Parasite.

(Reprinted from Memoirs, Agricultural Department for India, Entomology, Vol. I, No. 6.)



MUSTARD SAWFLY.

abdominal segments. This character at once distinguishes it as no *Lepidopterous* larva has more than five pairs of prolegs. The larva lives openly, feeding on leaves; in some the hind end of the abdomen is more flexible and tapering, and is twisted round in a characteristic manner to give support to the insect. The larva of *Athalia proxima*, Klug., the commonest plains species, feeds on mustard and Cruciferæ generally; its life-history is described elsewhere (Mem. Agric. Dept., India, Entom. I, No. 6). It is undoubtedly an immigrant from the hills which has adapted itself to life in tropical India by a prolonged period of rest during the hot months. The pupa is concealed in a cocoon between leaves or in the ground. It is recorded that *parthenogenesis* occurs in this family; this does not appear to be the case with *A. proxima*, where both sexes occur and coupling takes place normally.

The family is a large one with over 2,400 species described of which 90 are known from India, being mainly species collected in Assam, Burma and Simla. The hill fauna is very much larger than that of the plains but the large number described is partly due to the fact that this group has been collected there and has not been worked at in the plains. Cameron has described the majority of the species within the last ten years. Only two species are known from the plains of which *Athalia proxima*, Klug., alone has been reared. (Plate IX.) The most recent catalogue is th it of Konow in *Genera Insectorum*.

HYMENOPTERA PARASITICA.

From practically every herbivorous insect, as from many others, we rear parasites belonging to this group. From a single species we may get one or more egg parasites, and one or more larval parasites; we find also that these parasites have their parasites (called *hyperparasites* as they are parasites on parasites). Thus from one species we may rear several species of parasitic hymenoptera. It will be seen that this group is one of vast extent and number: it is also one whose study has not attracted sufficient attention; Indian forms have been described (in a great variety of somewhat inaccessible publications) by Cameron and others from specimens collected in the hills; we have reared abundant species which will require much time for identification and we are thus in a position of having a great mass of material which has not been worked at and we cannot attempt to give any satisfactory account of this great group. In no branch of entomology is study so much required and no branch is likely to give results of greater economic value. Parasitic Hymenoptera are the greatest checks on insect increase and their work is of the utmost importance; this has been recognised elsewhere and the study of Parasitic Hymenoptera should advance when more encouragement is given to Entomology generally. As it is we are unable to do anything to assist these insects save in very special cases; when it was learnt that the parasites of the Indian bollworm had been destroyed by cold, and these were reintroduced from places not affected by the cold, the first step to the utilisation of parasitic insects was taken in India; but this was a special case and until we know our parasites, we cannot expect to be able to make progress in this branch of entomology.

CYNIPIDÆ.—*Gall-wasps.*

Small to minute insects, the forewing with no stigma and not more than five closed cells, the hindwing with two or three nervures; the antennæ are straight with less than 16 joints. The pronotum reaches the insertion of the forewings.

Whilst the habits of the family are of great interest, almost none are described from our region and the habits of these are unknown. One species (*Onychia striolata*, Cam.) from Bengal will, if it shares the habits of the rest of the genus, be a parasite on a *Dipterous* insect. Others are known to inhabit galls. Cameron has described *Callirhytis semicarpifoliæ* as being reared from an acorn (*Quercus semicarpifolia*) collected in the North-West Himalayas. (Entomologist, 1902, 38.)

In general, the *Cynipidæ* are either (1) inhabitants of galls or other portions of plant tissues, (2) guests of the above gall-inhabiting species or (3) parasites on other insects. Taking first the gall-insect, it may be remembered that many other insects make galls and that not every gall is due to the work of the *Cynipid*; also that a gall may contain the *Cynipid* that caused it or either guests or parasites. A number of very similar insects may therefore be reared from the same galls and it is no easy matter to sort them out. It is very much to be desired that the study of galls may be taken up in India, and with it, the study of the relations of the insects inhabiting such galls. Galls abound even in the plains and those on the mango tree alone will give ample scope for investigation. Having cleared them up, the study of galls on other trees in the plains and then in the forests and hills may be expected to produce much that is new and second in interest to no other branch of insect bionomics.

An excellent account of some of the features of this group is contained in Sharp's Insects. The student is referred to this, and it is needless to here reproduce a similar general account of a group of which almost nothing is known in India.

GALLS.

There are a number of insects, which live in the tissues of plants and whose activities produce an alteration of the structure of the plant, an unusual growth of tissue taking place, leading to the formation of a "gall." Such galls are easily recognisable as quite distinct bodies, associated always with a particular insect and for each species of inhabitant assuming a peculiar form.

Obviously this is a clearly distinct form of injury to the plant from that caused by an ordinary boring or leaf-eating insect, in which there is no growth of tissue except in so far as to heal the wound caused, and where the damage done is limited to the effect produced solely by the destruction of so much tissue.

As a rule, the connected insect is in the gall, not necessarily in the fully developed gall but in it at some stage of its growth; put very broadly, the parent or the actual insect stimulates the tissues to an abnormal growth in which the gall insect lives; the precise nature of this stimulus is not known for any of our galls but may be either poison or some agent introduced by the parent when laying eggs, or it may be a chemical or mechanical stimulus produced by the larval gall-insect inside the tissues. The growth of a gall does not always terminate with the emergence of the inhabiting insect and in some instances very large woody structures are produced on trees after the original gall-insect has emerged.

Elsewhere, the Cynipidæ are the especial gall-insects either inhabiting the gall by right or as inquilines (guests). The larvæ of *Nematus* are said to form galls and insects of this family (*Tenthredinidæ*), will possibly be found as gall inhabitants in India also. The Fig Insects of the family *Chalcidæ* are probably gall producers, living in special gall flowers in the fig. An abnormal *Buprestid* (Ethon) is known to live in a gall and some of the *Curculionidæ* also produce galls. Among *Lepidoptera*, a few *Tineidæ* are known, and the transition from a boring larva to one that causes gall-formations is not a very wide one. *Cecidomyiids* are well known among the *Diptera* and are found in India behaving in this manner. Thrips (*Thysanoptera*) causes galls, as also do the three groups of *Homoptera*, the *Psyllidæ*, *Aphidæ* and *Coccidæ*; *Psyllids* are known to live in galls in India but do not appear to have been studied. Several have been reared from galls on leaves in India and it would appear that they are the commonest gall-insects. In Australia, a special division of *Coccidæ* (*Brachyscelids*) are inhabitants of galls. In India *Dactylopius nipæ* Mask. produces what is practically a gall, a swelling and distortion of the tissues of the plant, due to the presence of the insect; these are found on some varieties of cotton, on Hibiscus and on mulberry. We have indicated these families as being those in which gall-insects are known and in which they may be expected also in this country. Galls are not easy to rear in "captivity," since the removal of the gall from the growing plant interferes with nutrition, and moulds are a great trouble; gall-insects are also not quick in development and it is probable that success will be obtained only by breeding on the plant or by patient observation. We figure some galls as well as the insects causing them (see under *Cecidomyiidæ* and *Psyllidæ* below). The student should see Kieffer's paper on Gall-insects of Bengal (Ann. Soc. Bruxelles XXIX, p. 133, 1905).

PROCTOTRYPIDÆ.

Small insects, the prothorax reaching back to the tegulæ, with few nervures in the wings, the antennæ straight.

The classification of the parasitic *Hymenoptera* is as yet insufficiently understood and with such vast families to deal with, it is, without going far more deeply into the subject than we here can, impossible to give characters by which to recognise any *Proctotrypid*. They are essentially small parasitic *Hymenoptera*, with the above general characters; they differ from the *Chalcidæ* in fairly characteristic details, but include some insects very difficult to place if one has not a very thorough grasp of these families. These little insects exhibit great variety in structure. The ovipositor is a continuation of the end of the body. Many are of beautiful metallic colours, the body hard, like that of *Chrysidæ*.

The life is so far as known, wholly parasitic, though the habits of not many species are known. The Indian species reared are from insect eggs, one from a dipterous larva and one from a beetle larva. It is certain that a great number will be reared when more attention is paid to this group. The family is a very large one with numerous subdivisions. Judging from the number of undescribed species found or reared, the plains' species of India are little known. Dalla Torre's catalogue gives some five Indian species, besides a number more from Ceylon, but this number is an extremely small part of what would be known were the group to be collected; a great number of these as of other parasitic Hymenoptera are being found or reared and the family is probably an extremely important one.

Scelio acte, Wlk., and *Epyris orientalis*, Cam., are recorded as well as *Platygaster oryzæ*, Cam., bred from the maggots of *Cecidomyia oryzæ*, W. M. A species of *Scelio* attacks the eggs of the Bombay Locust, *Acridium succinctum*, Linn.; *Hadronotus sp.* and *Telenomus sp.* were reared from insect eggs and *Telenomus sp.* from the eggs of *Scirpophaga auriflua*, Zell., a *Pyralid* moth. *Scelio* (Homalotylus) *terminalis*, Say., is a parasite upon the larvæ of *Chilomenes sexmaculata*, Fabr.

THE SIZE OF INSECTS.

We are told that on other planets, man might be very much larger than he is on earth on account of the less force of gravity due to the smaller bulk of the planet. That is, the Mammoth or some prehistoric reptile represents the maximum size attainable on earth simply because the bones requisite to support a larger animal and to bear the muscular strains set up in moving it could not, with the material of which bones are constructed, exist. Gravity and the tensile strength of the material used in making the skeletons of animals thus puts a limit at one extreme. On the other extreme is another limit in the size occupied by a sufficient aggregation of molecules to carry on the complex reactions of physical life, a limit which possibly admits of the existence of forms of life smaller than can be perceived by our present methods; at any rate, there are organisms visible only under a magnification of thousands of diameters.

Between these extremes lie our insects; the smallest are less than a millimetre in length: the largest moth has a wing span of twelve inches, the biggest beetle a length of over half this and the bulk of our insects are between three and one-tenth of an inch long and between five and a fifth of an inch across the expanded wings.

Probably the essential feature in insect anatomy that has limited them in size is the chitinous integument; an insect has no bones, it has no separate internal skeleton round which the soft tissues can be grouped and which can give a central support to muscles and connective tissue; there is only an external integument, with processes internally, and the tissues take their attachment from this and are packed away inside it. There is further the delicate tracheal system, probably capable only of a certain amount of compression and thus limiting the amount of stress that can be set up by muscular action. Another point is that the chitinous integument is not, except in the adult stage, a permanent one; it is shed and this puts a very definite limit probably upon the size to which it can be produced.

Other factors probably are the very great specialization insects display; we may imagine a caterpillar, if omnivorous and without enemies, growing to the limit of the size that its chitinous legs, and prolegs could bear ; it might perhaps be six feet long and a foot high, walking along like a vast worm and browsing happily in the pasture. But there are no omnivorous caterpillars (plants protect themselves too well with poisons and other devices), the vast number and variety of species are correlated with great specialisation and whether from the limitations of chitin, or from the difficulties of metamorphosis, such vast creatures do not exist.

Possibly insects are dominant because they are small, reproduction can be quick and vast, an egg can contain enough food to produce an active self-supporting larva ; the difficulties of viviparism are avoided and the mother need not live over to care for her young. When the seasons are unfavourable, the female waits with her store of undeveloped eggs till the season is favourable. Above all, where there is one vast animal like a cow, conspicuous and slow breeding, you may have, in equal bulk, a horde of scattered insects, ready to concentrate themselves on one point but capable, in times of stress, of diffusion over wide areas and in inappreciable amount. It is the case of the fly which eats the carcase quicker than the lion, because the concentrated effort and increase of a thousand small creatures outweighs the efforts of the one large creature a thousand times their size.

The insect, with the lion, endures times of starvation but of a thousand, perhaps, ten insects survive, whereas the one lion dying leaves none. So that taking lives as units, the small insect is better off and it may be that in the very limitations of chitin and metamorphosis has lain its success, since strivings after mere bulk have been vain where natural effort at increase, with multiplication of species and function, has enabled the insect to overrun and dominate the earth.

Dryinidæ.

Female with the foreleg modified to form a pincer.

A family of nearly 200 species of small insects, usually included in *Proctotrypidæ*, and distinguished by the fact that the fore tarsus is modified in the female to form a pincer.

This modification of the foreleg is connected with the habits of the insect ; according to Kieffer, the female seizes the nymph of the *Homopterous* insect she attacks by means of the pincers, and lays one or two eggs in its abdomen ; the resulting larva develops, emerges and pupates outside, the *Homopterous* nymph dying. Three species only are known from India : *Dryinus trifasciatus*, Kieff., *Prodryinus bifasciatus*, Soy., and *Gonatopus maurus*, Kieffer

One has been reared from the Fulgorid *Pyrilla aberrans*, Wlk., the larva living in the nymph and emerging to produce a small white cocoon on the leaf of the cane plant. (Fig. 86.)

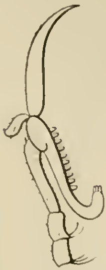


Fig. 85—ANTERIOR TARSAL JOINTS OF GONATOPUS GRACILIS.
(*From Kieffer.*)

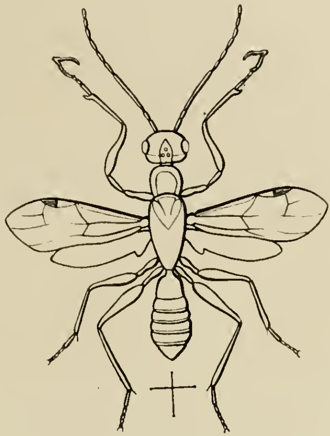


Fig. 87—DRYINUS FORMICARIUS.
(*From Kieffer.*)

Fig. 86—DRYINID PARASITE OF PYRILLA ABERRANS × 9 AND ITS COCOON ON A LEAF. × 2.

CHALCIDÆ.

Small insects, the antennæ elbowed, the wings with one vein, the protonum not reaching the tegulæ.

This very large family is most readily distinguished by the elbowed antennæ and single-veined wings. Many are of characteristic form and are readily recognisable as *Chalcids* in the field. The colours are sombre, though black and yellow is a frequent combination. They are nearly all small; though *Leucospis* measures nearly half an inch in length, less than a quarter of an inch is a more usual size and some are so small as to be microscopic and not really visible to the unaided eye. The head is well developed, with elbowed antennæ, large eyes and the usual mouth-parts. The thorax is compact giving great powers of flight to the tiny insect. The wings are hyaline with a single vein in the forewing. The abdomen is hard and in the female bears an ovipositor. Legs are well developed and the little insect walks and flies actively. The hind femur is frequently very much swollen, the narrow tibia fitting closely to it.

Fig. 88—CHALCIS CRICULÆ, MUCH MAGNIFIED.

The details of the life history of the group as a whole are very varied but most are parasites in eggs, larvæ or pupæ of almost all groups of insects including the *Hymenoptera*; some are hyperparasites, *i.e.*, lay their eggs in the bodies of parasitic larvæ which are already in the bodies of other insects; others are found in galls, as parasites; a few are fig insects living in peculiar gall-like structures in the fruit of wild figs; the greater number are parasites purely, and though the details of their life history would probably be of great interest if we knew them, practically nothing is known and we are probably sufficiently accurate in estimating the family as an important one owing to its rôle of general insect parasite.

The life history of no Indian species has really been studied and the utmost we know in most cases is that the imagines have been reared from particular insects. There are abundant points of great interest in the lives of these tiny insects; how do the imagines live when their host is not available; how do they hibernate, on what do they feed, when do they fly? How does the larva manage inside the body of a caterpillar and how does it get its air or dispose of its excreta, or moult? What is going on inside a caterpillar when there are perhaps twenty larvæ in it or as in some cases there are over 600? What are the details of the moults of the hyperparasites? One could continue enumerating points on which practically nothing is known at all, and absolutely nothing in India. Dalla Torre's catalogue enumerates about thirty species from our region: Cameron has added others (Jo. Bo. Nat. Hist. Soc., XVII, 578, etc.), a very large number have been and will be added to this, and it would be in no way surprising if *Chalcidæ* were found to be the family of which the greatest number of species occur in India.

The identification of these numerous forms, principally unclassified and undetermined, is possible only when one studies this family alone. It is then useless to do more than mention a few common species as examples of *Chalcidæ*. The following species and their hosts are known in India :—

Pentarthrum (Trichogramma) sp. is a tiny species reared from the eggs of *Chilo simplex*, Butl., the moth-borer of cane. A very high percentage of the eggs of this moth are infested, and the parasite is a very valuable check. *Tetrastichus sp.* is reared from *Chilo auricilia*, Ddgn., and is probably in itself a hyperparasite upon the *Braconid*, *Apanteles chilonis*. The imagines of the former emerge directly from the pupa of the caterpillar, not making an external cocoon, whilst the *Apanteles* larvæ, if not parasitised, emerge as full-grown larvæ and make white cocoons outside their host.

Syntomosphyrum (Cirrospilus) *sp.* is reared from pupæ of *Chilomenes sexmaculata*, F., a Ladybird beetle, where it is possibly a hyperparasite of *Scelio* (Homalotylus) *terminalis*, Say., which parasitises this beetle grub. *S. esurus*, Ry., has been reared from the cotton aphis (*Aphis gossypii*, Glov.) in which it is possibly a hyperparasite of *Trioxys sp.*, a Braconid parasite. *Omphale sp.* is a small insect of which 77 were reared from the grub of a Cotton Stem Borer, *Sphenoptera gossypii*, Kerr. It is probably a hyperparasite on the true parasite of this beetle grub. *Pteromalus oryzæ*, Cam., is a parasite of the grub of the rice weevil *Calandra oryzae*, L., and keeps this voracious pest in check. (I. M. N.) *Aphelinus theæ*, Cam., is recorded as a parasite of the scale insect, *Aspidiotus theæ*, Mask., on tea in the Kangra Valley. (I. M. N.) A species near to *Sycoryctes philippinensis*, Ashm., has been reared from the fruits of the pipal (*Ficus religiosa*) in India, and with it *Goniogaster*, (Idarnes) *stabilis*, Wlk., and *Sycophila decatonioides*, Wlk., which are parasitic upon it.

The following species are also recorded as having been reared from the figs of *Ficus indica* (? meant for *Ficus bengalensis*, the banyan tree) :—*Eupristina masoni*, Saund.; *Sycobia bethyloides*, Westd.; *Walkerella temeraria*, Westd.; *Sycobiella Saundersi*, Westd.; *Sycoscapta insignis*, Saund.; *Sycoscaptella affinis*, Westd.; *Micranisa* (Idarnes) *pteromaloides*, Wlk.

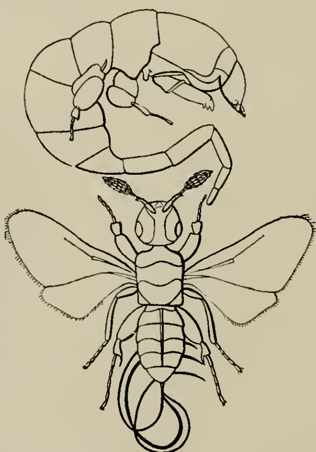


Fig. 89—EUPRISTINA MASONI, MALE ABOVE, FEMALE BELOW.
(*From Westwood.*)

Walker also described *Sycophila megastigmoides* and Mayr described *Sycophaga breviventris* from figs in India. The student should consult the original papers:—Westwood, T. E. S., London, 1840, Vol. II, p. 214; Westwood and Saunders, loc. cit., London, 1883, pp. 1, 29, 375, 383; Westwood, loc. cit., 1882, 47; Mayr, Mittheilungen Zool. Stat. Neapel, III, 1882.

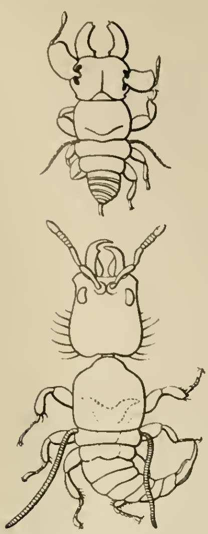


Fig. 90—Sycobiella saundersi sycoscapta insignis male. (*From Westwood.*)

These fig insects have been the subject of prolonged investigation in Europe and South America, and an unknown species which attacks *Ficus roxburghii* in Calcutta is discussed by Cunningham in an appendix to Volume I, of the Annals of the Botanic Garden, Calcutta. Cunningham finds that there are two crops of fruits yearly, some trees having receptacles containing gall flowers and males, others containing female flowers; in the gall flowers, which are peculiar structures, the fig insect lays its eggs, the larvæ living in the gall and eventually emerging in the winged condition. On emergence they fly, couple, and the females endeavour to lay eggs. In searching for the gall flowers, the females enter the receptacles, including those containing female flowers, and endeavour to deposit eggs in the female flowers. As a result the enormous numbers of embryos in each receptacle develop, as if they were fertilised. The inference, naturally, is that the female insects carry pollen from the male flowers, but Cunningham concludes that this is not the case and that the female embryos develop parthenogenetically but only after the irritation produced by the attempts of the female fig insects to lay eggs in these flowers. The fig insect then plays the part of an irritant agent, producing effects equivalent to fertilisation and the fig plant produces, on behalf of the insect, special "flowers" in which the insect lays its eggs. The *Chalcid* then in this case is simply a gall insect, as the *Cynipidæ* are.

Connected with these fig insects are parasites, insects very closely allied and which lay their eggs in the larvæ of the fig insects in the fig gall flowers; Cunningham does not appear to have been aware of this fact or to have known what fig insects he was dealing with and this is to be regretted as his conclusions may require to be vitally modified. (This applies equally to the same author's chapter in that popular but inaccurate work 'Pains and Pleasures of Life in Bengal.') Fig insects seem to be very abundant in India, and a great number of the wild figs produce large crops of them. The question has a special interest in view of the fact that the true fig is stated to produce the best figs only when its fig insect *Blastophaga psenes*, Low., is present; for this purpose a wild fig has to be cultivated with the cultivated fig to yield Blastophaga; so necessary is this considered that the wild fig (Capri fig) has been introduced to California and South Africa with the *Blastophaga*, in order to give the figs there grown the proper conditions for full development, though entomologists are not yet agreed as to the part played by the insect.

That the fruits of our common fig trees (the pipal, banyan, pakur, gular, &c.) are constantly infested with fig insects can be readily ascertained by examination, various caterpillars, weevils, flies, &c., also occurring in them, but the respective parts played by these insects, their mode of life and their relations to the tree are practically unknown and offer a very fertile field for inquiry. We figure from Westwood some of the insects obtained from figs in India; the problem is one of great complexity and interest, attention has been drawn to it more than once in the Indian press from the economic aspect since large quantities of fruit are constantly "destroyed" by these insects, but it is doubtful if any means can be devised of checking them and were it done, it is uncertain what would be the effect upon the production of fruit.

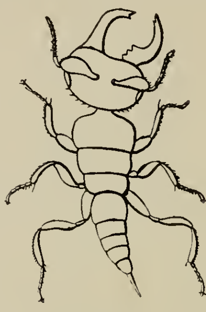


Fig. 91—WALKERELLA TEMERARIA.
(*From Westwood.*)

Podagrion minutum, Ashm., was reared from the egg mass of a mantis, the female with a long ovipositor many times her own length for lay-

laying her eggs. *Chalcis criculæ*, Kohl. (fig. 88) is recorded as a parasite of *Cricula trifenestrata*, Mo. a Saturniid Moth. (I. M. N. I., pl. V) *C. euplææ*, Ho., is also recorded as a caterpillar parasite. The number and importance of *Chalcidæ*, like the other *Hymenoptera Parasitica*, cannot easily be estimated. There are probably an enormous number of species in India, some widespread, many probably confined to this area. To the systematist as to the biologist they offer a wide field of research, and it is to be hoped that a really thorough investigation into the economy of at least one species may be made, as well as an investigation into the identity and hosts of our common crop pest-destroying species.

Ichneumonidæ.

Wings with two recurrent nervures and two or three cubital cells. Antennæ not elbowed.

This is a very large group of insects, clearly separate from *Chalcidæ* by the greater number of veins and cells, from *Braconidæ* by the venation. They are, as a rule, larger insects, the antennæ not elbowed, the legs moderately long, the body slender. The female has an ovipositor which is often long and conspicuous; males are destitute of any ovipositor or similar organ and are generally similar to the females. The colours are mainly warning, black and yellow, reddish yellow and similar bright colours predominating.

The *Ichneumonidæ* are a very large family, with a great number of species. These species are of limited distribution, confined to distinct areas and the Indian forms are, so far as known, confined to this geographical region. The number of described Indian species is over 200 but most are from the hills and but few have been reared.

Fig. 92 Pimpla predator, Fabr. × 2.

Limnerium sp. has been reared from the larva of a *Plusia*. *Pimpla punctator*, L., is a common insect, yellow with black markings, bred from several of the wild silk producing insects (*Saturniidæ*). *P. predator*, F., was reared from *Scirpophaga auriflua*, Zell. (I. M. N. V., p. 178.)

The family is divided into five sub-families; of the *Ichneumoninæ*, up to 1904, 119 species had been described from India, largely from the Khasia hills by Cameron and others have been added since. In the *Cryptinæ*, 84 species are listed up to 1908 (*Schmiedeknecht*, Genera Insectorum), mainly Cameron's Khasia hill species. The same author lists 59 species of *Pimplinæ* (1907), including the remarkable forest species *Rhyssa* and *Ephialtes*, allied to *Thalessa*. In the *Tryphoninæ*, Dalla Torre (1900) lists five Indian species, and in the *Ophioninæ* Szepligetti (1905) lists twenty-one.

Nothing is on record as to the hosts of these species and the forms occurring in India generally are practically unknown.

Braconidæ.

The forewings with one recurrent nervure and three or four cubital cells as a rule. Antennæ not elbowed, abdomen not inserted on apex of median segment.

These are closely allied to the *Ichneumonidæ* but in general distinguished by the venation of the forewing. There is an extra cubital cell and but one recurrent nervure. The colours are bright, probably generally warning, and aided by the bright colour of the forewings in some cases. In size they vary from small to moderate-sized insects with a wing span of over one inch. The head is large, distinct, with moderately long antennæ, which are probably very delicate sense organs. The thorax is compact, bearing the moderately large wings; the abdomen is long and slender. The general form varies very greatly, probably in relation to the stinging habits of the female, and some are greatly elongate or otherwise bizarre in appearance. The female has an ovipositor which may extend to a considerable length; the males

Fig. 93—Bracon nicevillei, female. × 2.

are closely similar to the females in general appearance, but without ovipositor.

The life history is, so far as known, parasitic, the larvæ living at the expense of other insects, usually *Lepidoptera*. In spite of the multiplicity of species and their great importance, little is known of the life history of these insects beyond the fact of their parasitism. As in other parasitic insects, there are points about the details of the larval life which are shrouded in darkness and deserve further study. The remarks made above as to the general life of these parasitic hymenoptera apply to this family.

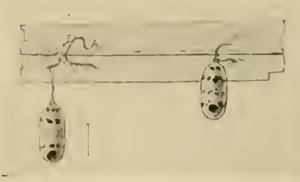


Fig. 94—Pupa cases of a braconid, suspended from a leaf.

This large family has representatives in every part of the globe, and though the Indian species are probably little known, 57 species are listed as Indian by Szepligetti.

Bracon is a large genus with nearly thirty Indian species largely Himalayan. Of these, *B. nicevillei*, Bingh., is parasitic on the larva of *Scirpophaga auriflua*, Zell. and other insects. This species is so named in honour of Mr. L. de Niceville who first reared it in Behar. (Indian Museum Notes, Vol. V, No. 3, p. 177.) It is a large insect, the wings orange and black (fig. 93), very conspicuous, and a valuable check upon this pest. The female has a long ovipositor with which to penetrate the cane and reach the larva. Little is known of other species, which have been principally collected in the hills. A number of plains species have been reared and the more important of these are the following:—*Aphidius avenæ*, Hal., is parasitic upon the wheat aphis

Fig. 95—Microdus fumipennis. [I. M. N.]

(*Macrosiphum granarium*, Kby), *Trioxys sp.* has been reared from the cotton aphis (*Aphis gossypii*, Glov.). *Microdus fumipennis*, Cam. fig. 95) and *M. tuberculatus*, Cam., are recorded as parasites of the castor caterpillar (*Trabala vishnu*). (Ind. Mus. Notes, Vol. V. p. 107.)

Apanteles glomeratus, L., is from a caterpillar attacking white gourd. (? *Sphenarches caffer*, Zell.) *A. chilonis* is parasitic upon the larva of *Chilo auricilia*, Ddgn., which attacks cane. *A.* (Urogaster) *indicus* is parasitic upon the cotton bud caterpillar (*Phycita infusella*, Meyr.) and *A. depressariæ*, on *Gelechia gossypiella*, the pink bollworm. *Apanteles* commonly pupate in very noticeable white cocoons, openly on the plant near their victim or on it. (Plate XXXVI.) *Rhogas Lefroyi* is a parasite of the spotted bollworms, *Earias insulana*, Boisd., and *Earias fabia*, Stoll, a very important check upon this common pest. *Microbracon leucaniæ* is parasitic upon *Nonagria uniformis*, Ddgn., the Wheat Stem Borer.

STEPHANIDÆ.

Antennæ many-jointed.

A small family of less than one hundred species, of which one is known from India. *Wroughtonia cornuta*, Cam., was found in Bombay by R. C. Wroughton.

EVANIIDÆ.

The abdomen is petiolate, the petiole inserted on the dorsal portion of the median segment. Antennæ filiform, of thirteen joints, straight.

A small family of almost certain distinction from the position of the abdomen, only a very few insects outside the family sharing this character. Less than three hundred species are known in all, of which six occur in India.

Evania is a genus of medium-sized insects, sombre in colour, with a very short abdomen, which is very slender at the base (peduncle) and broadly truncated at the apex. The sting is short, the wing comparatively small, the thorax robust.

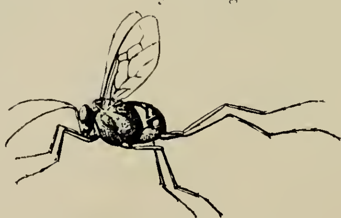


Fig. 96—EVANIA SP. × 2.

To any one who has seen these active insects flying about, the genus will for ever be at once distinct. The imago enters houses and other buildings in search of cockroaches (*Blattidæ*) in whose egg capsules the female deposits her eggs and is one of the few flying insects one perceives on board ship. The larvæ destroy the eggs and one species has been very widely distributed over the globe where the household cockroaches are to be found. *Evania appendigaster*, L., is the European species found now in all but the coldest parts of all continents. *E. antennalis*, Westw., is described from Bombay and *E. albitarsis*, Cam., as well as *E. curvicarinata*, Cam., are Indian.

Gasteruption is a genus containing a large part of the species of the family and includes *G. orientale*, Cam., described from Bengal, and *G. mandibulare*, Cam., of whose habits apparently nothing is on record. It is likely to share the habits of the known species, and prove to be a parasite on *Aculeate Hymenoptera*.

Aulacus bituberculatus appears to be the sole other recorded species. Other species are known in Ceylon and it is probable that these with others will be found also in India.

TRIGONALIDÆ.

Abdomen ovate, five-jointed, not petiolate. Trochanters not fully divided. Both wings with a complex venation.

Fig. 97—PSEUDOGONALOS HARMANDI. (*From Schulz.*)

A small family of insects of which little is known. Schulz has recently listed the species (Genera Insectorum, 1907), one out of forty-two being doubtfully Indian. The known species are parasites on Vespidæ and hyper parasites on Diptera; no pupal cocoon is made. *Pseudogonalos Harmandi*, Sch. (fig. 97) occurs in Darjeeling, *Poecilogonalos pulchella*, Westd., in

Ceylon and Burma, *Ischnogonalos dubia*, Magr., in Burma and *Lycogaster rufiventris*, Magr., in Burma.

TUBULIFERA.

Chrysidæ.—*Cuckoo Wasps.*

Trochanters one-jointed. Visible abdominal segments usually three.

This family is most easily recognised by the extremely hard, densely punctured integument and the bright metallic green or blue-green

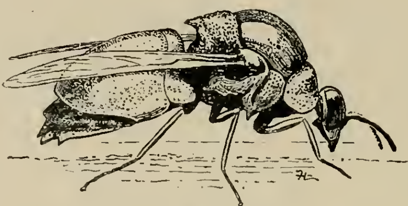


Fig. 98—Stilbum cyanurum. [F. M. H.]

colouring. They are small insects, with rather small dusky wings. The head is of moderate size with large eyes and ocelli; the antennæ are short, consisting of a longer basal segment (*Scape*) and a number of short joints (*flagellum*). The thorax is large and well developed, the abdomen distinct, with usually three visible segments, the remainder concealed. The female has a long retractile ovipositor. The bodily structure is hard, designed to enable the insect to curl into a ball (fig. 99). So far as is known, all are parasitic upon Aculeate Hymenoptera and a number have been reared from different species. In the greater number

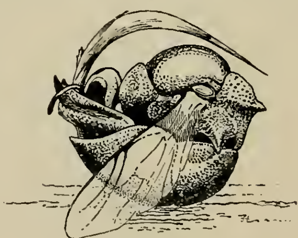


Fig. 99—Stilbum cyanurum; curled into a ball. [F. M. H.]

the host is not known and we are not aware that any Indian species has been carefully studied. The known hosts are tabulated here :—

Bembex sp.	parasitised by	*Hedychrum timidum*, Dohl.
Odynerus bipustulatus	,, ,,	*Hedychrum flammulatum*, Sm.
Megachile fraterna. ,, *monticola* *Eumenes petiolata* ,, *conica*	,, ,,	*Stilbum cyanurum*, Forst.
Eumenes conica ,, *petiolata* ,, *flavopicta*	,, ,,	*Chrysis fuscipennis*, Br. (see Jo. Bo. Nat. Hist. Soc. XII, p. 585).
Odynerus multipictus	,, ,,	*Chrysis angustata*, Mocs.
Sceliphron intrudens	,, ,,	*Chrysis durga*, Bingh.
Eumenes dimidiatipennis	,, ,,	*Stilbum cyanurum*, Forst. (vide *S. splendidum*, Cretin, in Jo. Bo. Nat. Hist. Soc. XIV, p. 823).
Pelopaeus, sp.	,, ,,	*Stilbum cyanurum*, Forst.
Eumenes conica	,, ,,	*Chrysis orientalis*, Guer (Pusa).
Sceliphron coromandelicum .. ,, *madraspatanum*, F. ..	,, ,,	,, ,, ,, ,, *Chrysis fuscipennis*, Br. (Pusa). *Hedychridium rugosum*, Sm. (Smith).
,, *bilineatum*, Sm. ..	,, ,,	*Chrysis* (?) *pubescens*, Sm. (Smith A. M. N. H. (2) IX. p. 45).

Bingham describes four sub-families :

Cleptinæ. Not known to be Indian.

Ellampinæ includes *Ellampus*, *Holopyga*, *Hedychridium*, *Hedychrum*.

Chrysidinæ includes *Chrysogona*, *Stilbum*, *Chrysis*, *Euchroeus*.

Parnopinæ includes *Parnopes*.

The identification of these genera and species can be found in the Fauna volume. *Hedychrum flammulatum*, Sm., is the only widespread species of its genus. *Stilbum cyanurum*, Forst., is said to be practically worldwide and is, in the plains, universal. The species of *Chrysis* are so far as known, mainly local but their superficial resemblance probably has led to the belief that they are all common and not worth observing or collecting. *C. fuscipennis*, Br., *C. fusca*, Fabr., *C. orientalis*, Guer., and *C. oculata*, Fabr., are widespread and common, likely to be found anywhere.

Collecting. Cuckoo-wasps are common in houses and in the open; they require to be caught with a net and may be killed with Cyanide or a B. C. bottle. Far more wanted than collecting is observation of their hosts and habits and rearing from nests of Aculeates. The part they play in the complicated relations of our insect fauna is not at present measurable and a far closer knowledge of them is required. They are common at nearly all times and as many infest the Aculeates that build in and around houses, are easy of observation. A really close study of one species would well repay the labour and time.

ACULEATA.

Our knowledge of this group is due largely to Wroughton, who worked in the Konkan, Rothney who worked for 14 years in Barrackpore and Bingham who worked for many years in Burma. The last has listed the species known up to 1896 in the Fauna of India, and there have been abundant papers since then adding new species. With the latter we are not concerned; Cameron has described hundreds of new species in a variety of publications. G. C. Nurse has added others and it will be long before all are described. Rothney's paper (Trans. Ent. Soc., London, 1903, p. 93) adds to our information and Horne's paper in Trans. Zool. Soc. VII, p. 168 (1870), must be consulted.

The most striking point about the Aculeates is the fact that the whole business of life is conducted by the imago; the larva is practically helpless and if not actually fed by the imago is at least provided with an ample supply of carefully gathered food which simply has to be devoured. Without careful search we never see the larva of an Aculeate and the imago alone is active. This specialisation in life history is associated with extraordinary specialisation in habits and consequently in structure; the activities of these insects excite the admiration of all who observe them and their extremely varied ingenuity is unparalleled in any other insect group; for this reason, they are placed at the head of insects in mental activity and intelligence and they are unquestionably very far removed from any of the primitive types of insect life.

At the same time it must not be thought that their activities show any mentality comparable to that of man: even ants are unreasoning and these insects are endowed with extremely complex and beautiful instincts, of so remarkable a kind that many naturalists see in these insects a powerful argument against the doctrine that such instincts, as all insect activities, are the result simply of natural selection and adaptation.

From man's point of view these instincts are in a sense admirable and are yet inferior since they are mere blind instincts which cannot vary and which involve no reasoning faculty. A dog has more reasoning power and a higher order of mentality than the highest insect; the absolute stupidity of the ant but the wonderful nature of its instincts is a curious contrast.

Mutillidæ.—*Velvet Ants.*

Male. Pronotum reaching the tegulæ. A constriction between the first and second abdominal segments. Middle coxæ contiguous.
Female. Wingless, ant-like without abdominal nodes.

The wingless females are very readily recognised by their ant-like appearance and bright colours, there being no nodes on the

Fig. 100.—Mutilla sexmaculata, male.

abdomen as in *Formicidæ*. The males are usually recognisable as they have a characteristic appearance and colouring, but the above characters must be verified in case of doubt. The wingless females are small insects from an eighth to a quarter of an inch in length; the colours are always warning, striking and vivid, red and black predominating with white and golden spots or bands on the abdomen. The males are larger, up to half an inch in length, coloured in black and red, the wings usually smoky, the abdomen commonly red. The colouring is less conspicuous than that of the females and is perhaps a milder form of warning colouration.

The family practically consists of one genus, *Mutilla*. There is, however, the peculiar insect *Apterogyna mutilloides*, Sm., a species likely to puzzle any but a close student of this group. This insect has, in both sexes, a constriction between both the first and second, and the second and third segments; the winged male has a peculiar upturned spine at the apex of the abdomen and the venation of the wings is much reduced not extending to the outer margin. The insect is not common but is striking and deserves mention. It is one of the few insects found in the sandy wastes of some parts of North India and is also known from Barrackpore. Of Mutilla, some 120 species are described in the Fauna of India; as, however, the males of some species only are known, and the females of some, and as these could probably be paired off if we knew more, the number of species may be exaggerated. The discrimination of these species is by the colour markings, which are extremely constant, and the student should consult the key in the Fauna of India volume.

Fig. 101.—MUTILLA REGIA FEMALE.

Mutilla.—Is one of the insects far more common and well represented in the hot plains than in the hills. The active females are to be found everywhere in moist as in very dry surroundings; the limited distribution assigned to so many species is due simply to the fact that in so few places have they been collected, though where they have been collected many species have been found. Anyone who observes closely the insect fauna of our fields is sure, sooner or later, to witness the mating of Mutillids. It varies in detail with the species; those seen by the author have been tolerably similar. The male is a powerful insect with long legs and strong wings; he finds the female, seizes her by the prothorax and flies off: on some convenient spot, he mates with her, clasping her firmly to him by his forelegs and standing erect on his others: she is perfectly helpless and is apparently firmly held throughout. The first time I was privileged to see this, I was much struck as in the frequent intervals the male shook the female with a twisting motion as we should shake a bottle whose contents we desired to mix well: this extraordinary performance is worth seeing, but occurs, so far as I know, not in all species, as in the majority I have seen the procedure was straightforward and not accompanied by this peculiar rite; unfortunately I was so interested that when I sought to capture them and determine the species they escaped.

It is impossible to discuss individual Mutillids in this place and the student will find full descriptions in the Fauna of India. The four commonest species are perhaps *M. dimidiata*, Lep. *M. interrupta*, Oliv. *M. analis*, Lep. and *M. sexmaculata*, Swed, but very little is known as to the geographical distribution in India of the majority of the species. All are parasitic upon Aculeate Hymenoptera, but few have been actually bred from their hosts.

M. regia, Sm. (fig. 101) was found in the nest of *Eumenes conica* and was also reared from the pupa of this wasp. G. C. Nurse also reared this species from the nests of *Eumenes esuriens* (Jo. Bom. Nat. Hist. Soc. XIV, p. 271). *Mutilla discreta*, Cam. has been reared from *Crabro orientalis*, Cam. in Pusa and *M. poonaensis*, Cam. from the nest of an *Eumenes* in the same place. (Plate XIII, figs. 1, 2.)

Collecting.—Mutillids are easy to collect, the females on the ground, the males in a net. The females should not be handled with the bare fingers as the sting is distinctly painful. Every mutillid seen "in cop" should be collected since this is the easiest way in which to match the sexes. A great deal of observation and rearing is required before we can estimate the importance of the group since their hosts are unknown and every opportunity of determining what their hosts are, should be taken.

SEX.

The *Mutillidæ* offer a striking example of that difference in structure connected with sex which is found in some form or another throughout the insect world. It is at first sight a striking thing to find that throughout a whole family, the female is wingless, but there are so many other striking differences that we may here draw the attention of the student to some salient points in this matter.

We may omit here all reference to structures such as ovaries, claspers, ovipositors, etc., connected with the primary needs of mating and egg-laying; these must obviously be present in every mature sexual form and on their examination must ultimately depend the determination of sex. Apart from these structures, which are not always readily discernible without dissection, there are a number of other differences less immediately connected with the actual sexual functions and which are often more readily discernible. We may at once notice the wingless females, so marked a feature in *Mutillidæ*. We are probably correct in saying that in this family the female has lost her wings since she does not require them in her search for the nests of her hosts but that the male retains them simply to aid him in his search for the female. The same is true of other forms, where the loss of wings appears to be an advantage but one which cannot be shared by the male as on him falls the work of seeking out his mate. Among Lepidoptera, the *Psychidæ* are an excellent example and a few *Lymantriidæ* exhibit the same phenomenon. All male *Coccidæ* are winged, all females wingless; many *Phasmidæ* have wingless females, while some of the species of the Reduviid genus *Physorhynchus* are winged only in the male, though some other species of the genus are wingless in both sexes, the wings however more completely absent in the female than in the male, as if the former had lost them first. In the Lampyride division of *Malacodermidæ*, wingless females are not uncommon and in some genera the females are practically unknown, only the males being found as winged beetles.

Uzel mentions the exact reverse of this in Thysanoptera, where we find a wingless species in which some females become winged to disseminate the species. This reminds one of the *Aphidæ*, where after a colony of wingless females is formed, winged females are found which fly away and start new colonies, though this last case is not connected with sex.

The next notable point in sex is size; here we have two groups, one in which the male is larger and the difference in size is connected with his functions; the other in which the female is larger apparently because on her falls the more arduous task of providing for the offspring or because the mere bulk of eggs to be produced and carried necessitates a larger body. Large males at once suggest the *Lucanidæ* (Stag beetles) and the *Dynastidæ*, the great size being connected with the hypertrophied mandibles or horns on the prothorax and head. Why these beetles should bear these large horns and have so massive a development is a question no one appears to have satisfactorily answered and we should like to see a careful inquiry made into the relative numbers of the sexes of these beetles either in one locality or in the offspring of definite parents. In these forms there is usually great variation in the actual amount of development of the horns or mandibles and in some species there are distinct types, known as *teleodont* (long mandibled) *priodont* (short mandibled) and *mesodont* (intermediate) in the one species. The large males of the *Mutillidæ* are accounted for (wrongly perhaps) when we consider that not only must they fly and be active, but that they usually seize and carry off the females and that further the eggs in this group are not bulky or abundant. Small males offer no apparent difficulty since it seems natural as we have said above. Marked difference occurs notably in *Phasmidæ*, in the social insects such as bees and termites, in many moths, some beetles, and in some *Acridiidæ;* it is probably correct to say that some preponderance in the female is the general rule in insects, but it is more marked for instance in *Atractomorpha* and some allied *Pyrgomorphides* than in most *Acridiidæ*, and the groups we mention will furnish conspicuous examples to the student. It is curious that this is less marked in Rhynchota and one is inclined to associate such sex differentiations with the more specialised and highly developed groups.

An interesting sex modification is that in which the female has more developed mouthparts than the male, as in the *Culicidæ* and blood-sucking *Chironomidæ*. In these forms the female alone can suck blood. It is possible that this really occurs more frequently than is recorded; there is, for instance, a marked difference in the size of the mouthparts of some Pyralids (*Lamoria*, etc.). Another and a fundamental difference that scarcely needs mention is the naturally longer life that the females enjoy: in a very great number of cases, the completion of the male's functions determines his death and this must precede the death of the female which has often to wait for a considerable time before she can successfully deposit her eggs. This is very marked for instance, in some species in which the female waits long periods as in the mango weevil (*Cryptorhynchus gravis F.*), where the males die in August, the females living until next March to lay eggs. We believe this occurs in a very large number of forms and it is a factor that must be taken into account in estimating the relative proportions of each sex found. It would be interesting to know, for instance, how far this occurs in long-lived imagines such as butterflies; do the males die early or do they wait until the females can lay eggs before mating?

We come then to a vast number of small modifications in one sex which are less directly connected with sex in the sense that they are connected only with courtship and the preliminaries to mating. The luminosity of some insects may be cited, the European glow-worm being an example of a female wingless beetle which is luminous possibly as a guide to the winged male. Our luminous beetles are so in both sexes and in the larvæ, so that this luminescence may not be connected with sex. A better example are the singing insects, in which the males sing, the females are silent. We have briefly discussed this elsewhere (under *Cicadidæ*) and it is not certain that song is really connected with sex, though it is likely to be so. In a great number of male moths and butterflies, scent production from special hair tufts is a feature of the males alone and the frequency with which this occurs points to its being an important factor in successful mating. The variety of situations in which these tufts occurs, their diverse form and size are marked features, for instance, in our Noctuidæ and Pyralidæ, while the male pouch and sexmarks of butterflies are simply scent producing organs.

Haase discusses this point (Zool, Anzeiger, XI, 1888, No. 287). Plateau remarks that in Lepidoptera, scent organs exist for three purposes; in *Danais* and *Euplœa*, they are defensive, the scent being unpleasant and derived from a caustic fluid; in some Lepidoptera, notably Bombycidæ and Saturniidæ, the scent is diffused by the female to attract the male, the latter having very sensitive organs of smell; in many butterflies the males emit a " seductive " scent, that has in some cases been compared to vanilla, and which is employed only in courtship. It is the last which Haase discusses; he states that scent organs occur in one of the following positions:

Wings.—On the whole upper surface of both wings. (*Pieridæ*). In tufts on the upper surface of both wings (some *Satyrides*). In a costal fold of the forewing (some *Hesperiidæ*). On the upper surface of the disc of the forewing (*Cynthia*, *Atella*, *Argynnis*, etc., and some *Hesperiidæ*). On the lower surface of the disc of the forewing (*Eurema*, etc.). On the folded costal edge of the hindwing (*Patula*). On the upper surface of the hindwing (*Pierids*, *Danais*, *Morphides*, *Satyrides*, etc.).

On the anal area of the hindwing above (*Papilionides*, *Ornithoptera*, *Pompeus*, etc.), or below (*Morphides*).

On the lower surface of the hindwing (*Plecoptera* in Noctuidæ). On the part of the two wings which rub together when in motion (*Catopsilia*, *Euplœa*, *Ergolis*, *Morphides*, *Mycalesis*, *Lycænides*, some *Hesperiides* and some Heterocera).

Thorax and abdomen.—Many Sphingids, Agaristids and some Noctuids have scent organs on the first abdominal segment. In some Pierids, in all Danaids, in Callidulids and some Noctuids, a tuft of odorous scales can be protruded from each side of the genital aperture.

Palpi and Legs.—In a Deltoid (*Bertula*) a tuft occurs on the palpi, in a few forms tufts occur on the tibiæ of all the legs, on the forelegs only (*Spodoptera*), on the middle tibiæ (many *Noctuidæ*), on the hind tibiæ (some *Hesperiidæ*, *Hepialidæ*, *Hyblæa* and many *Geometridæ*).

The student of *Pyralidæ* will find that he must study the male secondary sexual characters very carefully in distinguishing species and that they occur with great frequency in a very marked form. One of the commonest male characters, is a greater apparent development in the antennæ and this is shown in most moths, the female having often simple antennæ while the male has them ciliate, pectinate, fasciculate or modified in some way. Were more known of the actual habits of moths, we might be able to say whether these modifications gave the male a greater chance of finding the female, for instance, by giving the antenna a more delicate or special sense. At present nothing is known and there is no real information as to how insects find each other. This development of the antennæ is a feature also of *Culicidæ*, with a more astonishing difference in the relative development of the palps, those of the males being very much larger. There is also a surprising development of the antennæ in the male *Lampyridæ* in species in which the luminescence is little developed.

We cannot leave this subject without briefly touching the problem that every student finds of determining the sex of an insect. It is extremely irritating to find, for instance, characters given for the males only, while one has not enough of a species to have both sexes and one does not know, without dissection, what is the sex of the specimen one has. To deal adequately with this subject would require very many pages and a separate treatise. In some families sex-distinction is easy, as in *Locustidæ*, *Gryllidæ*, *Acridiidæ*, many Parasitic *Hymenoptera*, and those groups which have a distinct ovipositor. In others there is no such obvious distinction, and in some families dissection is actually necessary. This is the case, for instance, in the bulk of the *Rhynchota*, *Heteroptera* ; Distant is discreetly silent in the Fauna of India on this point except where such obvious differences occur as in *Physorhynchus*. In some species, the possession of claspers points to the males (*Leptocorisa*), the larger bodies and distended abdomen of the female sometimes marks the female (*Dysdercus*, etc.). Coupling unfortunately affords no evidence as these forms couple in opposition. (Coupling is by opposition in *Lepidoptera* and *Hemiptera*, by superposition in *Coleoptera*, *Orthoptera*, *Diptera* and *Hymenoptera*). *Coleoptera* is another order in which there is no one characteristic of the male. There are abundant small characters in different families, but they must be learnt for each. In *Orthoptera*, the matter is simpler ; in *Forficulidæ* the male has nine, the female seven abdominal segments ; the genital styles mark the male Blattids ; the male Mantids have two more visible ventral segments (eight, really nine), than the female (apparently six, really seven). The female *Phasmid* has the egglaying gutter or process ; while the *Acridiid* female has two pairs of digging processes ; *Locustid* and *Gryllid* females have usually an ovipositor. In *Rhopalocera*, the male sex marks are usually distinguishable in the form of glandular hair patches ; in moths, Hampson has pointed out that the frenulum is simple in the male, compound in the female. In *Diptera* the antennæ of the male are plumose in some families, the eyes are larger and more closely approximated on the frons in others, and there are in some cases very distinct claspers. In *Neuroptera*, it is necessary to look for male claspers which, however, are not always present.

THYNNIDÆ.

Pronotum reaching the base of the wings, basal abdominal segment not constricted. Posterior legs short, female apterous.

A small family containing two Indian genera and six species, none common or generally to be found. The winged males have a distinct upturned spine at the apex of the abdomen (as does also *Apterogyna*); the recorded species are *Methoca bicolor*, Cam. (Barrackpore); *M. orientalis*, Sm. (N. India); *M. smithii*, Magr. (Bengal, Burma); *M. rugosa*, Cam. (Ceylon); *Iswara luteus*, Westw. (Sind); *Iswara fasciatus*, Sm. (Sind). Any observations on the habits of these insects will be of value as nothing appears to be known. (*Methoca* is by some authors (*e.g.*, André) classed with *Mutillidæ*).

SCOLIIDÆ.

Pronotum reaching the tegulæ. A constriction between first and second abdominal segments. Middle coxæ separated. Both sexes winged.

This family includes a number of moderate sized flying insects classed generally among wasps; none are very small, while some are amongst the largest of the Aculeates. The colours are usually warning to a greater or less degree, black with yellow or orange predominating. The head bears the antennæ, which are larger and more slender in the males; there are the usual three ocelli on the vertex; the mandibles are large; the thorax and body is robust, heavier in the female and usually clothed with rather thick hair. The legs are short and spinose, the wings well developed, the venation valuable for the discrimination of genera.

Fig. 102.—ELIS ANNULATA, FEMALE.

PLATE X.—Fossores.

Fig. 1. *Eumenes conica*, nest seen from the attached side, containing green caterpillars and a feeding larva

" 2. Nest as seen from outside.

" 3. *Tachytes erythropoda.*

" 4. *Astata agilis.*

" 5. *Tachysphex testaceiceps.*

" 6. *Larra sumatrana.*

" 7. *Notogonia subtesselata.*

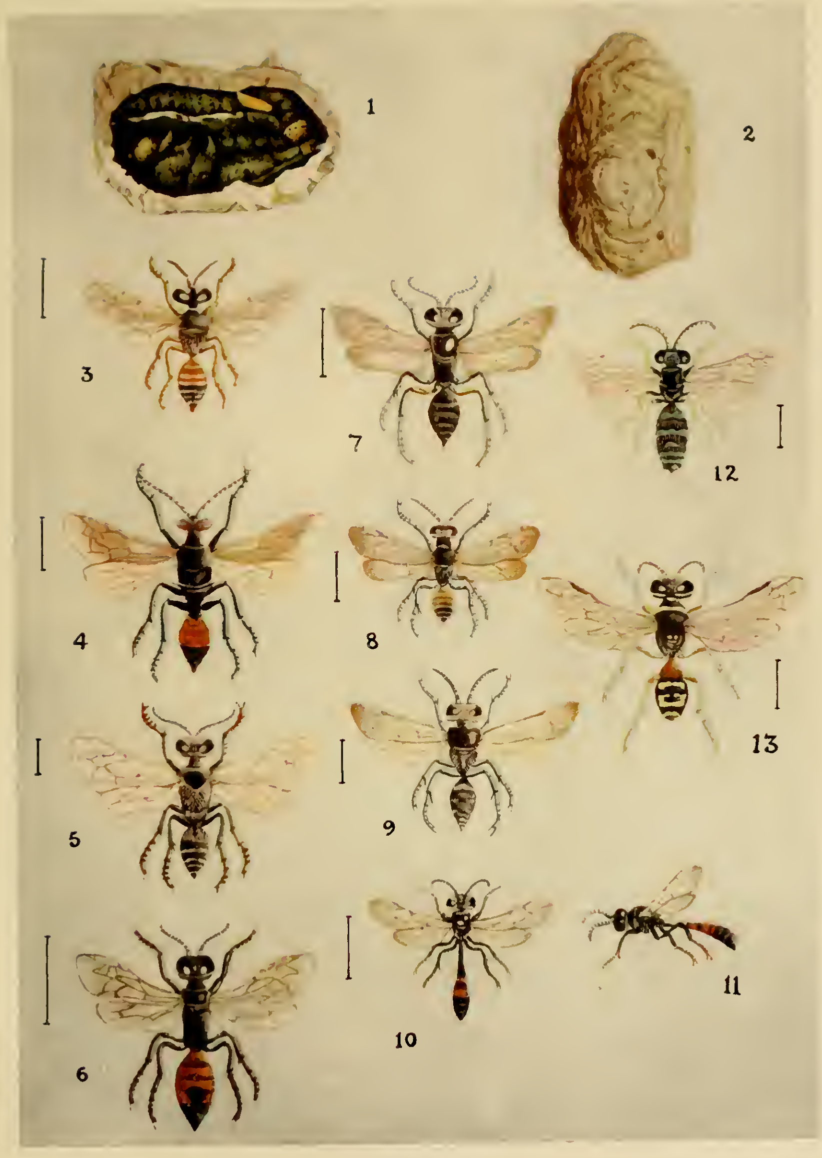
" 8. *Lyroda formosa.*

" 9. *Pison rugosum.*

" 10 }
" 11. } *Trypoxylon canaliculatum.*

" 12. *Stizus prismaticus.*

" 13. *Philanthus pulcherrimus.*



FOSSORES.

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Males are smaller, more slender and usually have spines at the apex of the abdomen.

Nothing appears to be on record as to the habits of this family in India ; as a whole they are probably parasitic upon the larvæ of Coleoptera in the soil, especially *Scarabæidæ;* they persistently fly over the soil, but none have been reared ; Froggatt (*Agri. Gazette,* N .S. Wales, 1902), records *Dielis formosa*, Guen., as an enemy of the beetle *Xylotrupes australicus*, Thoms., in Queensland ; the wasp burrows down to the grub in the soil, stings and paralyses it, lays an egg on it and goes away ; the larva on hatching devours the grub and pupates there. It is highly probable that our species have similar habits. The wasps visit flowers, not to obtain pollen but to feed on nectar.

Five genera and 87 species are recorded as Indian, of which nine are common in the plains.

Tiphia rufo-femorata, Sm., is a small black insect with red posterior femora, widespread but not very common. G. R. Dutt has ascertained that *Myzine dimidiata*, Guer. (known from male only), couples with *M. Madraspatana* Sm. (known from female only), and presumably they are one species.

Scolia includes large insects, thickly haired; *S. quadripustulata*, Fabr. (Fig. 103), is the very common species, black with the abdomen usually red on the side and sometimes across the upper surface. *Elis* falls into two series, according as it has two or three cubital cells. In the former are the common species ; *E. annulata*, Fabr., is very common, the female black with white pubescence, the male with yellow bands across the abdomen ; the latter are commonly captured asleep in the evening or early morning, on grass stems or plants, and it is no uncommon thing to see a number settling down for the night on a convenient cane leaf. *Elis thoracica*, Fabr., is the large black wasp that frequents cotton flowers, and which is, perhaps, an important factor in cross-fertilisation. *Liacos analis*, Fabr., is also common, black with a variable amount of red on the abdomen.

Fig. 103.—SCOLIA QUADRIPUSTULATA.

POMPILIDÆ (CEROPALIDÆ).

Pronotum reaching the insertion of the wings. Legs long.

The Pompilids are not a large family but contain some of the most conspicuous of the Aculeates. There are comparatively large forms, as well as very small ones. The colouring is sometimes distinctly warning, but not in all, the deep blue-black of *Pompilus analis*, for instance, not being of obvious utility. There are no striking structural features; the males are smaller, the abdomen with one more visible abdominal segment. The females have somewhat flattened forelegs in some cases, to fit them for burrowing and excavating in soil.

Fig. 104.- PSEUDAGENIA HONESTA.

The habits of some Indian species are known, but there is room for much observation. As a whole, these insects have the typical habits of *Fossores*, catching their prey, stinging it, laying it up in a convenient place for their young and depositing an egg there. Bingham states that "*Agenia*, *Pseudagenia*, *Paragenia* and, I suspect, *Macromeris* too, construct little earthen shells for nests." Others utilise available chinks or holes or make holes.

Macromeris violacea, Lepel., is a common insect, of whose habits practically nothing is known. Bingham records seeing a species carrying spiders, and G. R. Dutt has obtained clay cells (stored with spiders) under the bark of old trees, made of mixed mud and vegetable matter. *Pseudagenia blanda*, Guer., is a smaller metallic blue insect common throughout India.

G. R. Dutt has found that *Pseudagenia blanda* makes small earth cells under the bark of trees, the cells (filled with spiders), like those of *Sceliphron madraspatanum*, but smaller and always in pairs, the one cell smaller than another. From the larger cell the female emerges, from the smaller the (hitherto undescribed) male, the latter three days earlier than the former. It is apparent either that the mother wasp lays

Fig. 105.—Nest of Sceliphron coromandelicum occupied by Pseudagenia clypeata, × ½.

eggs of each sex alternately or that she can control the sex production, or that the greater amount of food stored in the one case makes a female imago.

Fig. 106.—Macromeris violacea var iridipennis; cell, × 1½.

We figure a large compound clay nest from which were reared *P. clypeata*. The nest consists of an old nest of *Sceliphron coromandelicum*, of which the cells were occupied by the *Pseudagenia*; since the latter requires a smaller cell, she divides the cells by a partition and then utilises them; but she also builds on additional cells round the old ones: in Fig. 105 the large cavities in the middle represent old *Sceliphron* cells. (the nest seen from below) the smaller holes round cells added by *Pseudagenia*. That the cells were originally made by *Sceliphron* is proved by the occurrence of a dead one in one cell. Hymenopterous and Dipterous parasites attack this *Pseudagenia.*

Salius includes a number of species, of which some are abundant. *Salius flavus*, Fabr., is the common yellow insect, the wings yellow with deep purple-black at the apex; it has been observed to store spiders in the ground. Bingham remarks that some store cockroaches or crickets in holes in trees.

The following notes record the observations of T. V. R. Aiyar, formerly Assistant at Pusa :—

From March to July this insect is the commonest of the bigger species of *Pompilidæ* in Pusa. It is found very generally in open meadows with a pretty hard soil and in such parts of the meadow where there are often found big holes made in the ground. Not uncommonly this insect is found under trees where the ground is covered by fallen leaves and twigs. In these localities it is found very busy searching holes for spiders; its active progression with its long limbs and occasional flight is very graceful to look at. With great patience it goes on visiting hole after hole. One has been watched searching every hole in half an acre in the meadow in the Botanical area for full two hours and a half with no success; at last finding the search fruitless, it flew away and perched on a distant tree.

Fig. 107.—Pompilus analis.

When, however, the *Salius* is fortunate and in its search comes across an inhabited spider hole, it comes out of it quickly and prepares itself for the affray. The preparation consists of a slight rest followed by the cleaning of the antennæ with the front legs and of the abdomen with the hind limbs. It then carefully enters the hole and disturbs the tenant. Within a second out come both the wasp and the spider. The extreme care displayed by the wasp in dealing with its antagonist is worthy of remark. As soon as it comes out of the hole, it goes a little distance away from it and then turns round. The spider which is commonly a pretty big ground spider comes out of its home and stands at bay at the mouth of the hole. It does so with the ferocity of a wild beast, with its erect cephalothorax and jaws (with the poison fangs) wide open. It never moves away from the hole until it is overpowered, but simply turns round always facing the wasp. Its action is entirely defensive. There is seen a series of tactics and movements displayed by the wasp, which appears afraid of the death-dealing jaws of the arachnid and so approaches with great caution. It turns round and round and occasionally tries to jump on the spider. The spider continues defending and for about 5 minutes the fight goes on. The fossorian, however, knowing the weak point of the spider, *viz.*, its inability to strike upwards, waits for an opportunity to jump on the spider. At last by a clever and agile jump it alights on the spider and takes it unawares. The moment it is on the spider, it never waits for a second, but applies the sting and inoculates the poison, first paralysing the victim's poisonous weapons from below. Then again it stings, thrusting the lancet along the side of the cephalothoracic shield. The spider being thus paralysed, the fight ends. In some cases the spider proves more than a match for the *Salius*, in which case the latter, after trying its best, gives it up and flies away. After making sure that the captive is helpless, it leaves it behind and goes searching for a convenient hole. In one case the *Salius* was clever enough to appropriate the hole of its victim itself. In this case it first enters the hole alone and remains alone for some time underground most probably inspecting the hole. It then comes back and making sure that the spider is paralysed, takes hold of one of its cheliceræ with its mandibles and walks back with its face towards the captive to the hole. When, on the other hand, it does not like the spider's hole, it leaves the captive and goes away some distance and begins to search for a convenient nest. In one case the wasp has been seen to leave the captive, go straight to a particular hole, not approaching any other on the way, and then come back to the spot where the spider was. From this it appears that the wasp keeps a hole ready before it goes in search of a spider. While it is engaged thus, it often comes back to the spider to make sure that it is safe in the original spot. At this stage if the captive spider is taken some feet away from the original spot the *Salius* comes back and then after strolling all round, it finds the spider and in this case it stings it once again and then drags it some distance forwards and there leaving it, goes again in search of a hole. Several times it visits the paralysed spider to be sure of its safety. At last it drags the spider to a hole and then it does not come out for a very long time.

Salius flavus is never found frequenting houses as it almost exclusively confines itself to catching ground spiders.

Pompilus is the largest genus with some widespread species, of which, perhaps *P. analis* Fabr. (Fig. 107) is the most common. T. V. R. Aiyar made the following observations on this species. This red and black wasp is found very commonly haunting the trunks of big trees, especially species of *Ficus*, which generally contain numerous holes and chambers inhabited by spiders. I have now and then found individuals on the walls of old buildings and also some hunting ground spiders, but I have not till now come across any nesting on the ground. The following were my notes on the habits of a specimen of this species :—

1st June 1906. As I was entering the lucerne field along the avenue close to the Waini road, containing clumps of bamboos, I heard a buzzing noise about me, and on turning round found a specimen of *P. analis* perch on the ground by my side and search holes. Watched the insect for about quarter of an hour. After some search it came across a hole very close to a small wooden post in the ground. It entered the hole and came back, followed by a big ground spider. Then ensued the usual fight. The combat was found to be exactly like that of *Salius flavus*. but with a display of greater fear on the part of the *Pompilus* and so additional care. After securing the captive, it disappeared for a few minutes and then came back to assure itself of the captive's safety as in *Salius*. This happened three times. On one occasion the spider moved a little when the *Pompilus* gave it a sting in addition to the ones administered during the combat. I found it impossible to follow it as it flew high up every time and disappeared, the black body and the transparent wings adding to the obscurity. In the end it took hold of the spider exactly like the *Salius* and began walking back. It directed its course across the avenue towards the bamboo clump on the side of the road. On reaching the clump of bamboos it began ascending one of these and then proceeded up for about 7 or 8 yards, when unfortunately it disappeared from my sight. I have very strong grounds for concluding that the wasp took the spider to a hollow in some bamboo, because although I have come across several individuals of this wasp dragging spiders, I have never found one taking a spider to a hole on the ground. It may be argued that the wasp dragged the captive up the bamboo and afterwards flew off with it, the burden being too heavy for conveyance to the nest without the vantage of an elevation to start from. But my having till now never seen any individual of this species nest on ground supports the former view.

The spiders which *P. analis* generally hunts on tree trunks and walls are web-spinning forms and compared to the ground spiders very small and powerless. In these cases the *Pompilus* finishes the fight very soon and at once drags the captive along the side of the tree trunk to an exposed hollow on the trunk ; it leaves its victim then and searches for a hole in the tree itself. Meanwhile, I have tried removing the captive and placing it on the ground below ; however, the wasp after some anxious search found it out and dragged it again up to the tree. This species also thus displays that power of finding out the paralysed spider if we remove the same and keep it away. When at last it finds a convenient hole in the tree to nest, it comes back and drags the captive home.

Aporus includes only three species, of which one, *A. cotesi*, Cam., may be found in the plains.

SPHEGIDÆ.

Pronotum transverse, not reaching the insertion of the wings.

This is a large family of Aculeata, with a great variety of forms. It includes large robust species with a length of an inch and-a-half and small slender insects not over a quarter of an inch long. The majority exhibit some form of warning colouration, bright yellow, metallic greens and blues, and similar bright tints predominating. The head is large, with ocelli and compound eyes, the trophi are well developed, not conspicuous, and the mandibles are robust. The thorax is massive, the abdomen often with a long petiole. The legs are of moderate length, the forelegs often modified for digging. Males and females are superficially alike, the latter having a well developed sting. As in all Aculeata, there is no free life history and none are social, the female storing food for the young. The larva is a white soft grub, without legs and with a small head. Pupation takes place in a silken cocoon.

Sphegids are the familiar digging wasps, whose prey consists of insects, stung to insure paralysis and laid up in this state in a suitable cell or burrow for the young to feed on. The process of stinging may be observed and is sometimes accompanied by other injury to the prey to insure its helplessness. So far as is known, the prey is, when laid in the cell, helpless, but not dead, and remains so until the grub attacks it; how far the permanence of this paralysis is due to the action of the wasp and how far it is induced also by the conditions in the cell is not known; a cricket stung by *Sphex lobatus* and laid up, presumably remains paralysed; but that cricket taken out and kept under other conditions may die if kept too dry or may to some extent recover under favourable conditions of temperature, moisture, air and light. There is no reason to doubt that paralysis is caused primarily by injuries inflicted by the wasp, usually in the form of a sting or several stings, which are directed against the nervous system and induce paralysis. The student will find accounts of some species below and further accounts in the literature mentioned. Horne described the habits of *Sceliphron* (Pelopœus) *madraspatanum* F. *S. bilineatus*, Sm., *S. violaceum* F. (P. bengalensis, Smith), *Trypoxylon rejector*, Sm., *Pison rufipes* Sm., and *P.* (Pisonitus) *rugosus*, Sm. There is a large field here for an observer gifted with patience and perseverance to add to our knowledge of the habits of these important insects. The actual economic importance of the group, so far as it can be gauged, is great since most of the species destroy insects of economic importance. It is, however, very difficult

Fig. 108.—SPHEX LOBATUS.

to estimate this since their work is not at onceobvious, and no estimates of number are easily obtained.

Sphegidæ are preyed upon by *Chrysidæ* and *Mutillidæ*, while the parasites of their prey indirectly check them because, in some cases certainly, when a *Sphegid* lays up a parasitised caterpillar, the parasite hatches and the Sphegid larva is deprived of its food. This is a curious fact and had we not observed it, we should hesitate to mention it. When we remember how large is the percentage of parasitised caterpillars very often, we may imagine that the Sphegid does often lay up parasitised caterpillars, which do not nourish their larvæ.

Astata agilis, Sm., though recorded from but few places, is probably widespread (Plate X, Fig. 4): it has been seen burrowing in sandy soil but its prey is unknown; it hunts usually among the decaying fallen leaves under trees.

Tachytes includes small and inconspicuous insects, nesting in soil and, according to Bingham, storing Orthoptera; *T. monetaria*, Sm., a black species with golden pubescence on the abdomen, is common, as is *T. erythropoda* Cam. (Plate X, Fig. 3).

Notogonia subtessellata, Sm., preys on crickets, storing them in burrows in the soil, or in the stems of plants (*e.g.*, in *Euphorbia neriifolia*) (Plate X, Fig. 7). This insect, which is the commonest of the genus in Pusa, is found very commonly in the vegetable garden and orchard, where the soil is fairly moist always. The reason apparently is that field crickets abound in these localities and the wasp is after them. The cricket generally hunted is a species of "Gryllodes" and very often not a full-grown one. In several cases the cricket escapes by its agile jumps, and it is only after allowing several crickets to escape that one is caught. The wasp paralyses the cricket by a sting (sometimes two) at the junction of the pro- and meso-sternum. It then drags the captive and leaving it in a prominent place, goes in search of a hole or to assure itself that its hole is ready to receive its prey. It soon returns and drags home the cricket. The process is different from that in a Pompilid. Here the wasp does not proceed backwards facing its captive, but instead poses itself almost above the captive and holding the antennæ by its mandibles proceeds forwards, both captor and captive facing one way. In this wasp there is distinctly a marked display of a high degree of instinct (intelligence ?) in taking advantage of an elevation to start on the wing with its pretty heavy load. The wasp drags the cricket to the foot of the nearest shrub or plant and slowly ascends to about a foot from the ground, and from there it starts on its wings with the prey. It continues thus often on its way to its nest, which is generally a hole on the side of the hard bank. An interesting point in the habits of this wasp is that it digs into the soil to find its prey even when the cricket has a burrow opening to the surface. On one occasion, one was observed flying over sandy soil; she selected a spot and commenced to dig ; when a little hole was made, she entered and came out carrying soil between her curved forelegs and her head, repeating this till there was a considerable heap of soil; this heap she then demolished by standing and kicking it away with her hind legs. While digging, a cricket came out from a hole by her, was eventually seen, pursued and captured.

Liris aurata.—This beautiful sand wasp is one of the most active among Sphegids. It is found in flower gardens and generally nests under thick bushes away from human observation. It is very often found haunting houses, especially store-rooms, in search of house crickets. The latter are notorious domestic pests attacking provisions, etc. This wasp, in frequenting dwellings, performs the part of an efficient natural check on these domestic pests. *Pison* includes small dark insects, of which *P. rugosum*, Sm., is common in the plains (Plate X, Fig. 9). Horne states that the nests of *P. rufipes*, Sm., are nearly globular, built in a group on a hanging creeper or tendril, and stocked with small spiders.

Trypoxylon (Plate X, Figs. 10-11) is common in houses, and I have seen *T. pileatum*, Sm., building in cane furniture in a verandah ; they are extremely slender graceful insects, storing small spiders in their mud nests : nests are also found in thatch, and on one occasion a female was seen plugging her nest, which was in a hollow reed previously utilised by *Ceratina viridissima.* The hollow is not lined but is partitioned off into cells, each containing small spiders (Fig. 109). *T. intrudens*, Sm., builds in holes in walls and in crevices in books.

Fig. 109.—TRYPOXYLON PILEATUM BRINGING A SPIDER TO HER NEST IN A HOLLOW STEM; THE NEST HAS BEEN OPENED TO SHOW THE CELLS. [F. M. H.]

Ammophila is larger, with a long narrow abdomen and a rather Ichneumon-like appearance. Several are very common and their habits have been observed. The habits of *A. lævigata*, Sm. (Fig. 110), are briefly described in Indian Insect Pests (page 271), this insect burying *Plusia eriosoma* larvæ in soil. So far as is known, caterpillars and spiders are their prey and they do not make mud nests but burrow in soil. *A. atripes*, Sm., *A. basalis*, Sm., *A. lævigata*, Sm., and *A. erythrocephala*,

Fig. 110.—AMMOPHILA LÆVIGATA.

Fabr., are the commonest species, but the distribution of some species is local. The last is a large robust insect, very unlike the remainder.

Sceliphron includes the more robust mud-wasps so commonly seen in houses, which lay up spiders in earthen cells. *S. madraspatanum*

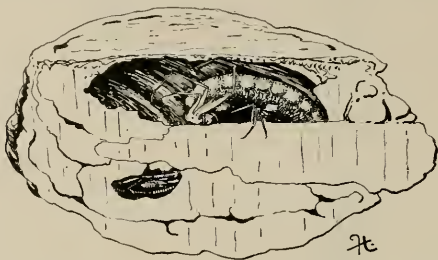


Fig. 111.—Sceliphron madraspatanum; nest removed from a corner and seen from behind; in one cell a larva feeding; in another a spider waiting to be eaten. [F. M. H.]

Fabr. (Fig. 113), is the commonest species; the female constructs mud nests, consisting of two to seven elongate cells, placed side by side; they are most beautifully constructed of mud and when unfinished are very striking objects (Fig. 112). But when the whole number are completed, stocked and closed, she puts mud over the whole in an apparently irregular manner but so as to give it the appearance of a rough lump of mud, when it is much less easily noticed. The nest is placed on a wall, a window-sill, on furniture or on tree trunks, and may be carefully concealed or in the open.

The cell is made, the first spider brought in and an egg laid on it near the base of the abdomen. The rest of the spiders are then brought; if the work cannot be completed before dark, a temporary mud cover is put on as the wasp does not sleep in the cell. When full, the cell is closed and a new one begun. The egg is white, soft, about 4 m.m. long. The larva on hatching feeds first on the abdomen of the spider it is on and then on its cephalothorax, proceeding afterwards to work upwards through the remaining paralysed spiders. (Fig. 111.) The larva is white, soft, leg-less, the segments indistinctly marked, the head very small : it becomes sordid-grey before maturity, when it measures about 14 m.m. Larval life occupies about 13 days, the

Fig. 112.—SCELIPHRON MADRASPATANUM INCOMPLETE NEST.

full length being attained on the sixth day. There are apparently no moults during larval life, the extremely soft and unchitinised integument not preventing expansion as in harder insects. The full-grown larva ejects a mass of black excreta at the bottom of the cell and then spins a tough cocoon of very fine yellow silk which turns dark brown. It rests for three to six days and then moults, placing the exuvium at the bottom of the cocoon where it often adheres to the hind end of the pupa. The limbs of the future wasp are symmetrically folded under the body and are free, being easily seen. The pupa gradually assumes the imaginal colour and on the twelfth or thirteenth day the imago emerges ; it cuts the cocoon and forces out the plug of mud that closes the cell, thus forming a circular orifice through which it can leave the cell. The total life from egg to imago is from 24 to 30 days, nest-making then occupies some time and there are probably five broods in one year in the plains. Hibernation takes place in the larval condition.

Fig. 113.—SCELIPHRON MADRASPATANUM.

This species, like others, is not allowed to work and increase unmolested but has enemies which prey upon it. *Chrysis fuscipennis*, Br., *Hedychrydium rugosum*, Sm., and an undescribed *Chrysis* are found in the cells ; a Tachinid fly, of which as many as six maggots are found in one cell ; a Bombyliid (*Hyperalonia sphynx*) is found in the pupal cocoon and in this case the pupa of the fly forces itself through the masonry so far as to allow of the emergence of the fly to the outside ; finally, a *Mutilla* has been once reared from this species, unfortunately only a male.

This wasp is the subject of a curious belief in the Punjab ; it has been noticed that it stores spiders and that eventually a wasp like itself is produced ; not knowing what occurs in the cell, it is commonly believed that the wasp has the miraculous power of imparting its shape and colour to the spiders, and that each spider reappears in the new form.

G. R. Dutt, who has studied this wasp at Pusa, once removed the cells of a nearly completed nest which only required covering with mud : the wasp had made two cells, and had commenced bringing mud to plaster all over them when this was done ; she however continued to bring mud and to plaster it over the marks left on the wall until she had produced the same appearance as she would have had the cells still been there, apparently unaware that the cells had been removed. The student should read the parallel cases described by Fabre, and translated in "Insect Life."

Fig. 114.—SCELIPHRON BILINEATUM CELL. × 2.

Sceliphron coromandelicum, Lep., is a large species of similar habits to the above. There are one to seven cells (rarely up to 12) in the nest, which is placed in buildings or on trees. It has similar parasites, and a Chalcid parasitises the Chrysid parasite, thus adding to the complicated fauna that centres round these nests.

S. bilineatum, Sm., is recorded from Western India, but occurs also in Behar. It constructs single cylindrical cells (Fig. 114) which it finishes by adding mud till the cell is smoothed over completely. The life history occupies about a month and this species is also extensively parasitised.

S. violaceum, F., is the common blue species which nests in houses, making no cell but taking advantage of natural holes, which it commonly closes with lime or plaster in preference to mud. It has been seen to utilise screw and nail holes in wood, bores in bamboos, the central hollow of a cotton reel, the tubular cavity of the handle of a cycle pump, and holes into which bolts were to fasten. It has also been found in the empty cells of *S. madraspatanum*, its larval cocoon being smaller than that of the latter. It is possibly the insect referred to in the following: Lahore Divisional orders:—The Ichneumon fly is particularly active at this time of the year, and the greatest care should be taken to prevent barrels of rifles becoming unserviceable from the rings of corrosion which invariably follow if the clay plug is not at once removed. The fly will build a complete nest within 24 hours, and every barrel should be looked through at least once daily to ensure its being free from this pest. (Statesman, 28th April, 1909.)

Sphex includes larger insects with a shorter petiole, best known from the very common green metallic species *S. lobatus* Fabr. (Fig. 108) which preys on the big cricket *Brachytrypes achatinus*, Stoll. Its habits have been described elsewhere (Journ. Bombay Nat. Hist. Soc., XV, p. 531); it has a curious habit of biting out a portion of the pronotum of its prey after it has paralysed it by stinging. It is seen actively at work from April to August; possibly the crickets are not sufficiently large before the end of April, necessitating a longer rest than that of other species.


Fig. 115.—AMPULEX COMPRESSA.

Ampulex compressa, Fabr., is a very beautiful insect, common in the plains. In Pusa this insect is purely arboreal in its habitat. The chief haunts are the trunks of old Peepul (*Ficus religiosa*) and

Fig trees, which possess numerous holes and chinks. It is not an uncommon sight to see an *Ampulex* hurrying along the tree trunk searching hole after hole for cockroaches and occasionally flying to a distant branch only to return and continue the search in a few seconds. As far as observed, this species confines itself exclusively to species of *Periplaneta* for its prey. The specimen of *Periplaneta* is invariably bigger in size than the wasp itself. This wasp does not construct any nest, but generally makes use of some empty hole on the trunk of the tree, wherein it drags its captive. The manœuvres employed in capturing and paralysing the cockroach are almost the same as in Pompilids, but here there is not so much careful tact and dexterity displayed on the part of the wasp in dealing with the cockroach. The reason apparently is that the cockroach is not armed with any poisonous weapons ; it has to depend solely on its active motions and irritating spines for defence. Unlike the Pompilid and spider fight, the scene of the combat often changes, the cockroach taking to its wings very often. The fight is simply a pursuit of the desperately flying blattid on the part of the wasp and the moment it manages to alight on the back of the captive, the latter submits. The wasp loses no time in administering the sting. The sting is thrust along the side of the big prothorax and reaches the œsophageal ganglia. The cockroach does not, however, appear much the worse after the sting, and if the wasp after this so-called paralysing strays away in search of a hole, the cockroach manages to slip away slowly into some adjacent hiding place. This has been observed more than once.

One species of *Stigmus* has been observed by Dudgeon to store Aphides in holes in wood made by a boring beetle. (Jo. Bo. Nat. Hist. Soc. XV, p. 12.) *S. congruus*, Wlk., and *S. nigripes*, Motsch., have been observed collecting aphids in Behar. *Gorytes alipes*, Bingh., is not uncommon in Western India ; we have observed it burrowing in the damp soil of flower pots, the burrows nearly two inches deep, and stocked with the very common Fulgorid, *Dictyophara lineata*, Don. *Gorytes pictus*, Sm., has been observed to visit the rolled up sissoo leaves inhabited by the larva of *Apoderus blandus* (Curculionidæ), but the observer was unable to determine that the larva was carried off. It is possible that, since the weevil larva is in a case, this species paralyses it and lays an egg on it, thus not requiring a nest.

Stizus includes wasp-like insects whose habits are unknown; *S. rufescens*, Sm. (Plate X, Fig. 12), is common in the plains, and sometimes comes in numbers to dig in the ground in flat places near houses.

Philanthus pulcherrimus, Smith (Plate X, Fig. 13). This wasp is common at Pusa during the months of March and April. It is usually found on flowering plants, on the flowers of which bees are also hovering. This wasp attacks them, stings them and then flies with them to the nest. The bee is held by the wasp below the thorax between the legs. Nests of this wasp are in sandy banks, and are in the form of long narrow tunnels. Females were observed bringing bees (generally belonging to the genera *Halictus*, *Ceratina* and *Apis*) to their nests and the choice seems restricted to the family Apidæ.

Bembex sulphurescens, Dahlb., is another wasp-like insect, robust, coloured in yellow and black. *Bembex* makes burrows, which it is believed to keep open, feeding the young daily with fresh Diptera; this is an interesting habit, and it may be hoped that the habits of the Indian species will be observed. This species is usually found flying over the soft sand by rivers, etc.

Fig. 116.—BEMBEX SULPHURESCENS.

Cerceris is stated to be predaceous upon beetles principally *Chrysomelidæ*, in India: they are small wasp-like insects; *C. pictiventris*, Dahlb., *C. instabilis*, Smith, and *C. flavopicta*, Sm., are the most common. *Oxybelus* is smaller with several species, none known to be widely spread. *O. squamosus*, Sm., has been observed by Purushottam Patel to collect the biting fly *Stomoxys calcitrans* and also the common housefly (*Musca* sp.), and carry them off to provision its nest which is in the form of an oblique tunnel in sandy soil.

Crabro buddha, Cam., is a small black and yellow species, which has been reared from pupæ in a tree. *C. bellula*, Cam., has been seen nesting in wet soil in a garden in Western India. *C. orientalis*, Cam., is similar, and has been reared from pupæ found in tunnels in a dry mango branch. The dry wood was bored through extremely thoroughly and contained large numbers of cells packed with Diptera ; a Mutillid (*Mutilla discreta*, Cam.), was reared from one of the cells. Bingham remarks that he saw a *Crabro* carrying off Aphides, as do the European species and this is likely to be the habit of some of the above species. Nurse records rearing *C. balucha*, Nrse., from hollow reed stems in which it had stored "houseflies." (Jo. Bo. Nat. Hist. Soc. XV, p. 16.) *C. ardens*, Cam., was observed in Pusa to have stored its nest with small flies and two species of *Crabro* were observed carrying off aphides from a Capsicum plant in a house.

EUMENIDÆ.

Wings folded longitudinally, middle tibiæ with one spine at the apex, the claws dentate.

These wasps include the small slender *Odyneri* measuring as little as a third of an inch in length and the large robust *Eumenes* which occa-

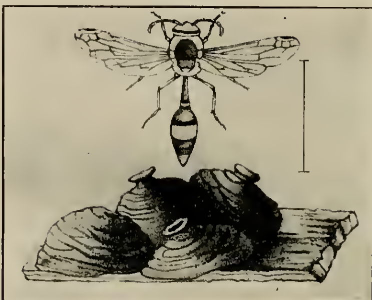


Fig. 117.—EUMENES ESURIENS WITH ONE FINISHED AND THREE INCOMPLETE CELLS (SIC).
(*From Horne.*)

sionally measure over an inch. The colouring is commonly warning and the females have a formidable sting. In some the petiole is well marked and long, in others it is less noticeable. The antennæ are of moderate length, with 12 joints in the male, 13 joints in the female. The pronotum reaches the base of the wings; the legs are of moderate length and slender. All are winged in both sexes and the females are commonly seen engaged in making or provisioning the cells for their young.

The life history of no Indian species has been really studied in great detail though the habits of some of the species are known. These insects have the habits of the typical stinging predators, paralysing insects with their sting and laying them up for their young to feed on. Our Indian species are solitary and make cells, not nests. They are beneficial in that they destroy caterpillars, but their influence is probably not very great as their numbers are not very large.

Bingham enumerates nine genera as Indian, of which all but three will be found in the plains. *Eumenes* is the important genus, containing the well-known "potters," which prepare mud cells in houses and store these with caterpillars. R. C. Wroughton describes rearing 11 cells, of which three yielded parasitic beetles (*Mordellidæ*), three *Chrysidæ*, two flies and only three were unparasitized and produced *Eumenes*.

An account of the habits of Indo-Malayan *Eumenidæ* by Mons. Maindron will be found in Ann. Soc. Ent. Fr. 1882, pp. 69, 169, 267 and 1885, 219; the latter refers to *E. petiolata* only. Horne also has notes on the habits of Eumenids. The readers should see the account of *Eumenes dimidiatipennis*, Sss., by Lt.-Col. Cretin (in Journ. Bombay Nat. Hist. Soc. XIV, p. 820), which is a model of what such observations should be.

Some are extremely common in houses and are a serious nuisance owing to the spots chosen for nest building. *E. petiolata*, Fabr., *E. dimidiatipennis*, Sss., *E. esuriens*, Fabr., and *E. conica*, Fabr., are common and may be looked for everywhere. *Eumenes conica*, Fabr., makes its mud cells on walls, window frames, cement floors, etc., in houses. A single nest consists of seven to ten cells, each of which is round in plan, semi-elliptica

Fig. 118.—EUMENES PETIOLATA.

in section. In making a cell, the wasp brings a pellet of mud and spreads it out in a curve; she brings more and more, working it all up into a wall rising from the base she builds on, and curving inwards till there is a small round aperture left; she then puts on a neat rim (Fig. 117) and the cell has just the appearance of the upper half of an ordinary Indian gylah (water-jar). Through the opening she slips paralysed caterpillars, usually green semiloopers (Plate X, Figs. 1, 2); if they are large, three to five is enough; if not, as many as eight are put in. The egg is laid before the caterpillars are put in and hangs by a thread from the roof of the cell; when the cell is stocked the rim is demolished and the cell closed; another is then begun above and when the full number are made, the whole is finished off with mud evenly. The wasp is very sensitive to disturbance and readily abandons the cells; if the cell is more than half stocked, the transformation still takes place though the wasp is of a much smaller size. When a cell is partly demolished and left undisturbed, the wasp will often repair the damage and in this respect she shows a much less fixity of instinct than does *Sceliphron* for instance. The complete making, storing and closing of a cell usually occupies one day.

The egg is a delicate white object, about 4 m.m. long and hanging by a stalk about 1·5 m.m. long. On hatching the larva puts out its head but does not leave the egg shell so long as it can feed from it; it attacks the nearest caterpillar and only when it has grown a little does it leave the egg shell completely. When it has eaten all the caterpillars it spins a delicate cocoon, pupates and emerges. The imago then cuts through the cell and escapes. *Chrysis orientalis*, Guer., *Stilbum cyanurum*, Forst., *Chrysis fuscipennis*, Br., and a Tachinid parasitise this species, and in one case every cell of a nest of ten contained a Chrysid. *Eumenes edwardsii* has been reared from a clay cell, oval with rounded ends, found on a blade of grass.

Rhynchium has similar habits, collecting caterpillars, and is found everywhere: the common species are *R. hæmorrhoidale*, Fabr., *R. brunneum*, Fabr., *R. abdominale*, Illig., and *R. nitidulum*, Fabr. The last makes a cluster of up to 25 oval cells coated with black gummy material in which are stored her prey. *R. brunneum*, F., stores her nest with the caterpillars of the Pyralid, *Marasmia trapezalis*, Guer. Chalcid parasites attack these species. (Fig. 119.)

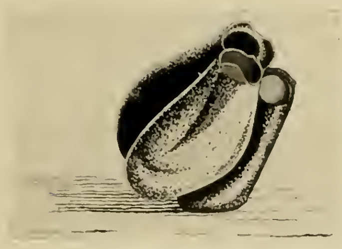


Fig. 119.—Rhynchium nitidulum nest.

Odynerus is believed to store caterpillars in holes or in small mud nests. Most are small insects, black and yellow in colour, without a petiole. A number of species are recorded, few of which are known to be widespread.

O. punctum, Fabr., and *O. ovalis*, Sss., are likely to be found anywhere in the plains. *O. punctum* has been observed by T. V. R. Aiyar to utilise the holes bored in chairs to fix the cane in, when the cane is broken and the hole empty; this hole she fills with small caterpillars, after which she closes it with mud. The same observer noted the latter carrying off the larva of the Groundnut Leaf Miner (*Anacampsis nerteria*, Meyr) to store in her nest.

Vespidæ.—*Wasps.*

Wings longitudinally folded in repose. Middle tibiæ with two terminal spurs; claws simple.

These are small to large insects, with warning colouration of an evident kind. The petiole is usually long and slender, the legs of moderate size, the pronotal angles reaching the insertion of the wings. The fore tibia bears a cleaning comb through which the antennæ is drawn, as is also the case in *Formicidæ*. The females have one more joint (13) in the antennæ than the males and one less abdominal segment (6) but are otherwise similar. In the majority of the species, social habits are observed; the nest may last more than one season, but in our common species this is not usually the case though

Fig. 120.—Icaria ferruginea.

successive communities may continue nests in the same spot. Workers, *i.e.*, imperfect females, are found in the more highly organised communities and a nest may contain a large number of individuals. Owing to the ferocity of their disposition and the virulence of their stings, precise observations have not been made into the habits of these insects in India and little is known of them.

Nests are commonly made of papery material consisting of chewed vegetable fibre. *Polistes hebræus* may often be seen working at dry

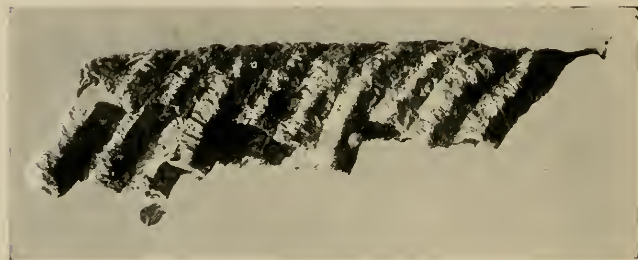


Fig. 121.—Nest of Icaria artifex.

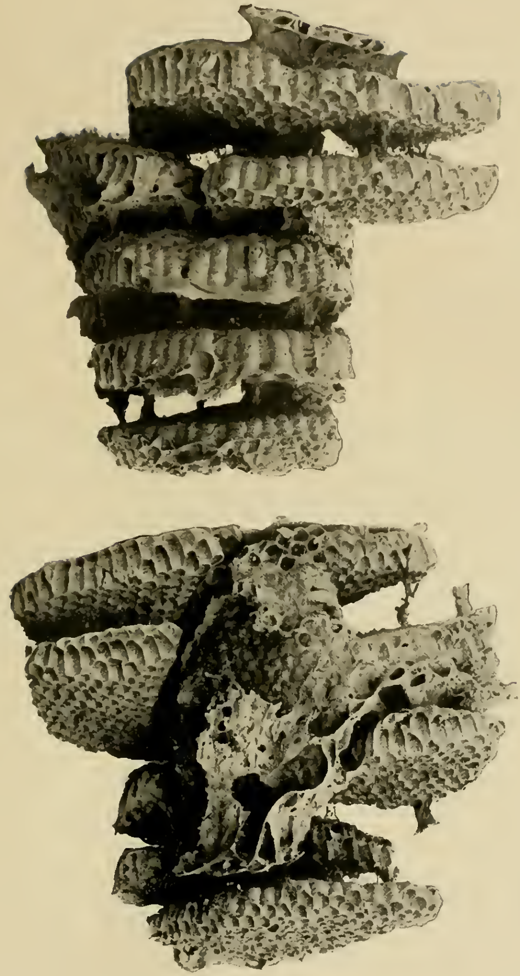
posts or trunks from which the bark has been stripped, first moistening a spot, then working off the fibre and taking it away. A nest consists of cells of hexagonal form, hanging with the opening downwards; in the simple nests of *Icaria* there are two rows of cells only; in the more complex nests of *Polistes*, the cells form horizontal combs, hung by stalks, and with a diameter of six or more inches in rare cases; there may be one comb below another but the combs are open all round. In *Vespa*, there is an envelope, the nest completely enclosed and with the combs inside clear of the envelope so that there is access to each comb all round; in others the comb is attached to the envelope and access is gained by a central space passing up through the combs.

The wasps feed on caterpillars, mantids, bugs, grasshoppers, beetles and other insects and some constantly seek for fruit juice, sugar, sweets and such material. The young are fed up on the crushed insects brought home by the parent or worker, but few details have been recorded. The number of caterpillars these wasps eat is apparently

PLATE XI.—VESPA ORIENTALIS.

Combs removed from the envelope. Reduced about three times.

PLATE XI.



VESPA ORIENTALIS.

very large indeed and large nests probably exercise a considerable influence in keeping caterpillars down. The females hibernate in shelter in the colder parts of India for about two months or longer and it is at this time they are found in houses. Wasps have a distinct economic value as predaceous insects but are in some cases not welcome neighbours. The "hornets" which attack persons in India are species of *Vespa* whose nest has been disturbed and their stings have been known to cause death.

Of this family, 7 genera and nearly fifty species are recorded as Indian. Bingham figures the nests of two species of *Ischnogaster*, one solitary, one social, and regards this genus as the link between the solitary Eumenids and the social Vespids (Journ. Bombay Nat. His. Soc. V, p. 244).

Icaria ferruginea, Fabr. (Fig. 120), is one of the common species in the plains; it is the red-brown wasp with the yellow band across the second abdominal segment found commonly in Bombay and the Central Provinces. The hanging nest consists of a small number of delicate elongate cells. (Fig. 121.) *Polistes hebræus*, Fabr., is the common insect making hanging nests in the verandahs of houses and in similar sheltered spots. This species has been to some extent observed; the fertilised females hide away in cracks and chinks in verandahs, roofs, trees, etc., in November; we have seen numbers of them flying about seeking a refuge and they fight freely when two are trying the same spot. Here they remain all the cold weather, emerging as the warm weather commences in March. In 1907 they emerged as early as the third week of February, as did other hibernating Aculeates. The female then builds the nest, lays eggs in it and rears the young till they emerge to help her; larger nests are then made and these may last until later in the year or new nests may be begun by single females at any time. This insect has been reported from Peshawar as being so abundant in the Field Telegraph Stores that these could not be removed and as rendering houses uninhabitable in the Deccan by nesting in the verandahs. The nests are the habitat of a Pyralid larva (*Hypsopygia Mauritialis*, Guen.) which feeds on the larvæ (see below).

Polistes stigma, Fabr., is the only other common species of this genus and it has been observed to nest in trees. Next to the yellow wasp (*P. hebræus*) this is the commonest of the genus in Pusa and the only other species often come across. We have found this insect attaching its slender paper nest made up of five or six hexagonal cells to the branches of trees overhanging the river.

Vespa includes the large wasps common in towns at sweetmeats and wherever sweet stuff is to be obtained. *Vespa cincta*, Fabr., and *V. orientalis*, F., are the common plains species; the very large *V. magnifica*, Sm., and *V. ducalis*, Sm., are notable hill species. *Vespa cincta*, Fabr., is not as common as *V. orientalis*, F. It is found generally in thick forest. It makes its nest in the holes of big fig and other forest trees and has been observed to attack the nests of *Polistes hebræus* and carry off the larvæ from the cells, the *Polistes* making no opposition.

Vespa orientalis, F., has also been observed hiding away for the winter in holes in buildings. Bingham states that the nests are in trees or at the foot of a tree or attached to the beams of a house. Their stings are, as he remarks, very painful and to be avoided if possible. There are many obscure points about this insect and we would like to see it properly investigated. It is the commonest of the species in India and is fond of selecting old buildings and walls to construct its combs (Plate XI) when many individuals are employed in the work. These nests are sometimes very large and extend far into loose masonry in old buildings, the communities being very populous. They are, in the colder parts of the plains, abandoned yearly, the fertilised females hiding away till the cold passes and then starting again ; in this way the same nest may be tenanted year after year. In sweetmeat stalls in bazaars this is a pest, perching on the exposed sweet stuffs in numbers, but it is curious to find that it injures no one, though driven away now and then.

Colletidæ.

Tongue emarginate at apex, short and broad.

This is a small family of somewhat rare insects which are not social. They are of small size, all black in colour and inconspicuous. Two genera and ten species are known from India and of these none can be regarded as common or widespread in the plains. *Prosopis mixta*, Sm., is perhaps the most common and will probably be found more widely.

Nine species are included in this genus and a single *Colletes* (*C. dudgeonii*, Bingh.) has been found in Sikkim.

Apidæ.—*Bees.*

Tongue acute, not emarginate. The thorax with branched hairs, the basal tarsal joint dilated.

It is not always easy to recognise a bee at a glance and a fair knowledge of other Aculeates enables one, by elimination, to place doubtful forms. Actually the group is not well defined structurally though it is so on a combined appreciation of habits and structure. Bees are of small to moderately large size, their colours often dull, often more or less warning. The head is well developed, usually with three ocelli; the antennæ are of moderate length with a scape and a flagellum; the mouthparts are of varied form but include a pair of cutting mandibles, a lower lip and maxillæ which form the tongue, often very long, and two pairs of palpi; there is great variety in these mouthparts and they are of value in the classification. Bees utilise their trophi in a great variety of ways which are really very little understood but they are essentially modified biting mouthparts of great complexity with the lower lip functioning as a lapping organ for imbibing liquid. The thorax forms a compact mass and is highly chitinised; the abdomen is oval, the petiole short and not noticeable. The ventral surface bears the *scopa* or pollen-collecting brush in those species which collect pollen in this way. The legs are short, hairy and the hind tibia and basal joint of the tarsus are dilated and densely pubescent for carrying pollen. The use to which most aculeates put the hairs is for cleaning antennæ and other parts; pollen-collecting hairs may be modified cleaning hairs.

The *Apidæ* include social and solitary species, the social instinct being well developed in *Apis* in particular though perhaps to a less degree than in some Termites and ants. The majority have essentially the same habits and life history; the females collect nectar and pollen of flowers to feed themselves, to feed their young or to store up for the benefit of their young. A minority are parasitic, laying their eggs in the nests of their more energetic food-storing brethren.

In the simpler cases, as in *Megachile*, each bee makes a solitary nest, preparing one cell at a time, filling it with a paste of honey and pollen, and laying an egg in it; we then find species which live in a common burrow with separate cells, (*Halictus*) or which prepare a number of cells in one place and have a "nest" which suffices for one or more complete broods (*Xylocopa, Anthophora*); finally we find the higher social forms in which a nest contains not only sexual individuals but imperfect winged females which carry on the nest, the reproduction being limited to a small number of individuals, and the multiplication of nests taking place in the highest forms by the joint efforts of workers and sexual individuals. *Xylocopa* is an instance, but in this genus the community lives for one year only, the impregnated queens living over the winter; the honey bees are the highest social forms, with however only three classes of individuals. males (drones), females (queens) and imperfect females (workers); in these forms the nests are more permanent, and continue for an unknown period in some cases, or if the actual comb is deserted, the community goes on. In all cases the larva is helpless and must either be fed or be provided beforehand with a supply of food, either for its own use or that of its host if it be a "parasite." There is thus no free life history and the activities of these insects are confined to the adults.

With nearly thirty genera and a large number of species it is impossible to mention more than those species which are likely to be found generally in the plains. The student must consult Bingham's Fauna of India for descriptions of species.

Halictus is a small bee with many hill species, and a few plains ones which nest in wet soil. The presence of an anal rima in the female distinguishes them. *H. senescens*, Sm., is a common plains form.

Nomia is the next genus (we omit *Sphecodes* and *Andrena*) containing common insects: *N. elliotii*, Sm., and *N. oxybeloides*, Sm., are black with silvery white pubescence; the known species nest in earth, carrying pollen on their hind legs to stock the cells. The nests of *N. westwoodi* are found in damp soil in flower boxes and gardens, about four inches below the surface. *Lithurgus atratus*, Sm., is the bee that visits cotton flowers so persistently; the habits of *L. dentipes*, Sm., are described by Horne (Trans. Zool. Soc., VII, p. 175).

PLATE XII.—Megachile Anthracina.

The Black Leaf-cutting Bee.

Fig. 1. Part of a series of leaf-cells taken from a hollow branch.

,, 2. A single cell opened to show the larva feeding on the pollen-mass.

,, 3. Full-grown larva.

,, 4. Cocoon, after the leaf covering is stripped off.

,, 5. Cocoon, after emergence of the bee.

,, 6. Imago, female.

,, 7. Leaf of Pigeon pea (*Cajanus indicus*) from which an oval side-piece (above) and a round end-piece for the cell have been cut.

,, 8. Complete series of eight cells in a tunnel in a branch; two of last year's cocoons, without leaf covering, are shown beside.

,, 9. Imago, male.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Megachile includes the very familiar bee that builds mud cells in our houses in any tubular cavity that offers itself. The work of the leaf-cut-

Fig. 122. Cells of Megachile lanata, × 1.

ting species is well known, though we doubt if many people have seen these insects at work. *M. anthracina*, Sm., is the common leaf-cutting bee of the plains, which cuts neat pieces out of the stiff leaves of rose, *Bauhinia* and pigeon pea. These it takes away to line its cells, which it fills with pollen paste. We figure the cells of these species found in a tree. (Plate XII.) A point of interest in this species is that it is found as an imago only after the rains, *i.e.*, October and November. In captivity the larvæ rested from December to September in the cell. This is the case in Behar, but it may not be true of all India. *M. disjuncta*, Fabr., is also common and makes mud cells filled with paste. It has the base of the abdomen covered with whitish pubescence. The commonest species is *M. lanata*, Fabr., with base of the abdomen red-brown; this builds the mud cells (Fig. 122) in houses and also, as does *M. disjuncta*, in soil. In the former case, a mud cell is made, in the latter case, a casing of leaves is applied to the sides of the burrow direct. It is common both in the dry hot weather and after the rains. *M. conjuncta*, Sm., makes its leaf cells in a hollow bamboo. *Megachile lanata* is attacked by mites, which fix themselves to the larval integument and draw in fluid so that their abdomen becomes immensely dilated after the manner of the 'honeypot' ants (*Myrmecocystus*).

Parevaspis is a parasitic bee found in the nests of *Megachile*; *Parevaspis carbonaria*, Sm., is the common Indian species. *Ceratina viridissima*, D. T., is the delightful little metallic green bee that tunnels in dry stems and lays up food there; it is common throughout India. (Plate XIII, Fig. 4.) The pupa is not in a cocoon but simply lies free in the cell separated by a wall of fibre from its neighbours. (Fig. 123.) The egg of *Ceratina* (like that of some other insects) increases in size after it is laid, from about 2 m.m. to over 3·5 m.m. in length; a chalcid parasitises the larvæ, four having been found in one cell as pupæ. The larval period is from 9 to 13 days, the pupal from 13 to 18 days in October, November. G. R. Dutt has found a cell in a hollow twig in thatch containing two larvæ, the cell sealed with black wax, which he reared to *Heriades parvula*, Bingh. This little bee is comparatively rare but occurs in Behar as well as in Burmah.


Fig. 123.—CERATINA VIRIDISSIMA PUPA IN CELL AND EMPTY CELL. [F. M. H.]

Coelioxys includes the black bees with rather sharply tapering abdomen that one sees hovering around walls and buildings. *C. basalis*, Sm., is said by Bingham to be parasitic upon *Megachile lanata*. *C. decipiens*, Spin., is the second common species.

Crocisa is said to be parasitic upon *Anthophora* and there is a resemblance in build and colour between them; of the former, *C. histrio*, Fabr., and *C. ramosa*, Lep., which are conspicuously black and white are common; *Anthophora* nests in the soil; *A. zonata*, Linn., and *A. violacea*, Lepel, are likely to be found. (Plate XIII, Figs. 5, 6.)

Xylocopa includes the familiar large carpenter bees which make tunnels in hard dry wood; they are large, usually black insects, with dark wings and are distinctly the largest of the bees in the plains. *X. æstuans*, Linn., in which the male is covered in yellow pubescence, the female in black, is the very common species, whose nests may be seen in posts and beams. (Plate XIII, Figs. 7, 8.) *X. fenestrata*, Fabr., *X. amethystina*, Fabr., and *X. iridipennis*, Lepr., are also common. *Xylocopa* *tenuiscapa*, Westw., in Ceylon is, according to Green (Ent. Mo. Mag., 1902, 232), the host of the Cantharid, *Cissites Debyi*, Fairm. He also figures there the cavity in the base of the abdomen in which lives the Acarid parasite *Greenia Parkinsi* Oudem.

Bombus, the "Bumble-bee" of Europe, is entirely a hill species and the beautiful Bombi one sees in the hills do not descend below 3,000 feet. (Plate XIII, Fig. 9.)

The species of *Apis* are the common honeybees, three species occurring in India wild. These are readily distinguished, so far as the workers go, by their size. *A. dorsata*, Fabr., being the largest, *A. indica*, Fabr., the medium sized and *A. florea*, Fabr., the smallest. While all three are common in India, they do not all appear to occur together; *A. dorsata* is the big bee that builds large nests in the forest and away from cultivation; *A. indica* is common generally in trees, as is *A. florea*, which in the plains of India is very often found making its single combs in any convenient position on a building. Bingham mentions *A. indica* as the commonest bee of Burmah, but *florea* is at least as common in India and its nests are far more often seen.

A great deal can be written about these bees and the reader is advised to consult Horne's article in Trans. Zool. Soc., 1879, VII, p. 181, as well as Hooper's Agricultural Ledger on bees-wax. An English abstract of Castets' article on bees of South India (Revue des Questions Scientifiques, Brussels, October, 1893) will be found in the Tropical Agriculturist, January, 1908, p. 48. It is of interest as containing an account of the wild bees, as also of *Melipona* (Trigona) *iridipennis*, Smith. For practical directions in bee-keeping in India Douglas' Handbook of Bee-keeping in India (1884) should be consulted.

Bees collect pollen from flowers, as well as nectar, and some collect a resinous matter from buds, from bark and other parts of plants. On the two former they feed themselves or their young; with the latter they make the nest tight. Wax is a secretion produced by young bees and used to make cells for honey and comb. About 16 to 20 pounds of honey is said to be eaten by young bees to yield one pound of wax.

Melipona is distinguished by having one cubital cell in the forewing only; it includes the small bees which build nests in trees and cracks of buildings; they are often called Dammar bees from the dark resinous matter they use in making their nests. *M. vidua*, Lep., is apparently the only Indian species at all common and the genus is probably found almost wholly in forest localities. Horne has remarks upon the habits of *M. smithii*, Bingh., (*Trigona ruficornis*, Sm.), which he found at Benares.

INSECTS AND FLOWERS IN INDIA.

I. H. Burkill.

The Xylocopas are the most important of flower-visiting insects in the plains of India, and are of very general distribution. They have large size and long tongues, and they visit persistently all day, and some of them also on moon-lit nights. The Sunn hemp crop is largely fertilised by them, and possibly the Indian pulses. Cassias in Calcutta are commonly visited by one of them and many large showy flowers.

The place of *Xylocopa* in the plains is, in the hills, taken by *Bombus*, whose methods of work, degree of persistence, etc., are more or less completely known from studies in Europe. *Bombus* ascends to the snows visiting Aconites, balsams, the small honeysuckles, etc., which grow high up.

The genus *Anthophora* has species both in the region of *Xylocopa* and the lower part of the region of *Bombus* ; one of its species, *A. zonata*, does great service to plants in the plains, being a diligent visitor often to flowers a little less showy than *Xylocopa* seeks, such as the Labiate weeds of India, and to flowers into which it creeps such as *Costus speciosus* or *Ruelia*.

Of Apis the three Indian species are important. They all seem to have the persistence of the hive bee, keeping generally to the same species of plants at one spell of work, and they are all diligent ; but they cannot work so fast as larger insects. Whereas *Xylocopa latipes* was observed to visit 30 jute flowers per minute and *Xylocopa æstuans* to visit 35 jute flowers per minute, *Apis florea* visited about 10—15 flowers per minute (see Journ. Asiatic Soc. Bengal, 1906, pp. 516 and 518). The rate at which *Apis florea* works on the extra-floral nectaries of cotton is about 16 fruits per minute. The short tongue of *Apis florea* sends it to comparatively insignificant flowers. It is common in places on *Corchorus* (jute), *Evolvulus* and other flowers about as broad as the insect is long. In the drier hills *Apis indica* is a very important flower-fertilising insect, especially where, as behind Simla, it is domesticated.

The effect of the water-logging of Eastern Bengal on the flower-visiting insect fauna might be very interesting to study ; Xylocopas nesting in trees, Apis dorsata, Apis florea, etc., persist ; but the ground nesting species cannot.

PLATE XIII.—MUTILLIDÆ AND APIDÆ.

Fig. 1. Mutilla poonaensis, cocoon.
,, 2. ,, ,, female.
,, 3. Steganomus nodicornis.
,, 4. Ceratina viridissima.
,, 5. Crocisa ramosa.
,, 6. Anthophora cingulata.
,, 7. Xylocopa æstuans, female.
,, 8. ,, ,, male.
,, 9. Bombus tunicatus.


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The habits of the flower-visiting shorter tongued bees are for India quite unstudied. *Halictus* is common enough in some places and *H. senescens* is recorded from Behar as having some connection with the pollination there of cotton. It is worthy of passing remark that in Europe some of these short-tongued bees have been found to have the very closest inter-relations with particular species of plants. For instance, Bryonia is visited by a Halictus and by little else, and the *Halictus hardly visits* anything else, but the Bryonia flowers. The tongue of *Prosopis* is very short indeed.

Among the wasps, we find both long and short-tongued species ; *Odynerus* for instance is long-tongued. *Vespa* short-tongued. *Vespa* seems to be not unimportant in the pollination of Chiretta (*Swertia Chirata*) in Sikkim. The long-legged, slow-moving *Polistes* of the plains go to exposed honey. Sphegids, Pompilids and Scoliids may be seen in India at exposed honey.

Of Lepidoptera there are many common plains species which doubtless do a considerable amount of flower pollination, *e.g.*, *Danais*, *Terias*, etc. They seem to require a good deal of liquid during the day but often much of it is merely water taken from a wet mud bank. The least inconsistent in habits are perhaps the Sphingids, which are not uncommonly to be seen flower visiting both by day and by night. Possibly some *Hesperiids* are also in a measure not inconsistent in their flower visiting.

Diptera in the plains seem to play but a small part in flower pollination. It is different in the Himalayas where large Bombyliids join the Bombi in going to rather specialised flowers, and where out of the *Syrphidæ*, *Rhingia* and *Eristalis* are not uncommon. Tachinids also have some importance in the hills, but perhaps not in the plains. It is to be assumed that our large evil-smelling Araceæ attract muscids, but so far no thorough investigations have been made. A little beetle crawls into a foul-smelling *Typhonium ?* which grows in Lower Bengal.

Bibionids are often common on flowers in the hills and Anthomyids not frequent both in the hills and the plains.

Of the relations of other insects to flowers there is really nothing to remark : and it may be added here that there is an uninvestigated field in the study in India of flower pollination by birds. Birds at times visit for honey, and at times for small insects lying hid within the flowers. Keeble's account of his observations on bird-pollination of *Loranthaceæ* in Ceylon (Trans. Linn. Soc. Bot. V, pp. 91-96), and a few remarks by Lieutenant-Colonel D. D. Cunningham in his "Indian Friends and Acquaintances," p. 130, comprise all that has been put on record. (The student should also consult Mr. I. H. Burkill's papers in the Journal of the Asiatic Society of Bengal, 1906, onwards.)

FORMICIDÆ.—*Ants.*

The basal one or two segments of the abdomen are in the form of detached nodes.

Ants are sufficiently familiar but the above character is occasionally required to verify the fact of a specimen really belonging to this family. They are in general small insects, of dull colouring, usually brown or black; in only a few is the length greater than a quarter of an inch and these large forms will be taken for wasps. The head bears antennæ which have a long basal joint (scape) and a number of short joints (flagellum); in the males of some species the scape is short. The mouthparts are small, the mandibles often of peculiar form. The thorax is much modified in different species and in different forms of the same species. The legs are long and most species can run actively. The abdomen is distinct, in the female and worker of six visible segments, in the male of seven, and is usually larger in the female.

FIG. 124.—SOLENOS ISPGEMINATA, WORKER.

Ants are social, living in communities in which there is a considerable amount of specialisation of forms to serve the purposes of a useful

FIG. 125.—CAMPONOTUS COMPRESSUS, WORKER MINOR, × 3.

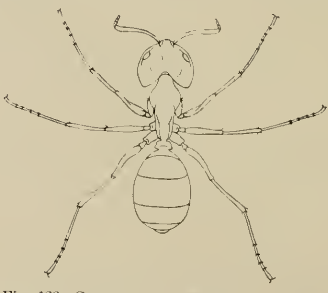


FIG. 126—CAMPONOTUS COMPRESSUS, WORKER MAJOR, × 3.

division of labour; the nest commonly consists of males and females, with various forms of workers; the degree to which this specialisation goes, varies very much with the species. Commonly there are two or three forms of workers, the soldier with large head and mandibles, the worker, major and minor, with more normal structure. A nest may consist of a greater or smaller aggregation of individuals and there are a few species which share the light-shunning habits of Termites, most nesting in soil, trees, etc., but working in the light.

In habits there is the greatest diversity; we cannot discuss this subject in this place nor have we much that is original to add to the little that is known. The reader should consult the following papers:— Jerdon (A. M. M. H. (2), XIII, pp. 45, 100); Wroughton (Jo. Bo. Nat. Hist. Soc., VII, pp. 39, 179); Rothney (Trans. Ent. Soc. London, 1889, p. 355); (Jo. Bo. Nat. Hist. Soc., V, p. 38); Rothney (Trans. Ent. Soc. London, 1895, p. 211); Aitken (Jo. Bo. Nat. Hist. Soc., IV, p. 151; V, p. 422); Green (Proc. Ent. Soc., London, 1896); Green (Jo. Bo. Nat. Hist. Soc., XIII, p. 181).

In general, the ants are scavengers, the workers bringing to the nest the food for the whole community. This food consists of dead insects,

Fig. 127.—CAMPONOTUS COMPRESSUS, MALE, × 3.

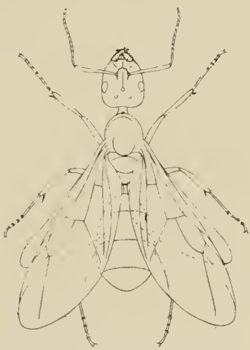


Fig. 128.—CAMPONOTUS COMPRESSUS, FEMALE, × 3.

any available nutritious animal matter, the sap of plants, any nutritious vegetable matter that can be obtained; in this sense ants are excellent scavengers and as they are practically everywhere in the open, they serve an extremely useful function. In some species this habit is specialised in one direction ; some are "harvesters," storing in their nests seeds of grasses and small millets, occasionally even that of rice. *Holcomyrmex*, *Messor*, *Phidologiton* and *Phidole* are the best known harvesting ants and these live entirely in this one manner. In others the "agricultural" habit takes another form and what correspond to our "cows" are kept and milked ; the latter are insects which suck the sap of plants and yield a sweet excretion which the ants remove ; Mealy bugs (*Coccidæ*), Green Fly (*Aphidæ*), *Psyllidæ*, *Membracidæ* are the important groups of "cows," while the larvæ of many Lycaenids are attended by ants and yield excretion. *Camponotus*, *Cremastogaster*, *Cataulacus* and *Œcophylla* have this habit as part of their activities and the care they take of their cattle is in some cases very marked : it is no uncommon thing to see a shelter built over a colony of mealy bug, and in South India *Lecanium formicarii* is found only under hard shelters erected by ants on trees. Other ants are predaceous and carnivorous, going out on foraging expeditions to seek live food, such as insects. Though termites live retired, they are attacked violently by some kinds of ants (*Lobopelta*). Rothney states that in Madras, two ants (*Monomorium salomonis*, Linn., and *Solenopsis geminata*, Fabr.) are deliberately introduced into warehouses to check the depredations of white ants. This practice is not uncommon in Northern India and the Natives of India are familiar with the kind of ant which should be brought in. The *Ponerinæ* and *Dorylinæ* include hunting ants, though one species of *Dorylus* has also the termites' habit of attacking plants underground.

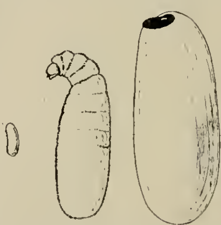


Fig. 129.—POLYRHACHIS SIMPLEX EGG, NYMPH, PUPAL COCOON, × 5.

The life-history is known in a general way but not in detail : the eggs are laid by the female and tended by the workers in the nest ; the larva is a white helpless grub without legs, which is fed by the workers and is itself incapable of exertion. These larvæ and pupæ are found in galleries in the nests, and one may often see the nest being moved, the little white larvæ and pupæ being carried by the workers. In some, the pupa is free, in others in a silken cocoon which the larva itself prepares.

An interesting feature of ants, especially of the fiercer and more war-like species, is the fact that they are mimicked by other insects extremely closely. *Sima rufonigra* is mimicked by a Sphegid *Rhinopsis ruficornis*, Cam., in Barrackpore and by *Rhinopsis constanceæ*, Cam., in the Konkan. It is also commonly mimicked by a spider, as is *Sima nigra*. Wroughton records the mimicry of a species of *Polyrhachis* by the nymph of a Coreid bug *Dulichius inflatus*, Kby. (Proc. Ent. Soc., Lond. 1891, p. XVII).

Bingham lists the Indian species in Vol. II of the Fauna of India. Hymenoptera. based on Forel's papers (Jo. Bo. Nat. Hist. Soc., VII, etc.). In this volume 498 species are enumerated as Indian, of which those mentioned below are common in the plains with a fairly wide distribution.

Dorylinæ.—Male large and wasp-like; workers blind, subterranean. Female apterous, blind and like a queen termite. Pupa in a cocoon. Worker with a sting.

Fig. 130.—DORYLUS ORIENTALIS WORKERS.

There are two common genera, *Dorylus* with one-jointed pedicel, *Ænictus* with two-jointed pedicel in the workers. *Dorylus* makes its

Fig. 131.—DORYLUS LABIATUS, MALE, × 1½.

nest below ground and behaves much like a termite. *D. orientalis*

Westw., attacks plants, eating them below or at the level of the soil. The workers have been observed to attack the workers of *Pheidole indica* and carry them off to their nest, where they were killed and cut into pieces. The males come to light and they are common towards the end of the cold weather in late February. *Ænictus* is a hunting ant. (Jo. Bo. Nat. Hist. Soc., VII, p. 177.)

Ponerinæ.—A constriction between the two basal abdominal segments ; sting powerful, exserted.

Lobopelta is said to make a sound ; it feeds on termites. Rothney remarks of *L. diminuta*, Sm., that it marches in two long lines in files of two. *Diacamma vagans*, Sm., was found to be common at Barrackpore by Rothney, nesting under stones or brick-work ; the sting is said to be "pungent." G. R. Dutt has observed it nesting in soft soil at the base of a big tree in Pusa ; outside the nest were several heads of workers of *Camponotus compressus*.

Myrmicinæ.—The pedicel two-jointed in all the forms. Pupæ not in cocoons.

Myrmicaria nests at the foot of trees with a kind of embankment round it. *Cremastogaster* is a tree ant, making globular nests of papery

Fig. 132.—CREMASTOGASTER DOHRNI ; NEST AND WORKER. [I.M.N.]

material, or nesting in hollows in trunks or branches; nests were found in Mantid egg cases, the eggs having been partly removed. It has a habit of turning up its abdomen over the body as if threatening to use its sting. It bites freely and is stated to keep "ant cattle." *Monomorium destructor*, Jerd., and *M. pharaonis*, Linn., like some later species, are widespread over the tropics and have probably been carried by shipping. *M. indicum*, Forel. is not uncommon in buildings in the rains, nesting in cracks in the masonry. *M. gracillimum*, Sm., is found in houses in thatched huts and on trees. A nest was found in the excavated pith of a dry stalk of Sann Hemp in the wall of a thatched hut; they have a very painful sting and are a decided nuisance in houses. They attend mealy bugs on plants and also carry off flour, fat, etc., from store rooms. *Holcomyrmex scabriceps*, Mayr., is the familiar harvesting ant of the Punjab, which gathers seeds of grass and millets into its nests and stores them in galleries. The nest is easy to find as there is a ring of chaff round it at a little distance and the ant's roads can be followed to the nest from some distance. Comparatively large quantities of seed can be extracted from a nest and, in times of scarcity, this grain is dug out of the nest and used as food. We have seen a pint of seed taken out of one nest .

Solenopsis geminata, Fabr., is the brown ant of India, nesting usually in the ground. *Phidole rhombinoda*, Mayr., is stated by Rothney to surround its nest with the leaflet of a mimosa, as a protection against the sun. *Sima rufo-nigra*, Jerd., is very common in India, nesting in trees. The sting of the female is, according to Rothney, "the most painful of any Aculeate I am acquainted with." This virulent insect appears in May. Nests have been found also in hollows in bamboos with neat round exit holes at intervals. *Sima alloborans*, Web., nests in young shoots of bamboos and in tree trunks; when disturbed, the ants discharge a drop of white liquid.

Cataulacus includes sluggish ants of a jet black colour; *C. taprobanæ*, Sm., nests in hollow bamboos and *C. latus*, For., in the branches of teak and siris trees.

Dolichoderinæ.—Tapinoma melanocephalum, Fabr., has once been found to be injurious under peculiar circumstances. The workers were found in large numbers in small temporary chambers at the base of young tur plants (Cajanus indicus) grown for inoculation with wilt in a special plot; these plants they ate into just below the soil level, eating right into the stem and through to the bark till the plant fell over, cut completely off; as much as half an inch of stem would be completely eaten and the object apparently was, not the removal of the plant but the actual soft stem for food. Plants that had been inoculated were most attacked, and it is possible that the tissues were specially attractive on that account. As a rule, this ant feeds on anything sweet and visits Aphides and Coccids constantly. The nests are underground, very deep and populous.

Iridomyrmex anceps, Rog., nests in sandy soil near plants infested with aphids, and there are regular tracks to these plants; the nests are deep and several minor ones are often connected to a larger central one, the workers freely entering all. The eggs and larvæ were found abundantly in February at a depth of one inch, sparingly in July at a depth of nearly a foot. The workers emit an unpleasant odour; they visit aphids, coccids, membracids, etc., the glands of *Cassia orientalis*, and also carry off dead insects.

Camponotinæ.—Pedicel with one joint. No definite sting, the poison being ejected from the orifice at the apex of the abdomen. *Oecophylla smaragdina* is the familiar red tree ant of India, which makes large nests in trees, often enclosing mealy bugs in a covering of webbed leaves. The green females are found yearly in June starting fresh nests on plants, and these nests can be easily observed from the commencement. The workers are very active and fierce, collecting all manner of dead insects and even living ones if these are inactive; caterpillars are attacked, cut up and carried off to the nest in pieces. A colony will have many small depots on one tree, each consisting of a number of leaves webbed together and containing a colony of

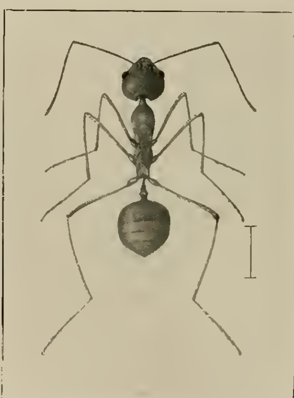


Fig. 133.—OECOPHYLLA SMARAGDINA WORKER.

Coccids or a store of dead dry insects. If one is opened and patiently watched, it will be seen that the workers draw the leaves together by their mandibles and legs, while others, from inside, web them together with silk produced from a larva held in the jaws. This is a really extraordinary sight and may be seen at any time.

Acantholepis frauenfeldi, Mayr., var *bipartita* nest in soil at the foot of trees, or in hollows in masonry. They visit Aphids and Coccids, and also collect dead insects. *Prenolepis longicornis*, Latr., is widespread in the tropics; the nests are under fallen leaves or in decaying tree trunks and contain *Paussidæ*.

Polyrhachis simplex, Mayr.—Nests of this species are found on low bushes, high trees, under bamboo sheaths, and on sugar-cane leaves.

Fig. 134.—WEBBING OF OECOPHYLLA SMARAGDINA ON PIPAL SHOOT ENCLOSING LECANIUM HESPERIDUM.

The nest is always constructed in such a way as cannot be easily discovered by a casual eye. A greater portion of it is covered over by leaves and the portion open to view is not easily recognisable. It looks from a distance as if it were made of clay and cowdung, mixed with dry pieces of leaves, straw and grass. In reality it is a brown silky cobwebby material, over which are thickly and closely laid dry pieces of leaves, straw, etc. Just as *Oecophylla smaragdina*, F., workers make use of salivary threads secreted by their larvæ in folding the edges of leaves together, so do the workers of this species. They catch hold of the larvæ between the mandibles and carry them over to the places where the web is required to be spread. The larvæ go on laying and stretching threads mechanically, as wanted. Other workers bring dry pieces of straw and spread them over the web while it is still fresh. When a nest is cut open from any part, a few of the workers at once rush up to the spot and plant themselves as sentinels to guard the breach, while others remove larvæ and pupæ or whatever there be in that portion of the nest, to a secure place. After the chamber opened to view is cleared of what it contained. the workers hold the torn portions between their mandibles and pull inwards. Thus the aperture is made as narrow as possible, and then a couple of larvæ are brought and the web is drawn across the rent in the usual way. The whole inside of the nest is lined with the brown silky cobwebby material, and the partitions between different chambers are also made of this material, but without straw, etc.

Ants of this species also tend cattle for whose protection they prepare byres of the same cobwebby material and covered also in a similar manner as their nest. Such byres were found on a sugar-cane leaf, and also on a weed, close to established nests of this species. Workers were seen going in and coming out of those cattle sheds. On removing the covering large clusters of sugar-cane, aphis were found in the former and *Monophlebus* in the latter shed. Workers of this species have also been observed carrying a large dead fly to their nest. Pupæ are encased in light brown cocoons. The winged sexes were obtained from nests in August and September.

Myrmecocystus setipes, Forel, nests in the ground in open places, and there is often a heap of soil thrown outside the nest. The workers collect dead insects and millipedes, and nests have been found stored with the wings and bodies of winged termites which they collect in great quantity; the worker-majors carry the worker-minors when on the march.

Camponotus compressus, Fabr., is the familiar black ant of India, the large worker-majors coming into houses. Nests are usually in the soil at the foot of a tree but occasionally in a wall. They visit Aphides, Membracids and Coccids and also feed freely upon termites if a nest or gallery is exposed. The winged sexual individuals fly at dusk on warm still evenings in the rains and are frequently to be seen at light.

Fig. 135.—OECOPHYLLA SMARAGDINA; QUEEN WATCHING OVER LARVÆ, WHEN COMMENCING TO FOUND A NEW NEST.

COLEOPTERA.—(Beetles).

The first pair of wings (elytra) thickened, accurately adapted to the body and completely covering the lower wings, which fold longitudinally and transversely in repose. Many species are wingless, and in many the elytra are abbreviated, not covering the abdomen. Mouthparts of the predaceous or herbivorous biting type. Antennæ of varied forms, never setaceous, usually eleven-jointed. Simple eyes usually absent. The integument is hard ; the parts accurately co-adapted to form a rigid outer skeleton.

Metamorphosis complex ; the larva a grub with complete or reduced legs, without suckerfeet and without tubercles bearing hairs. Silk is not utilised in the formation of the cocoon, but anal secretion takes its place ; after emergence from the cocoon the imago usually passes through a resting period during which the integument hardens.

The order includes minute to large insects, of varied habits, including herbivores, predators, scavengers, both aquatic and terrestrial, with no social and scarcely any parasitic forms.

No order is so easy to recognise as this, and only in rare cases, where the elytra are much reduced or are soldered together, will a beetle appear different. Looking at a beetle from above, the antennæ, the large prothorax, the scutellum, the elytra and the pygidium (plate over the anus) are seen, except where the last is covered by the elytra. The large wings are folded below the elytra. Looking from below, the antennæ can be seen, inserted below the head, the large mandibles and the labium, with usually two pairs of palpi ; the legs, with the coxa embedded in the sternum, the trochanter, femur, tibia, tarsus. The antennæ assume different forms as shown in figure 137 ; in 1, the basal joint is elongate and forms a scape, the apical three joints form a club and the remainder form a funicle, the whole antenna being elbowed (*Rhynchophora*) ; in 2, the antenna is simple, filiform (*Phytophaga*) ; in 3, it is moniliform, each segment a little expanded (*Cantharidæ*) ; in 4, it is serrate on one side (*Sternoxi*) ; in 5, it is clubbed, the three apical segments expanded on both sides (*Clavicornia*) ; in 6, it is filiform (*Adephaga*) ; in 7, it is clubbed, the club formed of leaflets closely folded together (*Melolonthidæ*) ; in 8, it is irregularly clubbed (*Hydrophilidæ*); in 9, it is incompletely clubbed, with the leaflets not forming a compact mass (*Lucanidæ*).

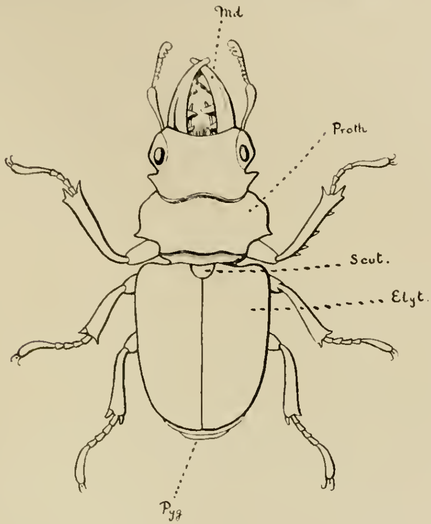


Fig. 135.—LUCANID BEETLE, MALE, DORSAL VIEW. MD., MANDIBLE; PROTH., PROTHORAX; SCUT., SCUTELLUM; ELYT., ELYTRON; PYG., PYGIDIUM.

The tarsi are composed of five joints in some forms, of four or three in others; in one division (*Heteromera*) the tarsi of the first two pairs of legs are five-jointed, of the third pair, four-jointed. In the *Phytophaga* the tarsi appear to be four-jointed, the tiny fourth joint being invisible at the base of the fifth.

There are characteristic features in the immature stages which mark the group as a whole. Eggs are of two types, the soft oval eggs laid in concealment, the harder variously-shaped eggs laid openly. The latter are not ornamented as are those of the *Lepidoptera*, are not of the form characteristic of Hemiptera with lids, nor of the typical Dipterous cigar-shaped form. The larvæ are without suckerfeet, and if free-living, frequently have the single anal tube, which functions as a suckerfoot, as well as two dorsal cerci or processes. The hairs or hair-tufts on tubercles arranged as in *Lepidoptera* are not found in this order, and larvæ, if hairy, have long tufts not arranged in series. No larval form can be confused with the Coleopterous larvæ which live free lives, the characters of Neuropterous, Hymenopterous, Lepidopterous or Dipterous larvæ being wholly different.

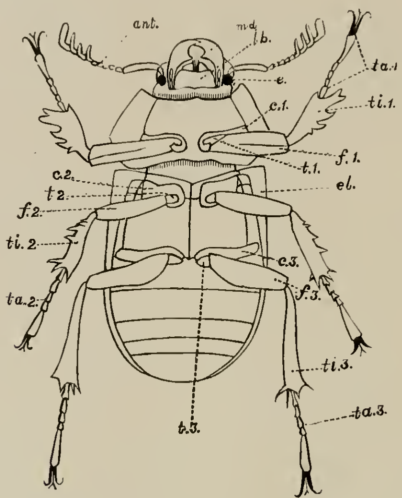


Fig. 136.—LUCANID BEETLE; FEMALE, FROM BELOW. ANT., ANTENNA; MD., MANDIBLE; LB., LABIUM; E., EYE; C. 1., C. 2., C. 3., COXÆ OF LEGS; T., TROCHANTER; F., FEMUR, TI., TIBIA; TA., TARSUS.

There are a few prominent points about Coleopterous larvæ that we may notice here. The tarsi are two-clawed in the *Adephaga* only (excepting *Haliplidæ* from these). Anal cerci occur only in *Haliplidæ*, *Hydrophilidæ*, *Silphidæ*, *Scaphidiidæ*, *Staphylinidæ*, *Histeridæ* and *Elateridæ* in part, as well as in the *Adephaga*. If we except the above, the larvæ of all have legs except *Bruchidæ*, part of *Cerambycidæ* and *Buprestidæ*. Omitting all the above, the Scarabæoid (white, curved, wrinkled) grub occurs only in *Scarabæidæ*, *Melolonthidæ*, *Lucanidæ*, *Passalidæ*, *Ptinidæ*, *Bostrichidæ* and part of *Chrysomelidæ* (*e.g.* *Clythrinæ*). In the *Dermestidæ*, the body is clothed in long fine barbed setæ, usually aggregated behind into tufts. All aquatic larvæ coming into none of the above divisions are either *Dascillidæ*. *Parnidæ*, *Haliplidæ* or *Chrysomelidæ* (part). In a number of families not included above, the apex of the abdomen is provided with prominent chitinised processes and the apical segment is harder than the others. These include *Rhipiceridæ*,

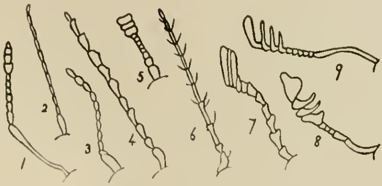


Fig. 137 —ANTENNÆ, 1 CURCULIONID, 2 CHRYSOMELID, 3 CANTHARID, 4 ELATERID, 5 EPILACHNID, 6 CICINDELID, 7 MELOLONTHID, 8 HYDROPHILID, 9 LUCANID.

Trogositidæ, *Colydiidæ*, *Mycetophagidæ*, *Melyrinæ*, *Cleridæ*, *Melandryidæ* *Pyrochroidæ*, *Mordellidæ*, *Tenebrionidæ* (part), *Cioidæ*, *Lagriidæ* and *Elateridæ* (part). The remainder exhibit none of the above general characters. More detailed characters for each family are given below, but these are based less on Indian species than on European or American larvæ. The number of larvæ of Indian beetles actually known is very small.

Pupation takes place openly (the pupa fixed at the tail), or in a cocoon of mud, of anal excretion or of fibres, never of fine woven silk. The peculiar resting stage of the newly emerged imago, while not universal, is general enough in forms whose pupæ are hidden as to be worth noting.

Classification.—The beetles are divided into series upon characters based upon the antennæ and tarsus as follows :—

Lamellicornia.—Tarsi five-jointed ; antennæ with apical joints expanded in leaf-like form and forming a club which can be opened and closed (figure 137, 7, 9). Four families.

Adephaga.—Tarsi five-jointed. Antennæ simple. Nine families.

Polymorpha.—Tarsi variable ; antennæ usually clubbed or serrate. 57 families.

Heteromera.—Anterior tarsi with five, hind tarsi with four joints. 15 families.

Phytophaga.—Tarsi with apparently four joints, densely pubescent. 3 families.

Rhynchophora.—Tarsi as in Phytophaga, head more or less prolonged into a rostrum. 4 families.

In actual practice, it is, as a rule, easy to place a beetle in one of these series. The peculiar antennæ marks the *Lamellicornia* instantly. The tarsi and simple antennæ distinguish the *Adephaga*. *Heteromera* are distinct by the tarsi; as *Phytophaga* and *Rhynchophora* have the same tarsi in most cases, the beginner will confuse some forms; but the simple antennæ of the *Phytophaga*, and the usually clubbed and elbowed antennæ, as well as the usually evident rostrum, of the *Rhynchophora*, clearly mark all the common species of each series likely to be met with. All other beetles, especially if with serrate or clavate antennæ, are *Polymorpha*, a series that includes the old Serricorn and Clavicorn groups, and in fact is an assemblage of all that are not clearly of one of the five distinct series.

The classification of the species that fall into each series is by no means simple and no agreement will be reached until more is known of tropical forms. Especially is it difficult to fix the families and the student will find very diverse views expressed in various books. We treat Melolonthidæ as a single family; there is little reason why it should not be regarded as consisting of several families. *Chrysomelidæ* are another large assemblage that could justly be regarded as at least 11 and more probably 15 families, as is done by some authors. We have preferred to retain these as sub-families, but the student will have no difficulty in finding the equivalents of any families he may see discussed by writers.

When a particular specimen has been placed in its series, there may be more or less difficulty in deciding on its family. There should be no difficulty in the Lamellicorn, Adephagous, Phytophagous, or Rhynchophorous series, provided the characters mentioned are compared. For the other series, no keys or sufficient characters can be given. Excepting the few larger families, very little is known of the smaller families, and while it is possible to give characters based on European or American species, these distinctions may not always apply to new and undescribed

Indian species, which alone the student is likely to find. We enumerate the diagnostic characters of the families known in India, with the reservation that these diagnostic characters are not as sharply marked as in other orders and that, outside the larger families, the logical use of these characters in referring an obscure beetle to its family may lead the student astray; if a beetle is shown to belong to a small obscure family, the specimen should be compared with specimens or good figures of others of that family to verify the determination. In Coleoptera more than in all orders, it is very difficult to place specimens that evidently do not belong to the larger families, owing to our ignorance of the Indian representatives of the smaller families.

In no order is the mere rudimentary sorting out of species into groups rendered so difficult as in this, not merely because of the complexity of the order, but because of the want of agreement among those who study this order. Had the general body of Entomologists any "business sense," a working scheme of classification to last, say for 50 years, would have been evolved and then the necessary and radical changes caused by further knowledge made at once; as it is, two authors disagree in a striking manner; they adopt fresh groupings arbitrarily and the student is from the commencement bewildered with conflicting terms.

For our purpose, a knowledge of the main lines to be adopted in the Fauna would have sufficed, but failing this, we have adhered to the classification given in Sharp's Insects, the standard in our work for the past, with a modification from Ganglbauer's views as presenting no radical changes and as possibly anticipating future views. The earlier authors based the main divisions upon the antennal and tarsal characters and it is only lately that authors have gone deeper into the matter and used both the wing venation and internal characters. This is, from the systematist's point of view, an advance, and those who wish to study the relationships of beetles will do well to consult the paper by Ganglbauer (Munchener Koleopterologische Zeitung, Vol. I); unfortunately such characters are useless in every-day work of classifying and arranging specimens and we have been compelled to disregard this aspect in the endeavour to give characters which can actually be used in sorting out ordinary collections. The result is, that while nine-tenths of a collector's captures will be readily sorted and placed, there will always remain a proportion which cannot be so placed; to those who wish to go more deeply into the subject, we recommend the voluminous literature; to those who simply want to know where to place the specimen, we would suggest sending it to Pusa. For ordinary daily working purposes, almost every beetle can be placed at sight in a family at least; to keep pace with changes in classification, to be able to place all beetles more or less accurately, one would have to drop all other work and become an expert in this one subject, a matter of many years of study. We have tried to give the essentials only of such a study.

A complete list of families will be found at the commencement of the volume where we have placed important families in heavy type, and families not known to be represented in India in italics. We have not tabulated sub-families in this list as these divisions do not imply groups of insects so distinct in habits or structure that the student should take heed of them.

Apart from the naturalists who collected in India or obtained specimens from this country in the early part of last century, and whose work laid the foundation of our knowledge of the common species, the work of a limited number of collectors in recent years requires notice. Thus, Father Cardon collected in Chota Nagpur and Kurseong (see Ann. Soc. Ent. Belge., 1890—1894); the collections of Messrs. T. R. Bell in Canara, of H. E. and H. L. Andrewes in the Nilgiris, Anamalais and other South Indian hill districts (loc. cit., 1895—1905), of Doherty in Manipur, Burmah, etc., the visit to India of Mons. Maindron (see Ann. Soc. Ent. Fr., 1903 onwards) and the visit of Mons. Harmand to Darjeeling (Ann. Soc. Ent. France, 1903, p. 108) have borne fruit in description of new forms, in lists of existing known species and so on; these collections, however, scarcely affect the real India (Mons. Maindron's visit alone excepted), since the insects collected were from hill localities like Darjeeling with its temperate climate and fauna; the same may be said of Signor Fea's visit to Burmah in another sense (Ann. Mus. Genova, 1892 *et seq.*) and of the visits of Mr. Lewis, Mons. Simon and Dr. Horn to Ceylon. The student of the fauna of "British India" will owe a debt to these workers, but there have been scarcely any such workers in India proper.

We have endeavoured to refer to most important papers or to give some clue to where the student may find literature; but this literature is practically wholly concerned with systematic work and descriptions of new species ; the student will look in vain for any biological work, of any kind almost, prior to the beginning of this century and it is yet to be done. There is an abundant field here for observers and, it is no exaggeration to say, that while thousands of forms have been examined, described, named, listed and put away in Museums, we have accurate data of the lives of not one in a thousand of these species.

We have had, therefore, to confine ourselves in these pages very largely to generalities, and we do this simply to guide the student and would-be observer in the direction he will probably have to go. Where we have accurate data, they are given in such detail as is possible, which must of necessity be brief.

Lamellicornia.

The tarsi are five-jointed, the antennæ have the apical joints dilated at one side, so that a more or less compact club can be formed by the approximation of the lamellar expansions.

It is only in very rare cases that any confusion as to this well marked division can arise and these beetles are readily distinguishable at sight. The number of species is large, nearly one-tenth of the known species of Indian beetles coming into this series. They are commonly divided into three families, *Passalidæ*, *Lucanidæ* and *Scarabæidæ*, the last divided into five sub-families. It is, however, better to distinguish the *Coprinæ* as a separate family, and we have here adopted the arrangement into four families, retaining the name *Scarabæidæ* for the *Coprinæ*. The arrangement is as follows :—

I. *Passalidæ.*—Antennal club imperfect. Elytra covering the pygidium. Labrum large and mobile.

II. *Lucanidæ.*—Antennal club imperfect. Elytra covering the abdomen. Labrum small and indistinct.

III. *Scarabæidæ.*—Antennæ fully clubbed. Elytra not covering the pygidium.

1. *Coprinæ* (*Scarabæidæ*).—No abdominal spiracle visible outside the elytra, all being on the connecting membranes of dorsal and ventral plates, in one line.

IV. (*Melolonthidæ*) 2. *Melolonthinæ.*—Three basal spiracles on connecting membranes, three apical slightly diverging and usually one visible beyond the elytra.

3. Spiracles in two lines, three on connecting membranes, three visible outside the elytra, on ventral plates.

(*a*) *Rutelinæ.*—Claws of tarsi of unequal size.

(*b*) *Dynastinæ.*—Claws equal. Fore coxæ sunk, not prominent.

(*c*) *Cetoniinæ.*—Claws equal. Fore coxæ prominent. (Scutellum large).

This arrangement is in accordance with the larval and imaginal habits as well as with the structure. The habits may be summarised as follows :—

Passalidæ, Lucanidæ.—Larvæ feed in decaying wood.

Scarabæidæ.—Larvæ feed in dung. Imagines feed on dung.

Melolonthidæ.—Larvæ in soil feeding on the roots of plants, in decomposing vegetable matter, in manure heaps, in ants' nests. Imagines feed on leaves, or on flowers.

In this group the larvæ are all white, soft, curved in ventrally, and much wrinkled, with a brown head, no ocelli as a rule, three pairs of well-developed legs and usually a much developed apical abdominal segment. This type of larva (Scarabæoid) is found also only in *Ptinidæ*, and some case-bearing *Chrysomelidæ* (*Clythrinæ*).

Passalidæ.

Lamellicorn beetles in which the antennæ, in repose, curl to bring the lamellæ together and in which the elytra entirely cover the abdomen. Labrum large and mobile.

These beetles are, as a rule, generally recognisable from the general form. They are brown or black insects, in length up to one inch, prothorax large, flattened and shiny, the elytra elongate, with ten lines of punctures, and entirely covering the abdomen. A few Indian species are cylindrical. All are a shining brown or black, the dorsal surface glabrous ; none are very small, most are of moderate to large size. The head is in some species distinctly roughened and knobbed above ; the characteristic antennæ are folded back under the head or are extended in front ; the large toothed mandibles meet just beyond the edge of the clypeus. The legs are strong, the fore tibiæ broadened and suited to digging, the posterior legs more slender, the tibiæ with long brown hairs. A feature of these, as of other lamellicorn beetles which live in decaying vegetable matter, is the presence of abundant fine brown hair on the legs and lower surface of the body.

Fig. 138.- BASILIANUS STOLICZKÆ.

The larvæ of insects of this family are found in decaying wood in forests and are large fleshy insects, similar in form to other Scarabæid larvæ, with the first pair of legs reduced in size and functioning as stridulating organs. The anal opening is transverse, the upper lip indented longitudinally. The imago lives also in decaying wood, under the bark of trees and among decaying vegetation. They are most abundant in forests and not found in the cultivated plains. A caustic fluid is secreted by some species, serving probably as a protection. They are almost wholly forest species and may be met with rarely in moister cultivated areas of East and South India, not in the dry plains.

Stoliczka remarks that *Passalidæ* are met with only in parts of India with a Malayan fauna ; he lists 23 Indian species, from South India, Eastern Bengal, Burmah, etc. *Basilianus* is the commonest genus. (J. Asiat. Soc. Bengal, XXII, p. 149.)

LUCANIDÆ.—*Stag Beetles.*

The antennæ do not curl, the club being indistinct ; the elytra cover the abdomen, the labrum is small and indistinct.

Beetles of large size in which the simplest distinguishing character is the large mandibles of the males, which project forward as two large and formidable jaws. These are, in the female, of moderate size and not conspicuous. None are small insects, the length varying from $1\frac{1}{2}$ inches to over four. The colouring is brown and black, as a rule, sombre and dull as in other beetles of similar habits.

These beetles are somewhat flattened, the head large, the antennæ moderately long; in the commonest species the eyes are divided by a

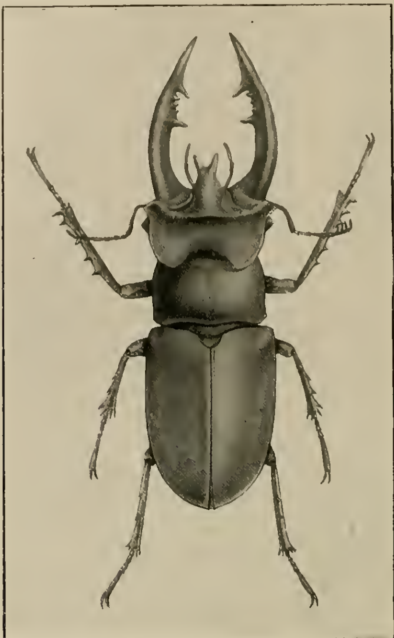


Fig. 139.—Lucanus lunifer, male. [I. M. N.]

projecting ridge, producing a small upper and a large lower eye. The prothorax is large and smooth, the elytra is smooth and shining. The legs are long, the tibiæ broadened, the tarsi long and conspicuous.

The beetles live in decaying trees and the males fly at night. The function of the very large mandibles is not always apparent and it is not clear that they use them; there is great variation in the degree of their development and intermediates from those resembling females to those with fully developed mandibles are found. (See page 189.)

The female lays her eggs in a decaying tree, the larvæ living upon decaying vegetable matter. The larva is a large fleshy insect, distinct from Passalid larvæ by the equal development of three pairs of legs and the longitudinal anal slit, closed by two lateral lips.

Fig 140. LUCANUS LUNIFER, FEMALE. [I. M. N.]

Lucanidæ are widely spread and find their greatest development in the Eastern Himalayas and Assam, where a great number of species, often of large size, occur. They do not occur in the plains and no species require mention. We figure *Lucanus lunifer*, Ho., one of the commonest in the Himalayas. Westwood figures a number of the Indian forms (Cab. Or. Entom., 1847). No species are of economic importance.

Thomson (Ann. Soc. Ent. France, 1862, p. 392) lists 36 Indian species which are only a proportion of the known species. The principal genera are *Lucanus*, *Hexarthrius*, *Cladognathus* and *Dorcus*. Parry catalogues the family in Transactions of the Entomological Society, London, 1864, pp. 1—113, listing 70 Indian species. Felsche published a later catalogue in 1898 on which Boileau's remarks should be also seen (Ann. Soc. Ent. France, 1898, p. 401), and since then Albers listed the Kurseong species (Ann. Soc. Ent. Belgium, 1903, p. 69). Altogether about 100 species are recorded ; some of these may prove to be forms of the same species, the great sexual differences having led to the multiplication of species founded on an insufficient number of specimens.

SCARABÆIDÆ.—*Dung-Rollers.*

Antennæ with a knob of closely folded leaflets. Elytra not covering the pygidium. Spiracles in one line, on the connecting membranes and all covered by the elytra.

A large group of small to large beetles, usually of sombre colours, some few metallic blue or green. The body is round, thickset, the head projecting forward as a flat plate, beneath which are the mouth-parts. The prothorax often has projections and the head a process or spine. or a number of teeth on the anterior edge. The hard rough elytra cover the abdomen completely. with the exception of the pygidium. The legs are large and powerful, the tibiæ broadened and spined at the apical half, the tarsi slender. In the larger species the fore tarsi are commonly absent. The robust spherical body, the large broadened legs, the platelike head, the spines or projections on head and prothorax are extremely characteristic, and the bodily structure is specially modified in connection with the peculiar habits.

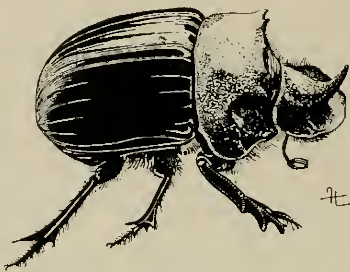


Fig. 141.—HELIOCOPRIS BUCEPHALUS, MALE. [F. M. H.]

Throughout this large sub-family the habits are, so far as known, fairly uniform. The beetles collect in dung. feeding upon it and making it into balls which they roll over the surface of the ground and take into the soil, where they either feed upon it or use it as food for their young. dividing it into portions in each of which an egg is laid, and which the larva inhabits and gradually eats. The flat head is used as a shovel in these operations, digging out the food, shaping it and consolidating it; the long legs assist the beetles in rolling these pellets over the ground and the digging forelegs aid in excavating or enlarging holes in the ground. In the dry hot weather, dung of cattle attracts great numbers of these beetles and the spot becomes lively almost at once with these active and energetic insects. It is a common sight to see beetles rolling these pellets, usually larger than themselves, rapidly along the soil and their antics are usually very grotesque. All do not roll dung, some (the smaller species) making a tunnel below the mass of dung and carrying down what they require. The end of the tunnel is filled with dung fairly closely packed; the beetles either feed upon it, remaining over it and devouring it while a long mass of excrement is deposited, or they lay an egg in it, the white footless grub feeding in the mass. April to June seems to be the period of greatest activity of the beetles. but the details of the life-history of few Indian species have been observed, and many forms fly in the rains. Elsewhere careful observations have been made and the extremely interesting accounts of M. Fabre should be read by every student. (There is an English translation of M. Fabre's first volume entitled "Insect Life;" the original volumes are in French, under the title "Souvenirs Entomologiques"). Major Popham Young sent a large ball found eight feet below the surface of the soil in Patiala when excavations were being made for a house, which was evidently the ball containing the larva of a large Copride. Sykes gives an account of the finding of the immense balls made by *Heliocopris midas* in Poona in the soil. One ball remained thirteen months before the imago emerged. another sixteen months. During this time the insect was in the larval and pupal stage, and the life-history would occupy probably two years. (Trans. Ent. Soc., London, Vol. I, p. 1835.) A few (*Onthophagus*) attack decaying animal matter and these are the little beetles which so promptly remove the larger dead insects; the disappearance of dead locusts is marvellously quick, and the powers of smell of these beetles must be very acute to bring them so quickly to the scene. A few are found in decayed trees. The larvæ are never seen and live below ground.

The members of this family exercise a very important function in the economy of nature; not only do they cleanse the surface of the earth of the excrementitious matter deposited on it, but they carry into the soil quantities of this valuable manure that would otherwise become dessicated on the surface and with the first heavy fall of rain, would be washed away and carried down in the streams and rivers to the sea. A very great quantity of manurial matter is probably rendered available in the soil by the activities of these insects, and though it is not possible to definitely estimate the effect of their work, it is certainly a very considerable one. Species have been imported to the Hawaiian Islands in the hope that, by destroying the droppings of cattle quickly, they may reduce the numbers of the Hornfly (*Hæmatobia serrata*) which breeds there.

Sound is produced in a variety of ways, by friction of two parts of the body. In *Bolboceras*, the male has a corrugated expansion of the lower surface of the head, and by moving his head up and down, he rubs it against the edge of the pronotum, producing a squeaking noise.

in *Trox* the abdomen rubs against a raised vein in the elytra. In *Heliocopris bucephalus*, sound is produced by a rotation of the hind coxa, the posterior and internal edge rubbing against the sharp edge of the socket and producing a curious "wheezing" noise.

This large family may be divided into seven sub-families as follows:—

I. Antennæ 9 or 10 joints:—		
A. Posterior legs with one spur.	1.	*Scarabaeinæ* (*Coprinæ.*)
a. Posterior legs dilated gradually.		*Scarabaeini* (*Ateuchini.*)
b. Posterior legs dilated suddenly.		*Coprini.*
B. Posterior legs with two spurs.		
a. Metathoracic parapleuræ simple.		
Antennæ 9 joints.	2.	*Aphodiinæ.*
Antennæ 10 joints.	3.	*Orphninæ.*
b. Metathoracic parapleuræ appendiculate.	4.	*Hybosorinæ.*
II. Antennæ 11 jointed.	5.	*Geotrupinæ.*
III. Abdomen with five ventral segments.	6.	*Troginæ.*
IV. Tarsi very long.	7.	*Glaphyrinæ.*

Scarabaeinæ.—Four large genera are included in the *Scarabaeini* (Ateuchinæ) with over 30 Indian species. *Scarabaeus* (Ateuchus) includes some of the larger European forms, and but few Indian. *S. gangeticus* Redt. is the common plains species. *Sisyphus* and *Gymnopleurus* include the common small beetles with long legs found at dung in the plains. *S. longipes*, Oliv., is one of the more abundant species, a small black insect common on roads in April; it makes balls of dung about twice its own size; usually two are found at one ball, rolling it along the soil, and they have been seen to take a ball over a hundred yards. *Gymnopleurus miliaris*, Fabr., is also common; it is dull black with shiny black spots on the elytra and thorax. *Gymnopleurus cyaneus*, Fabr., is the metallic blue species that may constantly be observed rolling dung balls. When a ball is made several assist in rolling it, apparently in the hope of securing it; the stronger individual appears to be successful in the end.

rolling the ball to a spot where the soil is loose and then, by digging the earth away below it, burying it to a considerable depth. *Caccobius* includes five species, one occurring in the plains and of which nothing is known. *Coptorhina* and *Caccophilus* occur in the hills.

Coprini.—The majority of Indian species are included in this division, over 100 species occurring in India proper. *Catharsius molossus* Linn., *C. sagax*, Quens., and *C. sabaeus*, Fabr., are common, moderately large black insects that fly at night and come freely to lights in the rains. *Copris* is represented by *C. repertus*, Wlk., which flies in the hot weather and at the first rain. *Heliocopris bucephalus*, Fabr., and *H. gigas*, L. (midas F.) are the giants of the family, large thickset beetles with very powerful legs and greatly chitinised prothorax. *Onitis* is well represented, moderate-sized beetles, of an olivaceous brown tint, without the exuberance of horns and tubercles of the previous genera. *Onthophagus* comprises a very large number of usually small forms with very varied developments of horns and tubercles in the males. They are common in the dry hot weather and while some come to dung, others feed on dead insects; the abundant locusts that died after egg-laying at Igatpuri in June

Fig. 142.—ONTHOPHAGUS LONGICORNIS; LARVA, EGG IN BALL, IMAGO.

1904, were fed on by *Onthophogus gravis*, Wlk., and the bodies very quickly destroyed. *Onthophagus longicornis*, Deyr., has been reared from larvæ found in balls buried to a depth of three to five inches below the surface immediately under cowdung. Each ball is oval, the long axis about twice the short, about $\frac{3}{4}$ inch long. This ball is hollow, and the single white egg is fixed inside. The larva feeds on the ball, leaving the coarser outer shell and then pupates within. The larval life lasts for 21 days and the total life from egg to imago is, in May and June, about 5 weeks. At other seasons these beetles are found in the soil. Many of our commonest plains species are undescribed and no observations appear to have been made on their habits. Over 60 species are recorded and many remain to be described. *Oniticellus cinctus*, Fabr., a black species with yellow fasciæ, and *O. pallipes*, F., a dull brown species, are abundant in the plains; the latter has been reared from eggs found in dung-balls buried three inches underground. The eggs are attached each to one end of the cavity in an oval ball; the larva has the first few segments of the abdomen much drawn out and enlarged, apparently for the reception of the alimentary canal which is more than double the length of the body and bent back upon itself more than once, being also very capacious and filled with food. In habits and appearance it differs little from that of *Onthophagus longicornis* described above. The larval and pupal life together occupy about 19 days.

Drepanocerus is represented by the tiny *D. setosus*, Wied., common in cowdung.

Aphodiinæ.—These beetles feed in dung, the larvæ being found in the dung-mass. They are small, brown or black species, cylindrical in form and readily confused with the Carabids of the Scaritine division. *Aphodius* is the principal genus, with over twenty Indian species recorded; they are extremely abundant in the rains coming to light in great numbers. *Aphodius* has been reared from larvæ found in a dung ball below ground. Three larvæ inhabit one mass, the eggs they hatch from being laid in different parts of the ball. The larvæ are of the typical form, white, wrinkled and bent, with well developed legs. They pupate in round black cocoons, apparently made of excrement, emergence taking place partly by biting through the cocoon, partly by bursting it. Larval and pupal life together occupy about sixteen days in July-August.

Rhyssemus includes very small species, resembling Scolytids; *Rhyssemus germanus*, Linn., is the common species in Bengal and Behar, and has been seen flying in very great numbers in warm still evenings in March. *Chætopisthes* is recorded by Wassmann from nests of *Termes obesus* in India and may be obtained by digging into the large central nests and fungus chambers.

Orphninæ.—Orphnus and *Ochodaeus* are Indian, with several species. *Orphnus picinus*, Westd., is common in the Himalayas, where it makes tunnels in the soil below masses of cowdung, carrying the dung down to fill the ends of the tunnels, its larvæ being found in the dung-mass.

Hybosorinæ. Represented by *Hybosorus orientalis*, Westd., and *Phæochrous indicus*, Westw., the latter not uncommon in the plains. It is a flatter insect, with the appearance almost of a Tenebrionid.

Geotrupinæ.—These are nocturnal insects, found abundantly in the rains and coming freely to light. Their habits appear to be practically unknown in India ; Boucomont says of the group in general that they dig long vertical tunnels in the soil where they remain by day, and where their larvæ live ; the beetles feed on dung and fly at night in search of it. *Lethrus* and its allies are remarkable for living in couples in burrows and feeding on the shoots of plants, but none are recorded as Indian. Boucomont has listed the species (Gen. Ins. 1902), mentioning as Indian *Geotrupes* (9), *Bolboceras* (26), *Athyreus* (2), *Ceratophyus* (1). *B. quadridens*, F., and *B. subglobosus*, Westw., are our common forms.

Fig. 143.—Trox indicus.

Troginæ.—Four species of *Trox* occur, (Harold Col. Hefte, IX, p. 1), the common plains forms being *Trox indicus*, Hbst., *T. omacanthus*, Har., both quite common. They feed on hard dry excrement, which appears to be their normal food, with small carcases and dead insects.

Melolonthidæ.

Antennæ with a knob of closely folded leaflets. Elytra not covering the pygidium. One or three spiracles visible beyond the elytra.

This very large family includes the familiar cockchafers, moderately large thickset beetles, the head small, the prothorax large and rounded, the abdomen, with the elytra, hard, round and robust. The forelegs are commonly broadened and fitted for digging in the soil. The posterior legs are strong, often well spined. Wings are present and the beetles fly well. The tracheæ contain dilations which are inflated before flight, thus increasing the volume and reducing the specific gravity of the insect as a whole. Stridulation of one hard part of the body against another is frequent, a variety of sounds being produced. Sexual distinctions are well marked in some by prominent secondary characters. The larvæ are fleshy soft grubs, the body wrinkled and curved in an arc ; the head is large, the apical abdominal segment very much developed. Legs are present but are little used. The four sub-families are distinct; their characters are enumerated above (page 242).

Fig. 144.—Thaumastopœus pullus, × 1.

Melolonthinæ.—*Cockchafers.* Moderate-sized beetles, with robust bodies, the elytra covering all but one spiracle, the legs only slightly broadened and without horns or spines on head and prothorax. These are mostly dull-coloured insects, brown predominating in the colouration, and they vary in length from a quarter of an inch upwards. The antennæ are short, with the knob composed of one more joint in the male than in the female, the leaflets also longer in the males; the prothorax is small, the elytra generally smooth and fitting tightly to the abdomen. The legs are moderately long, fitted for walking and to a less degree for digging.

The life-history of no Indian species is recorded in any detail. Generally speaking, the larvæ live in the soil, feeding upon the roots of plants. They are fleshy dingy-white in colour, the head brown, the body curved in an arch and the apical segment large and smooth. There are many folds in the skin and three pairs of short jointed legs. The mouth-parts are of the usual mandibulate type and the food is principally roots and underground plant tissues. The larva moves actively in soil, but is comparatively helpless on the surface, the curved body interfering with locomotion. When full-grown it makes a mud cell and transforms to a pupa in the soil. The length of the life-history is not known and may occupy one, two or three years as it does elsewhere though there is at present no reason to believe it occupies longer than one year. The imago flies by night and comes to light. The forewings are not moved in flight but are held rigidly and apparently serve for a parachute and as directors of flight. The food consists of vegetable matter, leaves and flowers being eaten at night, the beetles hiding by day. Few are active by day, but some may be found clinging motionless to grass stems.

The destructive species are so on account either of the destruction to roots by the larva, or the destruction to leaves or floral organs by the imago. In Europe immense numbers of *Melolontha vulgaris* constitute a very formidable pest in both stages and immense multitudes of these insects occur. Nothing of this kind has yet been observed in India, and, though species are plentiful, the enormous multiplication of any one species does not seem to take place and the place of the *Melolontha* in Europe is here taken by the Rutelid *Anomala*. The grubs of *Melolonthidæ* are the prey of *Scoliidæ* which seek them out and lay their eggs upon them, after they have been parasitised by stinging.

The number of species is very large and no complete list of Indian species exists. A number were described and listed by Brenske in Indian Museum Notes. The classification of such large numbers of insects is a very difficult matter and the sub-family as a whole is not studied to the extent it deserves. The identification of Indian forms is possible only by systematists with large reference collections and libraries at hand and cannot be undertaken at present. The more common species of the plains are figured (I. M. N.) and we can only advise collectors to collect patiently, to sort out their specimens into species under numbers and hope to get them identified as occasion may offer. The species of the Indian Museum were listed by Barlow (Indian Mus. Notes, IV, p. 234). The *Hoplini* include only *Hoplia* and *Ectinohoplia* with less than twenty species mostly hill forms. The *Sericini* have been monographed by Brenske (Die Serica-Arten der Erde) with 103 Indian species. *Serica* *lugubris*, Brsk., is a moderate-sized black species found commonly at light in the plains. *S. indica*, Blanch, has been reared from larvæ feeding on the roots of cane in Behar and is one of the most common species. *Macrodactilini* include one species, *Dejeania alsiosia*, Bl., a moderate-sized brown pubescent species which is found in the plains in June. The *Melolonthini* include over 160 species, chiefly in the genera *Apogonia*, *Schizonycha*, *Lepidiota*, *Holotricha* (Lachnosterna), *Bramina*, *Hoplosternus* and *Melolontha*. They are the larger cockchafers of the plains, most abundant in the moister areas. *Apogonia carinata*, Brsk., is a shiny black species of moderate size which is found passing the winter under the bark of trees. *A. proxima*, Wat., is extremely like it and is found flying in June. *A. uniformis*, Bl., is also common, a smaller brown species which comes freely to light during the rains. *Schizonycha xanthodera*, Bl., is a larger species, which flies during March and April. *Lepidiota* includes the very large species found in forest localities as a rule ; one species *L. rugosipennis*, Bl., is found in the plains, though rarely.

Rutelinæ.—Lamellicorn beetles, with three spiracles on the membrane between the dorsal and ventral plates, three on the ventral plates and visible, with the claws of the tarsi of unequal size. These are moderate-sized insects, in general form closely similar to the Melolonthids. Many are brightly coloured, blues, greens and browns predominating, and many are sombre.

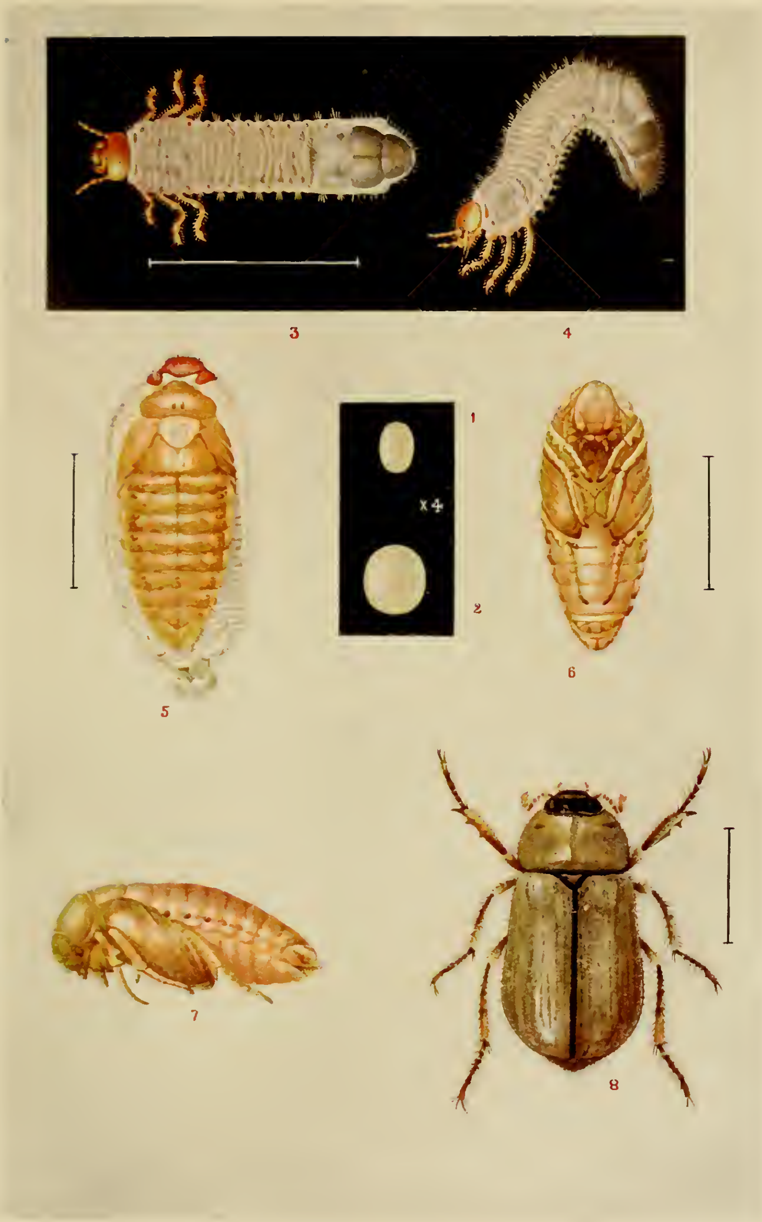
The life-history of one species is known, this being the common cockchafer of the plains, *Anomala varians*, Oliv. The stages are fully illustrated in Plate XIV and the details of the life-history are given in full elsewhere. (Mem. Agri. Dept. India, Vol. II.) The life-history occupies one year ; eggs are laid in the soil in the early rains, which increase in size and weight after laying. The larva lives in the soil eating the roots of rice, bajra and other cereals. It rests in the soil from September, pupates in March, April or May, and the imago emerges, after about ten days.

A large number of species occur in India, one subdivision, the *Anomalides*, being distributed through the tropics, another, the *Adoretides*, abundant in India and Africa alone. *Anomala* with over fifty species, *Popilia* with thirty and *Mimela* with twenty-seven are included in the first; *Adoretus* with twenty-four species in the second. To a greater

PLATE XIV.—Anomala Varians.

The Cockchafer.

Fig. 1. Egg when laid.
,, 2. ,, just before hatching.
,, 3. Larva, dorsal view.
,, 4. ,, lateral ,,
,, 5. Pupa, dorsal view, in the last larval exuvium.
,, 6. ,, ventral view.
,, 7. ,, lateral ,,
,, 8. Imago.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extent even than other groups, these are hill forest insects, very few occurring in the plains proper. *Anomala pallida*, F., and *A. varians*, Oliv., are common in the plains, both brown species like cockchafers. *Anomala viridis*, F., is the common green *Rutelid* found outside the hills, the remainder being mainly hill and forest species. *Anomala dorsalis* Fabr., was reported from the Victoria Garden, Bombay, as destructive to *Crinum latifolium* (Indian Mus. Notes, Vol. V, p. 130). *Pseudosinghala transversa*, Burm., is the small black species which comes up from the soil in myriads in May in the Khasi Hills and destroys flowers. *Adoreta cardoni*, Br., is recorded as destructive to rose bushes and cultivated plants in Calcutta (Indian Mus. Notes, Vol. IV, p. 136).

DYNASTINÆ.

These insects have the characters of the *Rutelini*, but are distinct in the labrum, which is not visible from above in this sub-division, and in the equal tarsal claws. They are usually large insects, the males with a horn on the head, and a tubercle or projection of some nature on the prothorax. The colours are usually dull, black and brown predominating; the body is usually massive and thick, and the giants of the insect world are here included. The males stridulate by moving the end of the abdomen in and out, by which the apical edge of the elytra rubs against a file on the upper surface of the abdomen. The larvæ are found in old trees, in decomposing vegetable matter and in soil rich in humus among plant roots. The pupa is enclosed in a hard case and the metamorphosis is believed to be long.

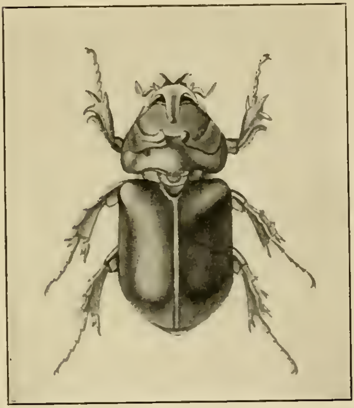


Fig. 145.—ORYCTES RHINOCEROS MALE.

India, America and Africa contain the majority of species, the number of Indian species not being large, probably less than 60 in all. *Oryctes rhinoceros,* Linn., is one plains species, found throughout the cultivated plains where toddy, cocoanut or other palms are grown. The beetle flies by night and eats into the soft tissues of the apex of the growing palm; in eating through the folded developing leaves it makes tunnels which are shown by ragged holes in the leaves when they open. Frequently the growing bud of the palm dies, growth is stopped and the whole palm withers. The insect is known by a variety of names in most parts of India where its ravages are known; the toddy-drawers know it and often know that its grub can be found in a heap of decaying vegetation or in a decaying tree. These larvæ are fat soft grubs, with a much wrinkled body, and as the tissues inside move, the whole suggests a well stuffed soft pillow in which is a small struggling animal. *Phyllognathus dyonisius,* F., is the only other common *Dynastid.* The life-history of this has been worked out from specimens sent in by A. M. T. Jackson, Esquire, I.C.S., as destroying rice in Belgaum. It is fully illustrated in Plate XV and has been fully described elsewhere (Mem. Agric. Dept., India, Entom., Vol. II). Shortly, the eggs are laid in soil in the commencement of the rains (June-July), the larvæ are mature by September and pupate, the imago emerges in October and remains in the soil until May, when it comes out. The larvæ behave like typical cockchafer grubs, feeding on the roots of plants.

Fig. 146—ORYCTES RHINOCEROS, LARVA.

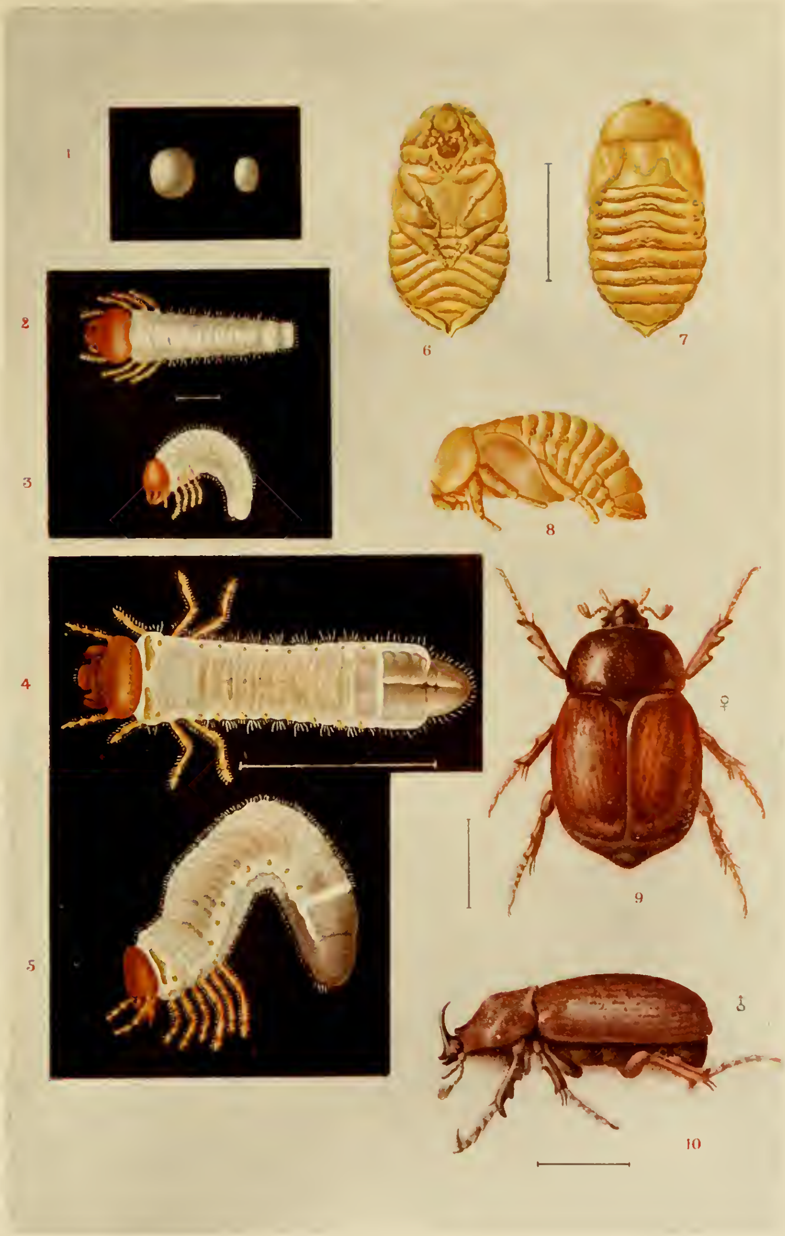
CETONIINÆ.

Moderate-sized insects, often of brilliant metallic colouring; the form of the body is slightly flatter than in the *Melolonthidæ* and the scutellum is often large. The males are rarely distinguished by prominent characters, such as horns, and the two sexes are closely similar in the common species. The colouring is very striking, metallic green in some, brown with varied yellow markings in others; and in conformity with this, many are diurnal species which are seen on flowers. The life-history

PLATE XV.—Phyllognathus Dionysius.

The Rice Cockchafer.

Fig.	1.	Egg, when laid and just before hatching.
,,	2.	Young larva, dorsal aspect.
,,	3.	,, ,, lateral ,,
,,	4.	Adult ,, dorsal ,,
,,	5.	,, ,, lateral ,,
,,	6.	Pupa, ventral aspect.
,,	7.	,, dorsal ,,
,,	8.	,, lateral ,,
,,	9.	Imago, female, dorsal aspect.
,,	10.	,, male, lateral ,,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is practically unknown in India; the larvæ are in general similar to those of other *Melolonthid* beetles, and live upon decaying vegetable matter or roots, or in ants' nests. The beetles are commonly diurnal, flying actively close to the soil under the trees of forests. They are often to be seen in abundance on a fine day in the rains in suitable localities.

Fig. 147.—THAUMASTOPŒUS PULLUS, × 2.

There are a large number of species in India and throughout the tropics. They are distributed chiefly in forest areas but extend into the plains and form part of the general plains fauna. Janson (Tr. Ent. Soc., London, 1901, p. 179), lists the *Cetoniids* collected by Andrewes and Bell in the Bombay Presidency; twenty-seven species are enumerated, of which twenty are confined to South India, four are found also in North India, and three widely spread outside India. The volume in the Fauna of India (now in the press) may be consulted. Nearly 200 species are described from India, exclusive of Ceylon. Four sub-families are recognised :—The *Euchirini* with *Euchirus*, an anomalous insect confined to the Himalayas; the *Cetoniini*, including the majority of the species, the *Valgini* with less than ten species and the *Trichiini*, with a small number of species of *Trichius*. Both sexes of *Eucheirus macleayi*, Ho., are figured by Westwood (Cabinet of Oriental Entomology). The enormously long curved forelegs of the male are the most striking feature of this insect, which is found in Assam and the Eastern Himalayas only.

Naricius opalus, Dup. is a metallic green species in which the head is produced into two porrect horn-like processes. In the brown *Dicranocephalus wallichii*, Ho., this process is branched, curved and like a stag's antlers. *Rhomborrhina* includes the large metallic species common in and near forests. *R.* (Torynorrhina) *opalina*, Ho., has the head produced in a flat plate. *Heterorrhina amœna*, Ho., is a delicate yellow-green insect with lines of black punctures on the elytra, found rarely in grass in the plains. *Clinteria* includes several green, brown or black species marked vividly in white or orange spots. *C. spilota*, Ho., is the variable species so abundant on grass in the hills. *Thaumastopœus pullus*, Billt., is a large shiny black insect found in Behar. In this species the prominent mesosternal process which projects forward between the fore coxæ towards the mouth is conspicuously shown. *Macronota* is well presented in South India by species with vivid yellow lines on the pronotum, elytra and abdomen ; the elytra taper a little and the abdomen projects conspicuously at the sides. *Glycyphana albopunctata*, F., and *G. versicolor*, F., are found in the plains, abundantly near forests. *Oxycetonia albopunctata*, F., is the brown species found sometimes in abundance at the flowers of cereals, with the green *Chiloloba acutawied.* In the Central Provinces both these species have been destructive, feeding on the anthers and stigma of juar, rice and millets. The latter is a beautiful pure green insect, with very marked golden pubescence. *Protœtia alboguttta*, Vig., is a conspicuous deep blue insect with vivid white spots, found throughout India. The pupæ have been found at the roots of trees, in cases composed of pellets of mud or excrement outside, smoothed mud or excrement within. *Anthracophora atromaculata*, F., is the large dingy black and white species found widespread over India.

Collecting.—Every possible member of these important families should be collected; it is unnecessary to pin at once, as beetles keep well in clean sawdust, free of dust, with enough naphthaline to prevent mould. For collecting there are two methods, the net or fingers by day, the lamp trap by night. It cannot be too strongly insisted that since these insects emerge often only once a year, dates of capture are of extreme importance. Beetles are pinned through the right wing case ; I have not found it necessary to remove the soft parts, but it is advisable to soak the dried insects in benzene to remove grease. Larger ones must be very carefully dried. Scarabæids are best got in the hot weather at their food and in this group careful observation and study of habits is required. Rearing is possible if the dung balls are obtainable. Melolonthids can be reared in earth if given roots enough and carefully tended. They thrive in soil in which plants are grown, *e.g.*, rice and can then live and feed under normal conditions.

ADEPHAGA.

This series is by Ganglbauer and others separated from all other Coleoptera on account of the wing-venation, the details of the internal anatomy, and the fact that the larva has two-jointed tarsi. It includes ten families, of which six are commonly found and should be familiar.

Cicindelidæ.—*Tiger Beetles,*

The clypeus extends laterally in front of the insertion of the antennæ. The maxillæ terminate in an articulated hook.

With few exceptions, these beetles are generally recognizable in the field from their general form, which is distinct from that of their allies, the *Carabidæ*. They are often brightly coloured, green, brown or black with spots or bands of white being most common. The majority are from one-half to an inch long, few under or over these limits. The head is short and thickset, in *Collyris* (Plate XVI, Fig 11), constricted behind the eye into a neck; the eyes are prominent, the antennæ moderately long. Long curved mandibles project in front of the head, the maxillæ and labium being conspicuous, the whole mouth-parts evidently of the predaceous type, formed for rapidly seizing and firmly clasping the insects they feed upon. The prothorax is large and cylindrical, the elytra usually smooth or only finely pitted. There are many wingless species, and some are very distinctly pubescent. The legs are long, slender, finely spined and formed for rapid running. The sexes are alike, the three basal segments of the male tarsi often elongated, while the males show six, the female seven visible ventral segments.


Fig. 148.—Cicindela sexpunctata.

The life-history is believed to be uniform throughout the group, and larvæ that can be referred with certainty to this family have been found in India; these larvæ are found in vertical burrows in the wet sand or mud near rivers ; apparently they require wet material which admits of the formation of a burrow, but their choice of locality may be determined by their prey ; the burrow extends vertically from the surface and the larva can move up and down by means of the legs and a dorsal hump or projection ; the head is flat, used to carry up the soil when excavating, and the very long jaws are turned backwards and upwards, so that when the flat head is blocking the upper end of the tunnel, the jaws have free play above and are in a position to seize any unwary insect that alights or walks within reach. The length of the life-history has not been ascertained, but as each species appears to emerge in the imago form for a definite period in the year, it is probable that the life-history occupies one year or multiples of one year ; the imago lives for several weeks. The student should read the life-history of *Cicindela campestris*, an English insect, which occupies three years (Proc. Ent. Soc., London. 1903, p. XV). R. Shelford figures the curious larva of *Collyris emarginatus*, Deg. from Java, which lives in burrows in coffee stems, feeding on the insects that go past. The larva has on the fifth abdominal segment six hooks, curved forwards, on a protuberance. A similar larva was found in China (Trans. Ent. Soc., London, 1907, p. 83).

Fig. 149.—CICINDELA LARVA, × 2

The majority of these beetles appear in the rainy months, some at the beginning, some later. Our common species are diurnal in habit, though some are known to be nocturnal. They are among the most active of insects, flying for short distances with great rapidity and also running quickly. So far as known all are predaceous on other insects, though their exact economic value is difficult to ascertain. Maindron records that *Derocrania longesulcata*, Mon., feeds on *Silis* (Drilinæ), and such records of food are noticeable for their rarity. The majority are found in damp places, in rice fields or thick vegetation, on river banks, on the seashore ; some are found only on trees in forest localities. Some are known to emit scents, not of an unpleasant character, but which probably serve a defensive purpose in association with the warning colouration.

The family is not a large one and the majority of the species are referred to the genus *Cicindela*. Atkinson's Catalogue (Asiat. Soc., Bengal, LIX, 1890), lists 119 Indian species, *Cicindela* (74), *Pronyssa* (1), *Megalomma* (2), *Dromicidia* (1), *Jansenia* (2), *Therates* (1), *Tricondyla* (5), *Collyris* (32), *Tetracha* (1). Maindron has added others (Ann. Soc. Ent., France, 1899, p. 379); Bates described Lewis' Ceylon forms (Ann. Nat. Hist., VI, 16, pp. 68, 143, 199). A revision of *Collyris* will be found in Ann. Soc. Ent., France, 1864, page 483.

Horn has described others (De. Ent. Zeitschr.), *Cicindela* (17), *Collyris* (10), *Tricondyla* (4), *Therates* (3), *Heptodonta* (2), *Neocollyris* (4), *Calochroa* (4), *Euryoda* (1), *Derocania* (1), *Prothysa* (1), are included in these later papers. Horn is now monographing the family in Genera Insectorum. Of these less than 20 *Cicindela* and one *Collyris* (*C. distincta* Chd.), occur in tropical India generally. *Cicindela sexpunctata*, Linn., is a striking species, found in the rice fields where it preys on the rice bug, *Leptocorisa varicornis*. It appears in August and September. *C. grammophora*, Chd. (Plate XVI, Fig. 12), is abundant in the rains in Behar, the commonest of the small species and very active on wet ground. *C. 4-lineata*, F., is a conspicuous insect with four stripes of yellow on the elytra, found abundantly on the seashore of Western India; in May, it feeds on the *Halobates germanus* so abundantly thrown up on the beach in the strong South-West wind and is a very conspicuous insect. *Cicindela 8-notata*, Wied., is common on the banks of rivers in the plains, a very gaudily coloured and noticeable species. *C. 20-guttata*, Hbst., with ten yellow spots on each elytron is abundant in rice fields with *C. sexpunctata*, Linn.

Collyris includes mainly metallic blue tree-haunting species which are difficult to distinguish; nearly all are forest species, some living on trees and bushes in the plains. *Therates*, like *Collyris*, has a long neck but is apterous, and includes robuster brown insects, found also in forests. The *Cicindelidæ* are often of curiously limited distribution with regard to individual species; the common forms of one part of India are limited to distinct areas and there appear to be few species really widely spread even over the plains. A number of our subtropical species are widespread outside India, and of the species recorded from Sind, many are probably not Indian at all.

Collecting.—These beetles cannot be caught without a good net and should always be killed at once or kept apart till they can be killed. Their larvæ can be found if looked for, but we have not heard of any being reared in confinement. The greatest desideratum is close observation of the food of both larvæ and adults as the actual species they prey on is known in very few instances and until this is known their economic value must be doubtful. They will be found only in moist soil, and are abundant in lands where silt is deposited after flood.

CARABIDÆ.—*Predaceous Ground Beetles.*

Antennæ filiform; the tarsi all five-jointed, clypeus not extending laterally in front of base of antennæ, maxillæ not hooked.

These beetles are widely distinguished from all others; the only family with which they are likely to be confused being the *Cicindelidæ* which have the lateral extension of the clypeus in front of the antennæ. The two families are very closely connected and authorities are not unanimous as to their separation. The beetles vary in size from small to moderately large, the smallest one-quarter of an inch long, the largest nearly one inch. The colouring is varied, often black or brown, sometimes with bright patches of yellow, and it is often strikingly warning. (*Anthia sexguttata*). As a whole it is the characteristic sombre dark colouring of ground insects, similar to that of *Tenebrionidæ*, *Blattidæ*, *Forficulidæ*, etc. The body is usually oval, broader than in *Cicindelidæ* and more flattened. The antennæ are filiform, rarely moniliform, not elbowed and projecting conspicuously in front of the head. The compound eyes are large, the mouth-parts conspicuous and long, the biting predaceous type with long curved mandibles. The prothorax is large, the elytra fitting tightly to the body, often with rows of pits or with lines. The body is, as in nearly all *Coleoptera*, enclosed in hard well-fitting chitinous plates, whose morphology is the basis of the classification of this large family. The legs are moderately long, fitted for rapid running or short and thickened, fitted for burrowing, the tarsal joints distinct, the claws well formed. In the males the basal tarsal joint of the fore leg is expanded. The elytra are in some species soldered together and do not open, there being no wings below and flight not being possible. (*Anthia*, *Carabus*). On the ventral abdominal segments are specialised setæ used in rapid locomotion along the ground.

The life-history is almost unknown in detail, but so far as is known elsewhere it is uniform throughout the group and the little known of the Indian species agrees generally. The larvæ are slender active insects, the head large with long mandibles and six ocelli, the thorax and abdomen smooth and tapering, with a terminal pair of dorsal cerci, an anal tube and three pairs of thoracic legs. The terminal processes are fairly characteristic; the colours are black or dull and the carabid larva is an insect that can usually be readily recognised. They are in the main predaceous and constitute part of the surface fauna and are best found when caterpillars are abundant on a crop, when they gather there to feed. Elsewhere some are known to feed in the roots of the crops, and one is a pest, but no record of such vegetarian larvæ exists for the Indian species, which are commonly predaceous. They suck out the juice of caterpillars and other insects, and though they must be extremely abundant, are very rarely found, except under these exceptional conditions. No details are available as to the length of the life-history. Pupation takes place in the soil. The eggs of one species (*Anthia sexguttata*) are large oval bodies, white and soft, measuring nearly one-quarter of an inch in length. One is laid at a time and dissection shows that they develop successively and are produced singly; apparently egg-laying is extended over a long period and the active imaginal life is probably long. The total number of eggs produced is probably small. Hibernation, so far as observed, takes place in the imago stage, the beetles burying themselves in the soil or otherwise taking shelter. Possibly it takes place in the other stages also.

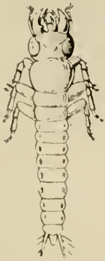


Fig. 150.—HARPALUS LARVA. (*After Packard.*)

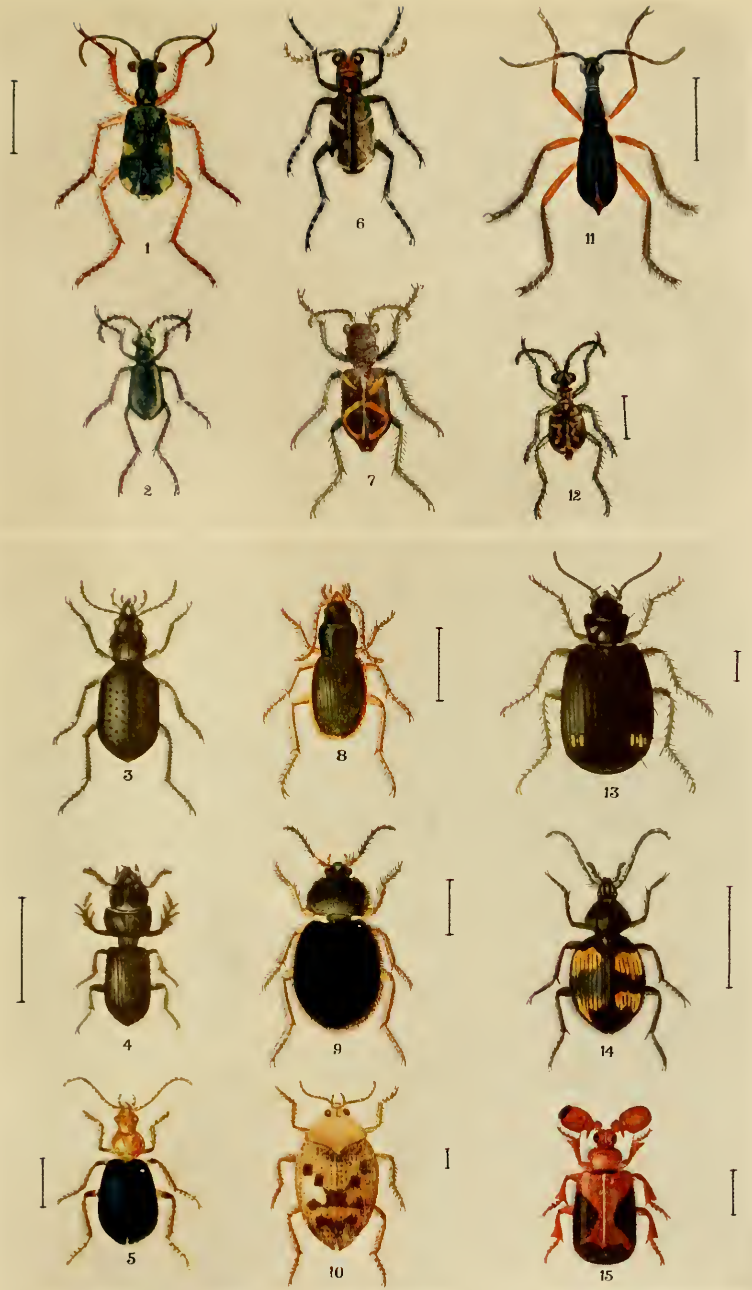
Carabidæ are partly diurnal, partly nocturnal, the latter species sometimes coming to light. Most can produce a caustic mal-odorous liquid from glands opening above the anus; in a few this liquid is volatile, and on being set free goes off with a little report; the enemy being overcome by the odour and detonation, the beetle escapes rapidly. No species is in India known to be destructive, and but very few are possible pests elsewhere, the carnivorous habits of the family apparently giving place to herbivorous habits in a very few species. The family can be classed among the great number of miscellaneous predators which check the general increase of other insects. They are protected by their ferocious habits, their hardness and by a volatile and offensive fluid (*Pheropsophus*). Their habitat includes every part of the earth's surface, and they are among the most universal of insects. Many thrive in the plains, some in the hills. Cultivated areas harbour many, as do the wastelands and jungles.

The number of species in India is a large one, and the family is one of the most rich in species. A list of the catalogued species of the region may be found in the Journal of the Asiatic Society of Bengal, Vol. LIX (1890), Appendix C. By no means all the species are described and there are large numbers to be added to this list. A total of fifty has been described since Atkinson's catalogue, showing how little attention has been paid to the group during the last two decades. The student may consult Bates' paper on the Ceylon species, collected in five months by Lewis, to realise the magnitude of the group (Ann. Nat. Hist., VI, Vol. 16, pp. 68, 43, 199). It is a noteworthy fact that this family are far more abundant in tropical than in sub-tropical or temperate India, and their place in the plains is to some extent taken in the hills by spiders so far as their predaceous function is concerned. Over 600 Indian species are enumerated by Atkinson. The groups are divided as follows :—

CARABINÆ.	*Omophronini* 4. *Carabini* 14. *Nebriini* 3. *Enceladini* 1. *Scaritini* 76.	HARPALINÆ I.	*Anchonoderini* 2. *Ctenodactylini* 5. *Odacanthini* 11. *Dryptini* 27. *Lebiini* 87. *Helluonini* 12. *Anthiini* 4. *Ceratocerini* 15.
HARPALINÆ I.	*Panagæini* 16. *Siagonini* 13. *Ozænini* 2. *Nomiini* 2. *Bembidiini* 19. *Pogonini* 2. *Pterostichini* 65. *Licinini* 6. *Platynini* 45.	HARPALINÆ II.	*Brachynini* 41. *Apotomini* 2. *Broscini* 4. *Chlænini* 90. *Harpalini* 38.
		PSEUDOMORPHINÆ.	9.

PLATE XVI.—Adephaga.

Fig. 1. Pronyssa nodicollis. (Cicindelidæ).
,, 2. Cicindela withilli. ,,
,, 3. Calosoma indica. (Carabidæ).
,, 4. Scarites nanus. ,,
,, 5 Dicranoncus amabilis. ,,
,, 6. Cicindela imperfecta. (Cicindelidæ).
,, 7. ,, aurofasciata. ,,
,, 8. Chlœnius circumdatus. (Carabidæ).
,, 9. Trichisia morio. (Carabidæ).
,, 10. Haliplus angustifrons. (Haliplidæ).
,, 11. Collyris distincta. (Cicindelidæ).
,, 12. Cicindela grammophora. ,,
,, 13. Tetragonoderus sp. (Carabidæ).
,, 14. Eudema angulatum. ,,
,, 15. Platyrhopalus denticornis. (Paussidæ).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It is impossible to attempt to discuss the classification and discrimination of our abundant Indian forms, which form one of the largest families. It may be hoped that these insects will soon be dealt with in the Fauna of India.

Carabus includes only a few Indian species and is more abundant in the palæarctic region. *Calosoma* (Plate XVI, Fig. 3), includes the species *Orientale*, Ho., found in Peshawar to be predaceous on young locusts (*Schistocerca peregrina*). *Ophionea* is a pretty little insect, common in the plains, and with several Indian species. The colouring and facies are distinctive, slender flattened insects marked in brown and red. *Dendrocellus* is another Indian genus extending also to West Africa. *Brachinus* is a widespread genus, usually black, with ferruginous head and prothorax, and greenish elytra. *Lebia* is another large genus, well represented in India; the beetles live chiefly on bark and plants, and are brightly coloured. The genus *Anthia* has a single Indian representative, the large *A.* (Pachymorpha) *sexguttata*, Ho.

Fig. 151.—ANTHIA SEXGUTTATA, × 1½. (F. M. H.)

This insect is one of the most striking beetles of the plains, black, with six large white spots. It is wingless and found wholly on the soil, spending the winter in holes. A few kept in captivity lived for some months, fed daily with from one to two hundred grasshoppers. Eggs were laid but failed to hatch. This is one of the few *Carabids* easily identifiable, and I have been told that it figures among the folk tales of natives of some parts of India. The *Scaritinæ* have a distinct facies (Plate XVI, Fig. 4), and are further marked by their pedunculate prothorax and enlarged digging legs, similar to those of the *Coprides*. They are black insects, some quite small, others of moderate size, and are, so far as is known, wholly digging insects. Some are diurnal, some nocturnal, and while most are predaceous, some appears to feed on decaying animal matter. *Clivina* is one of the larger Indian genera, with many Indian species.

Collecting.—Carabids are sufficiently abundant to be readily found and collected. They must never be put living with other insects but kept apart or killed at once with benzene. In this group, details of the food of the beetles is much wanted ; every larva found should be reared, feeding it on living insects ; though the beetles are extremely numerous, few larvæ are known and fewer still have been reared. Attempts to rear *Anthia* have failed, though their eggs were obtained and it will probably be more satisfactory to rear from captured larvæ. These should be carefully sought for whenever caterpillars are abundant, as they collect at such spots. Larvæ are best preserved in formalin.

Paussidæ.

A family of small beetles most readily recognised by the extraordinary form of the antennæ, which are usually very large, as well as by the truncate elytra which usually leave the pygidium exposed. Tarsi five-jointed.

These remarkable beetles are of small size, generally near to one-quarter of an inch long, coloured almost wholly in red-brown and black. The head bears the remarkable antennæ and the somewhat reduced mouth-parts ; the former have two, six or ten joints ; in many cases there is a small basal joint and a single large leaflike apical joint ; in others the expanded part consists of the apical five joints. The prothorax is well developed and of varied form ; the elytra are parallel-sided and truncate behind, the pygidium visible in most species. The legs are of varied form, sometimes expanded and leaflike, usually slender and formed for walking.

The life-history of no species is known. These beetles are found at light, have been repeatedly found walking on the soil and are found in

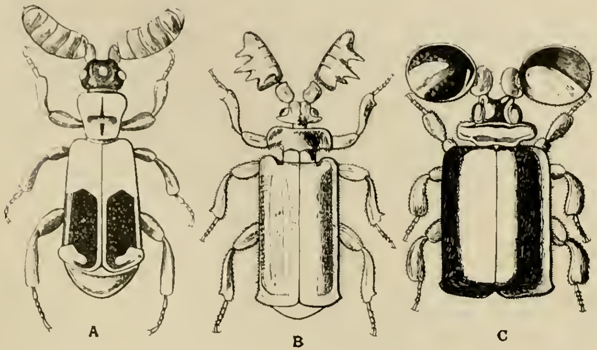


Fig. 152.—A. CERATODERUS OBERTHURI, B. EUPLATYRHOPALUS APLUSTIFER, C. PLATYRHOPALUS MELLYI.
(*After Desneux.*)

ants' nests. It is believed they are all myrmecophilous, living on varying terms of indebtedness in the nests of surface ants. They fly quickly and settle with the wings extremely quickly closed, so that they appear to fall rather than to settle. As in the previous family, these beetles secrete a liquid which is irritant to the human skin.

Of the known species (Desneux, Genera Insectorum), nearly 300 in number, about one-seventh are Indian, and the fauna is comparatively rich in forms. They are found in the plains as in the hills and probably many plains' forms remain to be discovered.

Platyrhopalus denticornis, Donov. (Plate XVI), is apparently the most common, found at light and walking on the soil. *Merismoderus Bensoni*, Westw., is known from the United Provinces and figured by Westwood (Cab. Oriental Entomology, Plate XLI, Fig. 4); he states that it was found in a "black ants' nest." Many Indian species of this family are figured in Westwood's Arcana Entomologica.

MYRMECOPHILOUS INSECTS.

In a publication, dated 1894, Wassmann enumerates nearly 1,200 insects which live in some degree of association with ants, and over one hundred living in connection with termites. The former are the "Myrmecophilous" insects; they possess a special interest chiefly on account of the fact that a large proportion of them are not inimical to the ants in whose nests they live, but they play an important part in the economy of the nest and are deliberately fed and maintained by ants. The ant community is much like the human community; it has species of insects that it domesticates, feeds, tends and preserves on account of the food it derives from them; there are others which live in harmony with them, are tolerated but are not known to have any value to the ants; there are insects hostile to the ants themselves, but which, nevertheless, maintain themselves in their nests; and there are parasites which live in the bodies of ants.

The same applies to termites but far less is known of them since they are tropical insects and have been far less studied. It is probable that the "termitophilous insects" are as varied and numerous as the myrmecophilous insects and there is here a great field for observation and research in this country.

Comparatively little is known of myrmecophilous insects in India; Wroughton, Rothney and others who investigated Indian ants, found a number of species and Wroughton has also found termitophilous insects; but the number recorded and the observations made covers only a very small part of the ground. We have here endeavoured to condense from Wassmann's Kritisches Verzeichniss not only the groups found elsewhere but the recorded Indian species.

Escherich describes three Termitophilous Thysanura, of the Genera *Assmuthia* and *Platystelea* from India (Zool. Anz., p. 743). *Myrmecophila* among Orthoptera is the sole recorded genus: Wroughton and Aitken record *M. acervorum*, Panz. var *flavocincta*, Wassm. in the nests of *Plagiolepis longipes*, Jerd. This little insect is one of the *Myrmecophilinæ* (Gryllidæ). Wassmann (Zeitsch. Wiss Insecten-biol. I, p. 334), describes *Myrmecophila prenolepidis* found in Bombay by Assmuth, running with the ants (*Prenolepis longicornis*) which were moving their nest at the beginning of the rains. The same *Myrmecophila* occurs with the same ant in Brazil. Two other species of *Myrmecophila* are known to live with *Pheidole Wroughtoni* and with *Camponotus compressus*. The author states that *Myrmecophila* lives with one ant species in its nymphal instars and with another when full grown.

Among *Neuroptera*, a single Psocid is recorded. Some *Eutermes* live in a friendly manner with species of *Termes* and are thus Termitophilous. In *Hymenoptera*, we have first the ants living in a social way with other ants; thus a small ant may make nests by tunnelling in the solid earth left between the galleries of a much larger kind of ant ; or two kinds of ants may share a nest. Wassmann records no instances from this country but our common ant *Myrmecocystus setipes* certainly allows another ant to build between its galleries, and there are probably other instances. Ants are also termitophilous in that they live in termites' nests. Two sphegid wasps, *Rhinopsis constanciæ*, and *R. ruficornis*, Cam., mimic and live where *Sima rufonigra* is common ; but the exact relations are doubtful. Elsewhere, Fossorial wasps prey upon ants, carrying them off to stock their cells with. Various Parasitic Hymenoptera destroy ants but none are yet recorded in India. *Lepidoptera* include a very few whose larvæ live in ants' nests (none Indian), and a number which are visited by ants, which have special "honey organs" and which in some cases pupate in the ants' nests. deNiceville remarks that some of these caterpillars will thrive only in association with their particular ants. These are all *Lycænidæ* ; the list embraces the following :—

Polyommatus bœticus, L.	visited by	*Camponotus compressus*, F.
	,, ,,	*Prenolepis clandestinus*, Mayr.
	,, ,,	*Tapinoma melanocephalum*, F.
Tarucus theophrastus, F.	,, ,,	*Camponotus compressus*, F.
	,, ,,	*Pheidole latinoda*, Rag.
Gerydus symethus, Cram.	,, ,,	? ?
Rapala schistacea, Ms.	,, ,,	? ?
Chilades laius, Cram.	,, ,,	*Camponotus compressus*. F.
,, *trochilus*, Frey.	,, ,,	*Pheidole quadrispinosa*, Jerd.
Zizera lysimon, Hubn.	,, ,,	*Tapinoma melanocephalum*, F.
Lycænesthes emolus, God.	,, ,,	*Œcophylla smaragdina*, F.
Lampides ælianus, F.	,, ,,	*Camponotus mitis*, Sm.
Catochrysops enejus, F.	,, ,,	*Camponotus compressus*, F.
,, *pandava*, Horsf.	,, ,,	*Prenolepis longicornis*, Ltr.
,, ,, ,,	,, ,,	*Monomorium speculare*, Mayr.
,, ,, ,,	,, ,,	*Cremastogaster* sp.

Among Diptera, there are less than 20 species recorded, chiefly European, *Microdon* being the best known. A single Indian example among Heteropterous Rhynchota is the Coreid *Dulichius inflatus*, Kby., which Wroughton found to mimic *Polyrhachis spiniger*, Mayr., and to live where this ant is common. Of the *Homoptera*, there are species of *Fulgoridæ* and *Membracidæ* which are visited by ants to get the sweet secretion. Our common species of *Leptocentrus* among the latter and *Pyrilla aberrans*, Wlk., among the former are examples. *Psyllidæ*, *Aphidæ* and *Coccidæ* also afford many examples, ants either simply visiting them to get honeydew, or building shelters over them, or maintaining them in their nests. *Œcophylla smaragdina* commonly sews together the leaves round colonies of Coccids and makes shelters for them ; a very large number of our Coccids and Aphids are visited by species of *Camponotus*, *Cremastogaster*, *Cataulacus*, etc., though we are not aware of any detailed information as to the species of ants which visit each. A small number of Poduridæ and Lepismidæ are also recorded as being found as guests in ants' nests. We have left the Coleoptera to the last, as they form the greater number of the recorded species. The following families are enumerated as having more than ten Myrmecophilous or Termitophilous species :—

		Myrmecophilous	Termitophilous.
Staphylinidæ	..	263	59
Pselaphidæ	..	113	5
Clavigeridæ	..	89	0
Paussidæ	..	169	0
Scydmænidæ	..	32	0
Silphidæ	..	35	1
Trichopterygidæ	..	14	0
Lathridiidæ	..	30	1
Thorictidæ	..	40	0
Histeridæ	..	128	7
Scarabæidæ	..	17	6

Below is a list of eleven species more or less definitely ascertained to be Myrmecophilous in India ; Wassmann includes many others which, from structural characters, he assumes are myrmecophilous, especially Paussids.

Clavigeridæ	*Claviger Hageni*, Motsch.	East Indies.
	Mastiger abruptus, Motsch.	Calcutta.
Paussidæ	*Merismoderus Bensoni*, Westw.	with black ants, Bengal.
	Paussus Fichteli, Don.	Black ants (? *Pheidole*).
	Paussus soleatus, Wasm.	*Pheidole Wroughtoni*, For.
	Paussus suavis, Wasm.	*Pheidole latinoda*, Rag.
	Paussus Wroughtoni, Wasm.	*Pheidole Wroughtoni*, For.
Colydiidæ	*Paramellon sociale*, Waterh.	In ants' nests.
Scarabæidæ	*Chætopisthes fulvus*, Westw.	In Termites' nests.
	,, *simplicipes*, Reiche.	,, ,, ,,
Pselaphidæ	*Aulacophora* sp.	,, ,, ,,

On the analogy of other countries it is probable that there are abundant myrmecophilous and termitophilous insects in India and we reproduce the list above as a guide to the student for what he may expect to find.

In a later paper (Deutsche Ent. Zeitung, 1899, I, p. 145), Wassmann describes the termitophilous insects found in the nests of the common white ant, *Termes obesus*, Ramb., at Ahmednagar by Father Heim. They are four Staphylinids, *Termitodiscus Heimi*, *Myrmedonia tridens*, *Myrmedonia Heimi*, *Myrmedonia sculpticollis* : and two Aphodiine beetles, *Chætopisthes sulciger* and *Corythroderus gibbiger*. As Myrmecophilous, Wassmann mentions the following species :—

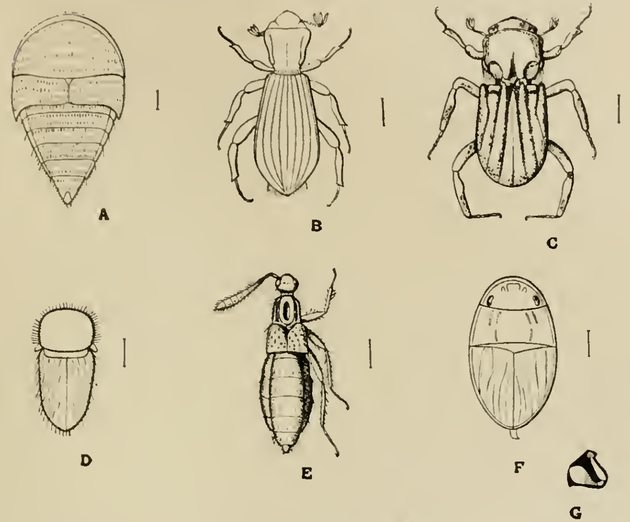


Fig. 153.—MYRMECOPHILOUS BEETLES.—A. TERMITODISCUS HEIMI.—B. CHÆTOPISTHES SULCIGER.—C. CORYTHRODERUS GIBBIGER.—D. THORICTUS HEIMI.—E. WROUGHTONILLA LOBOPELTÆ.—F. COSSYPHODINUS INDICUS.—G. C. INDICUS, ANTENNA FOLDED IN CAVITY.

[*After Wassmann*].

STAPHYLINIDÆ—

Wroughtonilla lobopeltæ, Wassm. with *Lobopelta diminuta*, Sm. Nilgiris.

THORICTIDÆ—

Thorictus Heimi, Wassm. ,, *Triglyphotrix walshi*, For. Ahmednagar.

LATHRIDIIDÆ—

Coluocera Beloni, Wassm. ,, *Pheidole sulcaticeps*, Rag. Ahmednagar.

,, *Holcomyrmex scabriceps*, Mayr. Ahmednagar.

COSSYPHODIDÆ—

Cossyphodinus indicus, Wassm.	with	*Pheidole sulcaticeps*, Rag. Ahmednagar.

TENEBRIONIDÆ—

Dichillus tenellus, Wassm.	,,	*Holcomyrmex scabriceps*, Mayr. Ahmednagar.
Schizillus Rogersi, Wassm.	,,	*Pheidole indica*, Mayr. Mussoorie.
Tetranillus costatus, Wassm.	,,	? ? Ahmednagar.
Stenosis dentipennis, Wassm.	,,	*Cremastogaster* sp. Thana.
,, *wroughtoni*, Wassm.	,,	*Pheidole latinoda*. North Gujarat.

RHYSODIDÆ.

Head with a slender neck. Antennæ filiform, eleven-jointed. Tarsi five-jointed. Abdomen of six joints, basal three connate. Front tibia notched on inner edge.

A small family of two genera ; they are elongate, the integument hard and with longitudinal impressed lines ; all are coloured black or brown. The few known species have been found under the bark of trees. Lewis revised the family in 1889 (Ann. Nat. Hist. VI, Vol. 2) and listed forty species of *Rhysodes* and *Clinidium*, of which *C. apertum*, Reit., *R. aterrimus*, Chevr., is Indian and *R. taprobanæ*, Fairm., is known from Ceylon. Three species of *Rhysodes* have since been described by Arrow.

DYTISCIDÆ.

Aquatic beetles, the posterior coxæ enlarged, the antennæ filiform. Hind leg formed for swimming. Males with the three basal tarsal joints of foreleg dilated.

These beetles are readily distinguished by the above characters from other aquatic beetles. They are practically aquatic Carabids with the bodily form and appendages modified to suit their mode of life. They include some of the larger beetles and many small forms; the colouring is sombre and probably renders the swimming beetle inconspicuous. The form is oval, the parts very closely united to form one continuous whole with no projecting angles or lines ; the head is broad, tightly fitting and only capable of slight movement. The trophi are similar to those of the Carabidæ, the biting carnivorous type.

The elytra cover the abdomen and the wings are large and functional in all species. The anterior legs are set close together, of the usual form except in the males, in which the basal tarsal joints are to a greater or less extent dilated; in some this dilation is so large as to form a conspicuous sucker-like organ and used by the male to securely hold the female. The hind legs are long and formed for swimming, the tarsi compressed and twisted so that the upper edge is outward; they are ciliated on one or both edges. The coxæ are very large and occupy a large part of the ventral surface. The sexes are similar in general appearance and are distinguished by the fore tarsi. These beetles excrete a whitish fluid from the articulation of the head and prothorax on being seized, and also excrete an unpleasant fluid at the anus.

Fig. 154.—CYBISTER CONFUSUS, MALE.

The life-history of no species appears to have been worked out in India and there is no reason to believe it differs from the general type. Eggs are laid in aquatic plants, under water, and hatch into elongated grubs with a large flat head, a long tapering body terminating in two ciliated processes; there are three pairs of long swimming legs. The apex of the abdomen ends in two spiracles which alone are open and functional; the larva comes to the surface tail upwards, the two processes lie flat on the surface film owing to their ciliations and support the grub, which takes in the air supply quickly. The head has a pair of long hollow sickle-shaped mandibles, and it has been shown that when these are in use the mouth is automatically closed; the larva grasps its prey by the mandibles, inserts them and sucks the blood through the hollow mandibles; the larvæ are extraordinarily voracious, and if confined together, attack and destroy one another. They are abundant in freshwater in India, especially if stagnant or nearly so. Pupation takes place in the mud near the water. The adults are aquatic, and carry their air supply under their elytra; they also come up periodically with the apex of the elytra upwards to renew their air supply. They are carnivorous but less voracious than the larvæ and fly at night from pond to pond. Nothing is known of the habits of the Indian species nor of their mode of hibernation, number of broods, etc.

Fig. 155.—Eretes sticticus larva and imago × 3.

Sharp in 1876 experimented with *Dytiscidæ* to find the ratio of the time spent getting air at the surface to that spent under water. He found in *Dytiscus marginalis* a ratio of 1 to 12. *Pelobius* has a ratio of 1 to 375. (Proc. Linn. Soc., 1877.)

The family is a large one, monographed by Sharp (On Aquatic Carnivorous Coleoptera); Regimbart in 1899 revised the Eastern forms (Ann. Soc. Ent. France, 1899, p. 186) listing 140 " Indian " species. Three new ones collected by Maindron were added (loc. cit., 1903, p. 333). The principal genera are arranged as follows:—

I. HYDROPORIDES—

1. *Hydroporini.*—Hydroporus, 4; Hyphoporus, 9; Hyphydrus, 3; Clypeodytes, 6; Bidessus, 6; Yola, 1.

2. *Hydrovatini.*—Hydrovatus, 15.

3. *Methlini.*—Methles indicus, Reg.

II. NOTERIDES—

Hydrocoptus, 4; Canthydrus, 6; Hydrocanthus indicus, We.

III. LACCOPHILIDES—

Laccophilus, 15; Neptosternus, 2.

IV. DYTISCIDES—

1. *Colymbetini.*—Agabus, 10; Platynectes, 3; Lacconectes, 5; Copelatus, 7; Rhantus, 5;

2. *Hydaticini.*—Prodaticus pictus, Shp.; Hydaticus, 8.

3. *Thermonectini.*—Sandracottus, 3.

4. *Eretini.*—Eretes stictieus, Linn.

5. *Cybistini.*—Cybister, 17.

Hyphoporus includes small oval thickset beetles found widespread in wells and tanks. *H. aper*, Shp., appears to be the commonest plains' species. *Copelatus indicus*, Shp., is a small dark insect, abundant in rice fields and found under the bark of trees during the time when the fields are dried up. *Hydaticus Fabricii*, Mch., and *H. vittatus*, Fabr., are the commonest plains species of this genus, medium sized brown insects found in tanks. *Sandracottus Dejeani*, Aub., is widespread and abundant in wells and tanks, a handsome black and brown mottled insect of moderate size.

Eretes (Eunectes) *sticticus*, Linn., is also extremely abundant and common; its larva feeds on *Culex* larvæ. *Cybister* includes the large forms which take the place of the European *Dytiscus*; *Cybister confusus*, Shp., is the large black water beetle with the lateral brown stripe found in fresh water in the plains. *C. tripunctatus*, Ol. var. *asiaticus*, Shp., is smaller, also abundant in rice fields and tanks.

INSECTS AS FOOD.

It is a matter of daily observation that many birds and some mammals find that insects are an excellent food and one may wonder that man has not found this also. But in nothing are the vagaries and caprices of man better shown than in what he will and will not eat, and so a very large supply of food has, and apparently will, daily perish.

Herbivorous insects live in exactly the way a herbivorous mammal such as a sheep does, feeding on the tissues of dry or green plants and transforming them into animal tissues, which differ little from the tissues of a mammal or bird and are but the concentrated nourishment of the living plant ; only in many cases they do so far more quickly and are far easier and quicker to rear in large quantities. Why then are they not more eaten ? It is pure caprice and we know that many insects are excellent and nourishing food. Unfortunately, there are not the data available to really deal with this subject ; in times of scarcity all the world over men have turned to insects and travellers have recorded the insects eaten and the expertness of the little-civilised portion of mankind in finding them ; but the subject rests in darkness precisely because the people who practise this habit are not those of whom much is known or whom civilisation reaches ; we fear that the spread of civilisation will lead to the total abolition of these interesting practices before we know about them, to the detriment of a later generation which will have to rediscover by experiment which are and which are not, good to eat ; unless they adopt the " monkey " test. It is stated in books that what a monkey will eat is good food for man ; it is certain that monkeys eat insects with avidity excepting the extremely nauseous ones with warning colouring. Mankind eats many curious things, including oysters, shrimps, whelks and cockles, dried sea slugs (Holothurians), and birds' nests ; the most civilised nation is addicted to eating snails, even uncooked ; and yet there is an absurd prejudice against insects, not universal, but certainly covering the more civilised portions of mankind. We may doubt if the deterioration in natural instincts that civilisation brings is not revealed in the races that eat so nauseous, deadly and unappetising a thing as an oyster and refuse to consider a nice clean white termite queen or a dish of locusts.

Among the few items of Entomology of this kind, the fact is on record that in Assam, the large bugs of the genus *Aspongopus* are eaten with rice ; in Burmah, the red ant (*Œcophylla smaragdina*) is reported to be a delicacy, its pungent flavour relieving the monotony of the daily fare. Locusts are appreciated in many parts of India and it is said that dried locusts form an ingredient of curries even in Calcutta, where a locust swarm is looked on as a providential occurrence. In Burmah, the larvæ of an aquatic beetle are collected and eaten ; this is the beetle, *Eretes* (Eunectes) *sticticus*, apparently the commonest species of Dytiscidæ in India. The following observations of this insect in Burmah, are by J. Carey, Esq., Sub-Divisional Officer :—

"An insect called the Twinpo (literally insect found in pits or hollows) is found in Twinywa, a village about 8 miles west of Budalin, situated in a large depression presumably caused by volcanic eruption. The long slender specimens without wings (Fig. 155), are the young insects: the oval shaped ones with wings are the fully developed insects (Fig. 155). They live and thrive in the waters of the lake in the middle of the depression. The waters of this lake are slightly salt and bitter. Among the developed insects, the male can be distinguished from the female by the circular extremities of its front legs. Besides the male is generally smaller than the female. The fully developed insects are seen only after a shower of rain, when the lake is simply agitated by their movements. This is a sign that breeding is going to take place; for soon after the shower the insects creep on to the land and remain embedded in the mud about three or four feet away from the water's edge. Whilst remaining in the mud with their heads slightly exposed, they lay eggs from which the slender needle-shaped insects without wings are found, on the third day. The young insects make for the water as soon as they are formed, and after twenty days reappear still retaining their original slender form, but slightly larger in size. They are then of the same shape and size as the samples. As soon as these young insects appear they make for the land and remain entirely embedded in the earth at a distance of about fifteen feet from the water's edge; the young insect remains hidden in the ground for ten days and after that period it emerges from the ground entirely transformed—instead of the needle-shaped insect devoid of wings, there appears from the ground an oval-shaped insect, possessed of a pair of wings. The insect returns to the lake as soon as it is fully developed.

"The fully developed insects are caught at the water's edge when they are creeping up the land to the mud. The undeveloped slender ones are caught at the edge of the water when they creep up to the land to go through the process of transformation. The insect is eaten in both forms and is considered a delicacy by the Burman."

Termite queens are also eaten in some places in India as in Africa, and we can imagine no more dainty or tempting morsel than such an insect, which is most carefully fed and tended and which presents a most pleasing appearance. In some parts of South India, every boy of an age of 12 to 14 is said to be given a termite queen to eat, after which he runs a distance of two or more miles; having once done this he will be able thereafter to endure fatigue and run well. The large fat grubs of *Oryctes* are also eaten, and probably many other similar insects. It is said to be a common practice among tribes in the wilder parts of India to eat the larvæ and pupæ of the big jungle bee, *Apis dorsata*, found in the combs. So also rearers of wild silk such as tassar (*Antheræa paphia*) are known to regard the pupæ in the cocoon as a delicacy and to eat it when the silk has been reeled off.

These are all the instances we have been able to gather in India; notable cases elsewhere are the egg masses of *Notonecta* in Mexico, and the Grugru worm of the West Indies; we can vouch for the excellence of the latter, which are the larvæ of the Palm Weevil, *Rhynchophorus palmarum:* these are eaten raw or cooked. Eaton records that in Nyassaland. a paste of Mayflies and *Culicidæ* is eaten under the name of "Kungu." The Mayfly is *Cænis kungu*, Etn. (Monogr. Rec. Ephem., p. 148). A species of *Elmis* (*Parnidæ*) is used as a relish in Peru according to Philippi (Stett. Ent. Zeit., 1864, p. 93).

The reader should consult Wallace's article "On the Insects used as food by the Indians of the Amazon" (Trans. Ent. Soc., London. 1854, p. 241). He mentions five insects belonging to distinct orders which are used as food; the female of an ant called Sauba (*Atta cephalotes*, Latr.) is captured "in basketfuls" when it swarms out of the nests; Wallace remarks "it is rather a singular sight to see for the first time an Indian taking his breakfast in the Sauba season. He opens the basket and as the great winged ants crawl slowly out, he picks them up carefully and transfers them with alternate handfuls of farina (Cassava meal) to his mouth." The worker of a termite (*Termes flavicolle*, Perty) is eaten on account of the mass of muscle in the head and thorax, a Homopterous insect (*Umbonia spinosa*) is eaten roasted, as well as the grub of the Palm Weevil (*Rhynchophorus palmarum*); finally Wallace's last paragraph is worth quoting entire. as it might quite correctly have been written in some parts of India. "The apterous insect which is eaten by the South American Indians, more, I presume, as a delicacy than as an article of food, is a species of *Pediculus* which inhabits the head of that variety of mankind. The method of capturing and devouring this insect is exactly the same as that which everyone has seen adopted by the monkeys at the gardens of the Zoological Society. A couple of Indian belles will often devote a spare half hour to Entomological researches in each other's glossy tresses, every capture being immediately transferred to the mouth of the operator."

The following extract from Cuvier's Natural History refers to the Migratory Locust (*Schistocerca peregrinum*):—

"Some people of Arabia and of some other countries of the East, take them in great quantities, have them dried, ground and made into a sort of bread, when their crops have failed. At Bagdad, they are brought to market and by this means the price of other provisions is said to be considerably lowered. According to report, the locusts have something of the flavour of a pigeon. One man can easily despatch two hundred of them at a meal. The modes of cooking them are various. The Bedouins of Egypt roast them alive upon the coals, and eat them as a great delicacy, having first removed the wings and feet. They also remove, at least in some places, the intestines. The women and children of some parts of Arabia Felix, string them together, and thus sell them. The Arabs roast these insects and steep them in butter, and when they wish to carry their luxury to an extreme, they give them but a single boil in water, and afterwards fry them in butter. The inhabitants of Morocco dry them on the roofs of terraces of their houses and eat them either smoked or broiled or boiled. Other people of Barbary preserve them in pickle. According to Forskæl, there is no great relish in this aliment, and if used to too great a degree, it thickens the blood, and becomes injurious to melancholic temperaments."

That the art of cooking insects is not extinct is shown by the following extract from Harry Roberts' "The Tramp's Handbook" (1903, p. 121). "The larvæ of cockchafers fried with a little salt and pepper are not to be despised, and many of our common caterpillars—including those of the cabbage white butterfly and of the currant moth—may be cooked in the same way."

The cabbage white butterfly is our *Pieris brassicæ*, abundant occasionally in Behar in April; this insect may then prove to be a blessing in disguise.

HALIPLIDÆ.

Posterior coxæ produced behind in a plate partly covering the abdomen. Antennæ bare, ten-jointed.

A small family distinct by the coxæ from *Carabidæ* and *Dytiscidæ*. The antennæ are ten-jointed, inserted near the eyes; the scutellum is absent; the tarsi are narrow as in Carabidæ, and not formed for swimming; in the males the basal three joints in the anterior legs are slightly dilated. These small beetles are found in fresh water, such as ponds and streams; they have a habit of coming out to gather on plants near the water and may sometimes be captured in numbers. No Indian species seems to have been reared and but a very few species are known from India at all. Cardon's collections yielded *Haliplus pulchellus*, Cl., and *H. angustifrons*, Reg. The latter is a small yellow brown insect with black speckles, found also at light. (Plate XVI, fig. 10.)

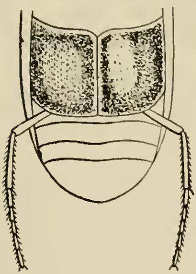


Fig. 156.—HALIPLUS ANGUSTIFRONS, VENTRAL VIEW OF ABDOMEN TO SHOW THE LARGE PLATE-LIKE COXÆ.

Gyrinidæ.—*Whirligig Beetles.*

Antennæ short, eyes divided, posterior coxæ fixed, posterior legs formed into paddles. Larva aquatic, imago on surface of fresh water.

There is little difficulty in recognising members of this family, small shiny beetles which move in incessant activity on the surface of streams and tanks. They are usually of a black colour, the submerged portion pubescent, the rest shiny. The head, prothorax and elytra are closely fitted, the antennæ short and inconspicuous, inserted in a groove in front of the eyes: the head is well developed with the large compound eyes divided, so that one part is in the water, one part in the air. The fore legs are long and slender, the tarsi in the males of some species dilated to form a plate which is set below with little suckers. The posterior legs are modified to serve as paddles, the femur and tibia each dilated into broad plates, the tarsal joints forming a single broad plate. The elytra may be wholly smooth or simply sculptured, or the "submergence line" extends along it, the part below being pubescent, as is the ventral surface of the body. A fœtid liquid is excreted by these beetles, presumably as a protection.

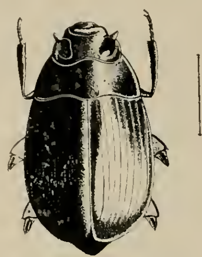


Fig. 157.—Dineutes indicus.

Nothing appears to be on record as regards the life-history of any Indian form: elsewhere the known larvæ are aquatic, living in fresh-

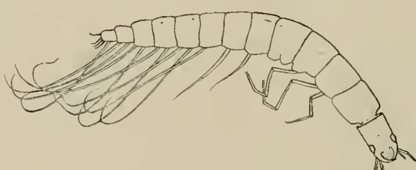


Fig. 158.—Gyrinid larva, × 4.

water tanks and streams near or at the bottom; this larva has lateral processes on each abdominal segment, functioning as gills, as also four apical abdominal hooks and is active and predaceous on other aquatic insects. The pupa is in a papery cocoon fixed to water plants. The adult lives on the surface of the water, the broad paddles propelling it swiftly along the surface, where it feeds on small insects which it finds near the margin. Numbers may be seen on the margins of fairly still water, continually describing complicated movements together; when alarmed, they plunge below the surface of the water, carrying a bubble of air attached to the hind end. Some species are confined to smooth still water, others to swift mountain streams. All are unable to walk on land and they are found away from water only when flying at night, when they come to light. The family has no economic importance and has been little studied: nothing is known of their hibernation, enemies and the like.

Regimbart's latest monograph (*Genera Insectorum*) enumerates 34 Indian species, in the genera *Dineutes* (4), *Aulonogyrus* (1), *Gyrinus* (2). *Orectocheilus* (27). *Orectocheilus gangeticus*, Reg., is the common plains' species, a medium sized black species found abundantly at the margin of rivers. *Dineutes indicus*, Aube., is a larger insect found on streams and stagnant water both in the plains and in the hills.

POLYMORPHA

If we omit the large distinct, series of beetles the *Lamellicornia. Adephaga*, *Phytophaga*. *Rhynchophora* and *Heteromera*, there remains a great assemblage of beetles. many of which fall into well marked families, but a proportion of which are extremely difficult to unite into natural families. Especially is this the case with the numerous forms which live in decaying wood, under the bark of trees, or in mushrooms; these beetles are imperfectly known, their structural characters are very varied and no simple and accurate method of classing them has yet been arrived at, largely through the fact that but few are known. This, while true of these insects as a whole, is still more the case with the Indian forms, of which scarcely anything is known. Nominally these beetles fall into two series, those with antennæ distinctly clavate, those with antennæ distinctly serrate; but many which have other structural affinities with one series have not clubbed or serrate antennæ: their tarsal characters vary in even what are regarded as the limits of a family or sub-family; and actually many families are characterised by such a number of characters relating to the trophi, antennæ, coxæ, tarsi, ventral abdominal segments and the like that the diagnosis to be of any use must be extremely full and detailed, occupying far more space than is available here. While we have given a brief diagnosis of the families we know to be represented in India, we are not sanguine that the student will place every beetle in its family by consulting these diagnoses. Some of the larger families are distinct enough; for the rest if the characters obviously agree with any diagnosis, the beet'e can probably be placed provisionally in that family; if, as in many cases, the student abandons the task as hopeless, there is no remedy but to consult some work in which the diagnoses are given in fuller detail.

Actually a large majority of the smaller obscurer Polymorphous beetles found will undoubtedly be new and while their characters may agree with known genera, they are likely not to and we must anticipate the formation of new groups of beetles when our fauna is better studied. Finally in this heterogeneous group above all, a good reference collection is essential as the actual interpretation of the characters and their just appreciation is no easy matter and is only to be gained by practice and experience. The majority of the following families can usually be distinguished, so far as known Indian forms are concerned :—

Hydrophilidæ.—Antennæ of three parts, fitting under head; a sternal spine often. Part aquatic.

Pselaphidæ.—Tarsi three-jointed. Elytra truncate. Abdomen of 7 or less segments, not mobile.

Staphylinidæ.—Tarsi three-jointed. Elytra truncate. Abdomen 7 or 8 mobile ventral segments.

Sphæriidæ.—Tarsi three-jointed. Antennæ clubbed. Three ventral segments.

Trichopterygidæ.—Tarsi three-jointed. Wings fringed with hairs. Very minute beetles.

Corylophidæ.—Tarsi four-jointed, first joint very small. Wings hair-fringed. Very small.

Scaphidiidæ.—Tarsi five-jointed. Antennæ with the five apical joints broadened.

Histeridæ.—Tarsi five-jointed. Elytra truncate. Short clubbed antennæ. Hard compact beetles.

Phalacridæ.—Tarsi five-jointed, fourth very small. Posterior coxæ contiguous.

Nitidulidæ.—Tarsi five.jointed, fourth very small. Posterior coxæ not contiguous. Elytra often abbreviate or truncate.

Trogositidæ.—Tarsi five-jointed, first very small. Antennæ with apical joints broadened on one side only.

Erotylidæ.—Tarsi five-jointed, basal three broadened, fourth small, fifth long (c.f. *Chrysomelidæ*). Antennæ clubbed.

Coccinellidæ.—Tarsi four-jointed, third very small. Antennæ not clubbed.

Endomychidæ.—Tarsi four-jointed, third very small. Antennæ clubbed.

Lathridiidæ.—Tarsi three-jointed. Five visible ventral segments (c.f. Staphylinids).

Dermestidæ.—Tarsi five-jointed. Antennæ short, clubbed, and hidden in a groove in prothorax.

Byrrhidæ.—Tarsi five-jointed; small, hard compact beetles, the femora fitting into the coxæ.

Heteroceridæ.—Tarsi four-jointed. Antennæ with seven apical joints broadened. Aquatic, in mud.

Parnidæ.—Tarsi five-jointed, fifth long. Aquatic.

Bostrichidæ.—Usually cylindrical, hard, and rugose. Tarsi five-jointed, basal joint small. Antennæ often serrate.

Ptinidæ.—Usually cylindrical, hard, and rugose. Tarsi five-jointed, basal joint not small. Antennæ often serrate.

Malacodermidæ.—Soft beetles, with 6, 7 or 8 ventral segments, antennæ pectinate or serrate.

Elateridæ.—Antennæ pectinate or serrate usually. Prosternal process. Hind angles of prothorax prolonged backwards, prothorax movable.

Buprestidæ.—Antennæ serrate. Prosternal process, prothorax fixed. Tarsi five-jointed, basal four with pads.

HYDROPHILIDÆ.

The antennæ with a long basal joint, the remainder forming a club, the apical joints broadened, fitting below the head. Tarsi five-jointed, basal joint often small.

This family is recognisable by the antennæ, which are of the form figured (fig. 137), the broader apical joints being pubescent. They consist of a basal joint, a club of three to five joints and one to three small intermediate joints. They often bear a general resemblance to *Dytiscidæ*, the aquatic forms having a similar oval form but being less compact. The terrestrial forms are more globose and rounded, but with the general facies of the family. They are black or dull-coloured insects, generally less than half an inch long. The head, prothorax and elytra fit closely, and are usually smooth and shining. In the aquatic species, the hind

Fig. 159.—HYDROPHILUS OLIVACEUS.

legs are slightly flattened and set with hairs, so as to render them capable of acting as paddles.

The life-history of no Indian species has been worked out and nothing appears to be on record. The life-history of aquatic species elsewhere is known and the student should consult Miall's "Aquatic Insects." The eggs are laid in a case formed of filaments excreted from the silk tubes at the anus of the female beetle; this case is hollow and has a projecting process like a mast; it is fixed to aquatic plants at the surface of the water. The young are similar in general form to those of the *Dytiscids* (the tarsus with one claw) and also predaceous; air is obtained by bringing the large spiracles at the hind end of the body to the surface. Pupation takes place in the mud. The beetles swim actively and obtain air by coming to the surface head up, the air being contained on the lower surface of the body and communicating with the cavity in which the antenna lies; when the head comes up, the air supply is in contact with the atmosphere through this channel and is renewed. The beetles are principally vegetarian and not predaceous. Only a part are aquatic, some being found in mud, near streams and ponds, under the bark of trees and in dung.

Fig. 160.—HYDROPHILUS PICEUS LARVA. (*After Chapuis.*)

The family is a moderately large one, divided into five sub-families as follows :—

I. Basal joint of posterior tarsi short, second long.

(*a*) Posterior tarsi formed for swimming. A sternal process present .. *Hydrophilinæ.*

(*aa*) Posterior tarsi normal. No sternal process .. .. .. *Hydrobiinæ.*

II. Four basal joints of posterior tarsi short and equal .. .. .. *Spercheinæ.*

III. First basal joint of posterior tarsi very short, rest short and equal .. .. *Helophorinæ.*

IV. First basal joint of posterior tarsi elongate .. .. *Sphæridiinæ.*

Régimbart's papers (Ann. Soc. Ent., France 1903, p. 52 and p. 331), should be consulted for descriptions. The *Hydrophilinæ* are aquatic and eighteen Indian species were listed by Atkinson, 7 having been since described. *Hydrophilus* includes among several species the common species *H. olivaceus*, Fabr. ; this may be found in tanks and should be handled cautiously on account of the large spine projecting from the sternum beyond the hind coxæ. The European *H. piceus*, Linn., is not an Indian species properly, though captured in the Himalayas. *Hydrous* has the sternal spine shorter and a double keel. The larger forms of these two genera are revised by Régimbart under the same *Stethoxus* and *Dibelocelus* : (Ann. Soc. Ent., France, 1901, p. 188). Out of forty species the seven following are given as "Indian :"

H. senegalensis, Perch. ; *H. olivaceus*. Fabr. ; *H. cashmirensis*, Redt. ; *H. rufoinctus*, Bedel. ; *H. indicus*, Bedel. ; *H. acuminatus*, Mots. ; *H. piceus*, Linn.

These larger forms can be identified from this paper, but the student must remember that the smaller forms are still listed under *Hydrophilus*.

Hydrobiinæ.—These include the smaller aquatic beetles which are found in water, but which crawl along the bottom near the edge rather than swim freely. The females lay eggs in cases fixed to plants or which they carry with them. The larvæ are predaceous.

Philhydrus nigriceps, Westw., is common and widespread. *Berosus, decrescens*, Wlk., is a small species found in tanks. *Berosus indicus* Motsch., *Brachygaster indica*, Muls., and *B. metallescens*, Muls., are recorded. *Globaria leachi*, Latr., represents this genus.

Spercheinæ.—So far as known, these are aquatic, their larvæ predaceous in stagnant water. *Spercheus* is the common genus but none are known in India.

Helophorinæ.—Not strictly aquatic but living in mud ; *Hydrosus binodosus*, Motsch., *H. opacus*, Motsch., and *H. violaceomicans*, Motsch., are the recorded representatives of this group.

Sphæridiinæ.—Terrestrial beetles, except *Cyclonotum*, which is aquatic. *C. orbiculare*, Fabr., occurs in India, as also Europe *C. capense*, Deg., and *C. abdominale*, Fabr., also occur.

Sphæridium 5 maculatum, Fabr., is common in the plains, a small black and brown species. *Cercyon* is well represented in Ceylon and by five Indian species. *Pachysternum apiatum*, Motsch, also occurs.

Silphidæ.

Antennæ usually clubbed. Abdomen of five or six segments, free. Eyes finely granulated. Tarsi of four or five joints. Anterior coxæ conical and contiguous.

A larger family of beetles of varied form, usually of small size. The elytra are sometimes truncate, exposing the apex of the abdomen, but usually cover the whole abdomen. The posterior coxæ are contiguous. The known larvæ are flat, tapering to the hind end, with a pair of anal cerci and a distinct labrum; no Indian larvæ are known. The beetles have, in general, similar habits to the *Staphylinids* but a few (*Necrophorus*, etc.) of the larger are the so-called Sexton or Burying Beetles, which by removing the soil below small animal's corpses bury them, and then feed and breed in the decomposing body. The latter are not known inTropical India. One species has been sent in as being destructive to dry cured fish in Sylhet, with *Necrobia ruficollis*, Fabr. (*Cleridæ*).

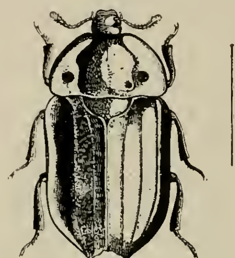


Fig. 161.—Silpha tetraspilota

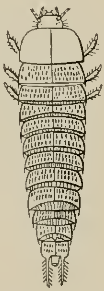


Fig. 162.—Necrodes littoralis; larva. (*After Chapuis.*)

Necrophorus is represented by *N. nepalensis*, Ho., in the Himalayas, and *N. encaustus*, Fairm., from Simla. *Necrodes osculans*, Nig., is Indian, as are 7 species of *Silpha*, of which *S. tetraspilota*, Fabr. (fig. 161), is not uncommon in the plains. *Nodynus nitidus*, Ho., *Apatetica lebioides*, Ho., *Cholera restita*, Murr. and *Aclypea sculpturata*, Grouv., are the remaining species. Portevin has recently described eleven new species (and four new genera) from the collection made by Mons. Harmand at Darjeeling. (Ann. Soc. Ent., France, 1901, 1905.)

Apatetica lebioides, Westw., is described and figured from the Himalayas (Cab. Or. Entom. Pl. XLI, fig. 9). It is in appearance a Carabid, and with its ally *Pteroloma* was formerly placed in the *Carabidæ*.

SCYDMÆNIDÆ.

Elytra covering the abdomen, which is six-jointed below. Eyes coarsely granulated. Tarsi five-jointed.

This family includes small, usually winged beetles, of brown colour, covered with erect hairs, and in structure closely allied to the last family from which they differ in the eyes and the more conical form. They are found in ants' nests, in decaying vegetation, under bark, etc., and are probably largely predaceous, though there are few actual records of the food. The 14 known Indian species belong to the genera *Scydmænus* (9), *Syndicus* (1) and *Eumicrus* (5): they are of no economic importance whatever, are only seldom found and are never abundant.

PSELAPHIDÆ.

Elytra short: abdomen of five (rarely six) ventral segments; maxillary palpi large and tarsi three-jointed.

An extensive family of small beetles, imperfectly known. It differs from the next chiefly in the abdomen. The colours are sombre, brown predominating. The beetles are known to be predaceous on small forms of life, such as mites and in some cases (*Claviger*) are myrmecophilous; the family is widely spread but little known. Two sub-families are recognised, *Pselaphides* with many genera, *Clavigerides* with few. The family are of no importance economically and our knowledge of Indian forms must remain small until Indian beetles are far more carefully collected.

Raffray has catalogued the known species (Ann. Soc. Ent. France. 1903-1904, and Genera Insectorum, 1907). He lists 53 *Pselaphines* and one *Clavigerine* as occurring "in India," the majority having been found in Ceylon and Burma. (No less than sixty additional Indian species are characterised by Raffray as "species mentioned by Motschoulsky but not "described;" these are included in Atkinson's catalogue but are not valid species). Raffray has since described nine species from the Nilgiris and Belgaum (Ann. Soc. Ent. Belge, 52, 205). We have found one species in an ant's nest (*Myrmecocystus setipes*) in Behar; the only known Indian *Clavigerine* beetle is *Mastiger abruptus*, Mots., described as from Calcutta.

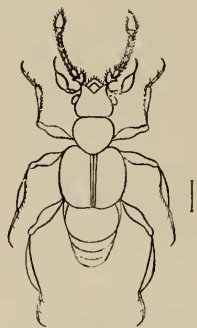


Fig. 163.—DINOPTERUS CEYLONICUS. (*After Raffray.*)

STAPHYLINIDÆ.—*Rove Beetles.*

The elytra truncate and covering only the base of the abdomen, which is long with ten dorsal and at least seven visible ventral segments. Tarsi variable, three, four or five-jointed.

In this family are small beetles, rarely exceeding one-quarter of an inch in length, usually recognisable in the field from all but *Nitidulidæ*. The colours are usually sombre, browns and blacks as in most surface insects, while a few which live openly on plants exhibit a brighter colouring (*e.g.*, *Pæderus*).

The antennæ are of moderate length, simple, the head large with short biting trophi; the prothorax is distinct, the sides of the body more or less parallel and the abdomen long, tapering and flexible. The large folded wings are concealed under the small truncate elytra, which meet in a straight line in the middle over the base of the abdomen.

The legs are short, formed for rapid running; the tarsi are often three-jointed, in some four or five-jointed throughout, and in a number the fore tarsi are four-jointed, the posterior tarsi with five pairs of joints. The integument is less thickened and hardened than in most beetles, the abdominal segments are mobile and readily turn up, suggesting the

Forficulidæ which these beetles much resemble at first sight. The tip of the abdomen is curled upwards over the dorsum to assist in packing away the wings under the small elytra after flight.

Nothing is on record as to the life-history of Indian species. In general the larvæ resemble the imagines in general form, with large

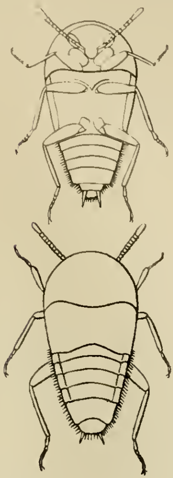


Fig. 164.—LEUCOCRASPEDUM PULCHELLUM. (*From Kraatz.*)

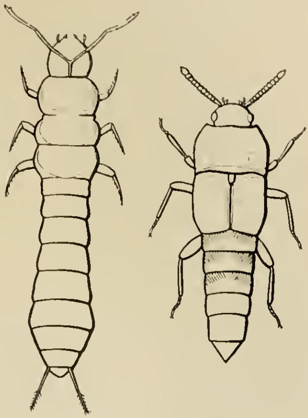


Fig. 165.—LEPTOCHIRUS MANDIBULARIS LARVA (LEFT): HOLOSUS TACHINIFORMIS. (*From Kraatz.*)

heads, shorter antennæ and prominent mandibles : the body tapers and is provided with two dorsal processes and a short anal tube. The latter assists in locomotion much as the anal prolegs of a caterpillar. The larval habits are probably similar to those of the imagines, though the larvæ live a more retired life and are not readily found. They form part of that great fauna which lives on the surface of the soil in concealment, and of whose habits we are profoundly ignorant. The study of the habits of this immense fauna is far less advanced than that, for instance, of the plant feeding species and there is here an immense field for research.

The beetles have a variety of habits, feeding on decaying vegetation, decaying animal matter, small insects and probably other small

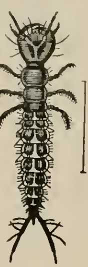


Fig. 166.—STAPHYLINUS CHLOROPTERUS. LARVA. (*After Perris*).

Fig. 167.—HEAD OF LARVA OF STAPHYLINUS CHLOROPTERUS. (*After Perris*).

forms of life. A few frequent plants for the purpose of obtaining plant sap or pollen. Some live upon fungi and none are known to be feeders on living plant tissues or directly injurious. They are, on the whole, scavengers, with a tendency to being predatory. Exceptional species have been found in ant's nests, and there are probably a considerable number of these Myrmecophilous forms in India. The larger forms can exsert two vesicles from the hind end, which set free a noisome fluid.

The family is a very large one, not much studied. Atkinson lists 286 Indian species and over 60 have been since described. The papers of Motschulsky and Kraatz prior to the Munich Catalogue, and those of Fauvel and Eppelsheim more recently, contain the descriptions of most of our species. Wassman has described the Myrmecophilous forms. We figure the large *Staphylinus semipurpureus*, a giant among the species of this family found in the moister parts of India.

The only common genus likely to attract attention in the plains is *Pæderus* which includes several small species coloured in dull red and blue, which are common on plants and run actively about on crops. They have been seen to feed on pollen but have not been found to be injurious and at times they are certainly predaceous on small insects; in one instance they fed upon the egg masses of *Caradrina exigua* and destroyed large numbers.

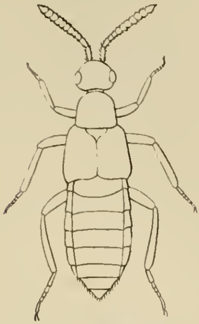


Fig. 168.—MYRMEDONIA LÆVIGATA KR. (*From Kraatz*).

Fig. 169.—STAPHYLINUS SEMIPURPUREUS.

Collecting. Staphylinids are found most readily by searching in damp decaying vegetation, in rotting fruits, under stones, at small carcases; many come to light and a few are found on plants or running on the surface of the soil. Moisture seems to be a necessary condition for their well being. None appear to have been reared in India. For the collection all but the largest forms should be very carefully gummed on card, the abdomen being carefully drawn out as it is apt in drying to shrink. It is to be hoped that more attention will be paid to the habits of these small and insignificant insects, which may be found to play an important role. Careful observation and rearing is required coupled with through and exhaustive collecting; results of great interest and possibly of economic value will reward the patient investigator.

TRICHOPTERYGIDÆ.

Antenna with a three jointed club. Elytra abbreviated or complete Wings fringed with hair.

The smallest known beetles are here included, measuring from 1/25 to 1/75 of an inch in length. A characteristic feature is to be found in the wings, which consist of a narrow stalk bearing a blade set with long hairs on each side. These wings fold under the elytra. These little beetles are found amongst decaying vegetable matter and under the bark of trees; most are shining brown and are apt to be passed by on account of their small size. They are often found in numbers together. No Indian species appear to have been reared. The larvæ of the known species are stated to be active and predaceous on small insects. *Ptenidium macrocephalum*, Nietn., with several Ceylon species is recorded.

Corylophidæ.

Very small beetles, the antennæ of peculiar form, six free abdominal segments, tarsi apparently three-jointed.

Like the *Trichopterygidæ*, many of these small beetles have fringed wings. Eleven species are known from Ceylon and one from Burmah.

Scaphidiidæ.

Abdomen with six or seven visible ventral segments, the basal ventral segment large. Tarsi of five joints. Elytra truncate, with two longitudinal striæ, with raised points between. Antennæ with the five apical joints broadened.

These small beetles are found in mushrooms and beneath stones. They are recognisable only from careful examination of the whole characters. The antennæ are but slightly clubbed. The truncate elytra expose only the apex of the abdomen. The wings are well developed and the beetles are active. The apex of the abdomen as seen from below is conical and rather long. Only a few genera are known and these are widespread. *Scaphidium conjunctum* Motsch., *S. lunatum*, Motsch. and *S. cyanellum*, Obart. are recorded as Indian with several Ceylon species.

Histeridæ.

Elytra usually truncate. Integument hard, body compact. Antennæ of one long basal joint, a number of small joints(7), *and an apical club of three joints.*

These small hard beetles are generally recognisable at sight from their general build and the above characters. Nearly all are black or dark blue, a few variegated with brown or yellow. The colouring is that common to so many beetles which live in concealment and on the soil. The body is thickset and short, sometimes very markedly flattened; the integument is peculiarly hard and the whole structure compact and neat. The upper surface is commonly bare and shining, the elytra smooth or with indented lines between which are punctures, whose form is sufficiently constant to serve in species discrimination. The head is small and retracted, the antennæ short, hidden in repose, the biting mouth-parts well developed, the mandibles often long and conspicuous. The prothorax is large, receiving the retracted head and broadly united to the abdomen. The elytra are truncate behind and do not cover the pygidium. The legs are short, folding under the body in repose, the tibiæ broadened and fitted for digging.

No species appear to have been reared in India, and little is known of the details of the metamorphosis of the family at all. So far as known the larvæ are active and predaceous. They have anal cerci, the labrum and ocelli are wanting and they live wholly in concealment. The adults are found under bark or stones, among roots, in dung, in carcasses, in dead insects; some (*Teretrius*, *Teretriosoma*), are known to be predaceous in the bores of Bostrichid beetles, others on insects found in the spots they frequent. A species of *Hister* is stated to feed on *Agrotis* larvæ in Corsica (Ann. Soc. Ent., France, 1864, p. 304). How far they are scavengers themselves and how far predaceous upon insects is uncertain; none are in any degree injurious and it may be found that as a whole they are beneficial. They are rarely found in the open by day and are principally nocturnal in habit.

Marseul's Catalogue (Ann. Soc. Ent., France, 1862), enumerated 1010 species of which 51 were Indian. Many additions have been made since that time and Lewis has published descriptions of many new species in the "Annals of Natural History." In his recent Catalogue, Lewis enumerates 95 as occurring in India and Assam, apart from Ceylon and Burmah. These are *Niponius* (3), *Hololepta* (5), *Trypeticus* (1), *Teretriosoma* (4). *Teretrius* (1), *Plæsius* (1), *Apobletes* (2). *Platylister* (3), *Platysoma* (6), *Eblisia* (1), *Pachylister* (5), *Hister* (23), *Epierus* (1), *Pachylomalus* (1), *Cypturus* (4), *Phelister* (1), *Anapgymma*

(1), *Notodoma* (1), *Sitalia* (1), *Epiechinus* (1), *Abræus* (3), *Halacritus* (1), *Saprinus* (14), *Gnathoncus* (1).

Fig. 170.—PACHYLISTER BENGALENSIS.

Fig. 171.—HOLOLEPTA INDICA.

The family is divided into a number of sub-families which need not concern us. *Hololepta* and *Platysoma* include flattened black species found under the bark of trees, where they prey upon bark-feeding insects. In *Hololepta elongata*, Er. this flattening is carried to an extraordinary extent, the beetle being scarcely thicker than a visiting card. *Hister* is the abundant genus with many species; *H. javanus*, Payk. is common in cow dung in the plains as is also *H. bipustulatus*, Fabr. var *immaculatus*. *Saprinus interruptus*, Payk. represents this genus commonly, the beetle being black with a large yellow blotch on each elytron.

PHALACRIDÆ.

Antennæ with a distinct three-jointed club. Tarsi five-jointed, fourth joint small. Abdomen five visible ventral segments; front coxæ globular, hind coxæ contiguous.

A family closely resembling the next, but distinct in the structure of the coxæ. There are but few genera and the Indian species appear to be little known. *Olibrus* (5 spp.), *Augasmus* (3 spp.), and *Phalacrus* (5 spp.) are the recorded genera.

Nitidulidæ.

Antennæ with a club of three joints. Tarsi five-jointed, fourth joint smallest; abdomen with five free ventral segments. Anterior coxæ transverse; elytra often truncate.

Small beetles, of brown or black colour, finely pubescent above, which have a general resemblance to *Staphylinidæ* as many have the

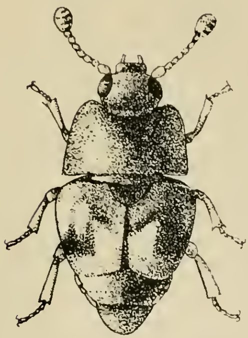


Fig. 172.—Carpophilus hemipterus, × 20.

Fig. 173.—Larva of Amphicrossus dis-color.

elytra truncate, leaving the apical half of the abdomen exposed. The structural characters above separate them from other beetles and they can often be recognised in the field.

The known larvæ live principally in flowers, feeding, for instance, on the anthers, but also in dead animals and in decaying fruits. *Carpophilus hemipterus*, lives in dried fruits and similar food articles, feeding on this or possibly on moulds or fungi growing on this material. It has been reared from larvæ found under the sheathing leaves of bamboos. The beetles are found in a variety of situations; many come to fallen fruits or to damaged fruits or plants to obtain the sap. Others are found in flowers, particularly cotton flowers, in injured bolls, in the bores of insects, at cut canes, in almost any situation where they can obtain the sap of plants. Others are found at decaying animal matter, or in hiding at the roots of plants, under leaves, etc. They have also been found breeding in the decaying fibres of the fruits of a palmyra palm and are common among decaying vegetable matter breeding freely in decaying mangoes, for instance. Others are found killed by the sticky leaves of the tobacco plant.

Fig. 174.—CARPOPHILUS HEMIPTERUS, LARVA, × 32.

Murray summarises the habits of the group as follows :—

"The chief function of this family is that of scavengers. Their main business is to clear off decaying substances from the face of the earth, especially those minute and neglected portions which have escaped the attention of other scavengers whose operations are conducted on a larger scale. We may characterize them in one point of view as retail scavengers. They are so to speak, users-up of waste materials. After the beast of prey has satisfied his hunger on the animal he has slain, after the hyana and the vulture have gorged themselves on its carrion, after the fly with its army of maggots has consumed the soft parts, after the burying beetles and the Silphidæ have borne their part in the clearing away and when nought but the bones remain, then come the *Nitidulariæ* to go over what they have left, to gnaw off every fragment of ligament or tendon and to leave the bones as nearly in the state of phosphate of lime as external treatment can. In another point of view, however, their employment is wholesale and wide enough. They conduct their operations all over the world, their branches extend into the most remote district; the materials with which they have to do, although mere waste, have no other limit to their variety or their number than the organized substances found on the surface of the globe. As in all great establishments, too, the principle of division of labour is carried to a great extent. Each different kind of substance has a different member of the firm told off to take charge of it. One species confines itself to rotten oranges, another to bones, a third to putrid fungi, a fourth to decaying figs. Decaying wood, decaying bark, decaying flowers, decaying leaves, all furnish distinct employment to different species. They are not all scavengers, however. Many pass their lives in flowers; others feed upon fresh victuals; and Mr. Frederick Smith of the British Museum has, whilst I write, brought to my notice a species of *Brachypeplus* (*B. auritus*) which he has received from Australia, in a wild bee's nest, where it feeds, both in the larva and perfect state on the wax and honey." (Trans. Linn. Soc. Lond., XXIV, pp. 211-414 1864.)

Though of no economic importance, they are common insects and will be readily observed on crop plants under circumstances that would, in the absence of careful observation, give rise to the suggestion that they were themselves the originators of damage, whereas they are essentially the followers of decay.

Murray monographed part of the family in 1864. (Trans. Linn. Soc., XXIV), while Reitter completed the work in 1873 (Verh. Ver. Brunn., XII, pp. 5-194). Many species have been added since by M. Grouvelle, including Father Cardon's species (Ann. Soc. Ent. Belge, 1891, 1892), and Harmand's Darjeeling species (Ann. Soc. Ent. France, 1903, p. 108). A total of over 100 are known from India inclusive of Ceylon. *Carpophilus foveicollis*, Mur. and *C. hemipterus*, L., are found under the sheathing leaves of bamboos where their larvæ live and the latter, with other species, breeds freely in dried fruits in stores and godowns. *C. dimidiatus*, F. var *mutilatus*, Er., is the common small brown species found in borer holes in canes, in cotton flowers, etc., in the plains. It has been reared from larvæ found in bores of *Chilo simplex* in juar, the larvæ feeding in the decomposing tissues. They pupated in the soil and remained two months as pupæ during the cold weather. *Amphicrossus discolor*, Er., is a rounder deep brown insect, which has been bred from larvæ found under the bark of Semul (*Bombax malabaricum*).

COSSYPHODIDÆ.

A small family of beetles, separated by Wassman from the foregoing and following families to receive certain Myrmecophilous insects.

Cossyphodinus indicus, Wassman, lives with *Pheidole sulcaticeps*, Rog., and is the sole recorded Indian species. (Fig. 153).

Colydiidæ.

Antennæ clubbed or dilated towards the apex. Tarsi four-jointed; five visible ventral segments.

These are small beetles of varied form found under bark in decaying trees or in fungi. They are not common and but few species are known from India. *Tarphiosoma indicum*, Wal., is described from Coimbatore. *Dastarcus* and *Colobicus* are also represented. *Botrideres* is, in Europe known to be predaceous on the larvæ of the *Bostrichid* beetle, *Sinoxylon*, which bores in wood, and Stebbing records the same in India. A total of 17 species are recorded. *Dastarcus indicus*, Fairm., being common under the bark of trees in the plains.

Fig. 175.—Dastarcus indicus.

Lathridiidæ.

Tarsi three-jointed; antennæ with a club formed of one, two or three joints. Ventral abdominal segments five or six, free, the first longest.

Small beetles rarely more than one-tenth of an inch long, found in ants' nests and in decaying vegetable matter, where it is supposed they eat fungi. None appear to have been reared in India. Wassman writes about *Coluocera maderæ*, Wall. and *C. Beloni*, Wasm. Zeits. Wiss. Insecten Biol. I, p. 384) which live with *Prenolepis longicornis* and *Pheidole* spp. in India. Assmuth observed the former to move with the ants along their runs when shifting nests and Wassman comments on the fact that *C. Maderæ*, like *Myrmecophila prenolepidis*, is found in the nests of this ant in South America as in India, the beetle and cricket having apparently been carried by shipping with the ant.

Eighteen species are recorded in Genera Insectorum as Indian: *Coluocera* (1), *Holoparameeus* (6), *Lathridius* (1), *Ericmus* (1), *Corticaria* (3), *Melanophthalma* (5), *Migneauxia* (1).

Trogositidæ (Temnochilidæ, Ostomidæ).

Tarsi with four apparent, but five actual (the first small), joints. Antennæ with terminal segments dilated at one side.

These beetles may be recognised with care, though superficially they closely resemble those of other families. They are small dark coloured beetles, with short antennæ, a well developed prothorax, the elytra closely fitting over the abdomen and short running legs and are predaceous in their habits. The species are in general found under the bark of trees and in decaying woody matter. *Tenebroides* (Trogosita) *mauritanica*, Linn., is a cosmopolitan insect of which much is written but little known. It is commonly found in stored grains such as wheat, etc., and in almonds and similar seeds, but is generally accounted as a predaceous insect, really useful since it feeds on other insects that feed on the wheat; against this must be put the fact that it has been reared in India more than once from almonds and rice in which no other insect was found; it is probable that, in view

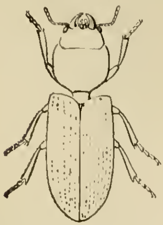


Fig. 176.—Trogosita mauritanica, × 3.

Fig. 177.—Trogosita mauritanica larva, × 3.

Fig. 178.—Alindria parallela, × 1½.

of all the evidence, the larva is grain-eating, the beetle predaceous, that it was once a grain-eating insect, became predaceous, but still can feed on grain if insects are not available. A. M. Lea records both larva and imago as feeding on caterpillars in Tasmania (1908). The larva causes a peculiar form of injury to wheat seed, eating out the embryo only and leaving the remainder of the grain intact. It is worth noting that it is found living in the open, the larva feeding on larvæ that live under the bark of the oak and chestnut trees in Europe. *Alindria parallela*, Lev., is a larger black insect caught at light during the rains and *Lardites chevrolati*, Reitt., is to be found under the bark of trees.

A. Leveillee has catalogued the family (Ann. Soc. Ent., France, 1900, p. 1). He gives 17 species as found in the Indian region including *Alindria* (3), *Melambia* (4), *Temnochila* (1), *Asava* (1), *Tenebroides* (1), *Acrops* (3), *Gryncharina* (1), *Ancyrona* (3) .

MONOTOMIDÆ.

Two Darjeeling insects are recorded, *Europs indica*, Grouv. and *Europs harmandi*, Grouv. (Ann. Soc. Ent., France, LXXII, p. 123).

CUCUJIDÆ.

Usually small brown flattened beetles, tarsi apparently four-jointed, the first joint often small. Antennæ long, with a small club (often absent).

These little beetles do not readily come into a general definition and are not easily recognisable. The family as a whole are found under tree bark, in decaying wood and attacking stored produce. Several species are found feeding upon grain and stored produce in India, and others have been recorded in Indian Museum Notes. The most noted is *Silvanus surinamensis*, Fabr., whose larva lives in dried fruit, flour, dried mohwa (the calyx of *Bassia latifolia*) and similar vegetable matter. The complete life-history occupies about 7 weeks ; the eggs are laid in the food, the larvæ feed inside or between two pieces and pupate in a chamber closed in with bitten pieces of their food. This insect causes considerable annual loss in India, attacking Mohwa, for instance, during the rainy weather and breeding in it steadily till much is lost. *Læmophlæus pusillus*, F., is a brown beetle which has been reared from larvæ in dried fruit and in ship's biscuit in Calcutta. *Læmotmetus ferrugineus*, Gerst., was recorded as feeding upon cut cane and probably habitually feeds upon sap. *L. insignis*, Grouv., was found in the wood of a tree bored by *Sinoxylon* and is probably equally harmless. *Hectarthrum heros*, F. (*brevifossum*, Newm.) is a larger black beetle, found under tree bark and in wood tunnelled by borers. About twenty species are recorded as Indian, and many remain to be recorded when they are more collected.

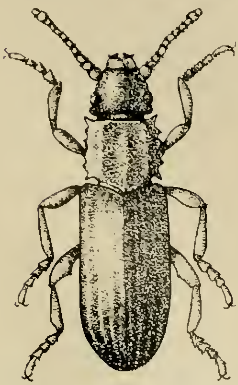


Fig. 179.—SILVANUS SURINAMENSIS, × 20.

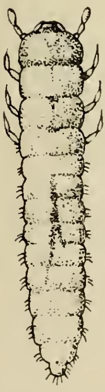


Fig. 180.—SILVANUS SURINAMENSIS, LARVA, ×20.

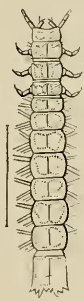


Fig. 181.—CUCUJUS HÆMATODES LARVA. (*From Chapuis.*)

Cryptophagidæ.

Antennæ with a three-jointed club. Tarsi five-jointed, rarely heteromerous in males. Five abdominal visible ventral segments, first longest.

Small oblong beetles, pubescent above, found in mushrooms and decaying plants. Ten Indian species are described by Motschulsky Reitter and Grouvelle.

Helotidæ.

Five visible ventral segments. Basal tarsal joint reduced.

This is a small family of beetles resembling the *Erotylidæ* in appearance and found feeding on the flowing sap of trees. *Helota* is represented by twenty species from the hills, mainly described by Ritsema (Notes, Leyden Mus., 1893-1901). *Helota mellyi*, Westw., is described and figured from Simla (Cab. Or. Entom., Pl. XLI, Fig. 8). *H. servillei*, Ho. (Coleopterists' Manual, 3, p. 187) from Poona and *H. Guerinii*, Ho. (loc. cit., p. 188), are the previously described Indian species.

Thorictidæ.

Antennæ clubbed; prothorax large, elytra short. Tarsi five-jointed. Head sunk in prothorax.

A small family of peculiar beetles, of which very little is known, and which are separated on the above structural characters. *Thorictus heimi*, Wassm. (Fig. 153), is myrmecophilous and *T. indicus*, Grouv., was found at Belgaum.

Erotylidæ.

Antennæ with a three or four-jointed club. Tarsi with five joints, the fourth joint reduced in some forms, the basal three often broad and pubescent.

A moderately large family of small beetles, found chiefly in mushrooms and plant stems, where also their larvæ live. The fourth tarsal joint is so small as to be scarcely visible and they appear to have four-jointed tarsi. The individuals of the family will scarcely be distinguished by the above characters and the accurate diagnosis of the family includes the trophal characters also. Males and females are much alike with no marked sexual characters. Apparently no Indian species has been reared and but few larvæ are known at all. The greater number of the species are found in the New World; Fowler and Kuhnt have listed the family in Genera Insectorum (1909).


Fig. 182.—TETRALANGURIA ELONGATA.

Languriinæ are represented in India, by elongate slender beetles, the elytra with metallic blue or green colouring, the prothorax dull red or metallic green; they are found on the leaves of plants but not apparently in the plains. One species (*Tetralanguria elongata* F.) is very common in the hills and can be caught in numbers. This genus in America contains the "Clover Stem Borer" (*T. mozardi*, Lac.) a minor pest and the Indian species will probably be found to be borers in plant stems also. A total of 35 species are described from India, wholly hill forest insects.

Erotylinæ—A total of 31 species are known, from hill and forest localities almost wholly. *Amblyopus*, *Triplax*, *Aulacochilus*, *Episcapha* are the commoner genera. Gorham's papers on the collections of Andrewes should be consulted. (Ann. Soc. Ent. Belge., 1895, p. 328, 1903, p. 323.)

MYCETOPHAGIDÆ.

Antennæ with a two or three-jointed club. Tarsi four-jointed, the anterior tarsi three-jointed in males.

Small beetles of dull colour found in "Mushrooms" and under the bark of trees. No Indian species are recorded, though several are known from Ceylon.

COCCINELLIDÆ.—*Ladybird Beetles.*

Tarsi apparently three-jointed, the second joint expanded and pubescent. Antennæ short, not clubbed.

These small beetles are most readily recognised by their oval or rounded form, and their warning colours which include black, red, yellow and brown, alone or together. The tarsi at once separate them from the family they are most readily confused with in the field, the *Chrysomelidæ*, these having apparently four-jointed tarsi. They are most closely allied to the *Endomychidæ* but differ in the antennæ, which in the latter are clubbed. These beetles are rarely more than one-quarter of an inch long; the head is small and nearly hidden by the prothorax (see *Hippodamia*) which fits smoothly into the rounded elytra.

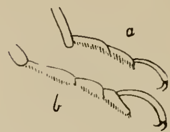


Fig. 183.—A. COCCINELLID B. CHRYSOMELID TARSUS.

The antennæ are not distinctly clubbed, moderately long. The short biting mouth parts are not conspicuous. The legs are short, hidden under the body and formed for running. Males and females are not distinguishable on superficial characters and are of the same size, as a rule, the male sometimes smaller.

The life-history is well known and several Indian species have been reared. Eggs are laid in clusters, openly on the plants, and are cigar-shaped yellow bodies laid on end. (Plate XVII.) The larvæ are active, widest in the middle and tapering to either end; the head is small, the thoracic segments broad. Each segment has spines or tubercles bearing hairs. The abdomen tapers and there is an anal foot which assists locomotion. Most are black or slate coloured, some a vivid red and a number have waxy processes similar to those of the mealy bugs on which they feed and which render it difficult to distinguish them from their prey. When full grown, they pupate openly on a plant, the larva firmly fixing itself by its anal foot and the pupa remaining often partly enveloped by the larval skin which bursts along the dorsal surface. The larval, as the pupal, life is short, the whole life history occupying but a short time, often not more than three weeks.

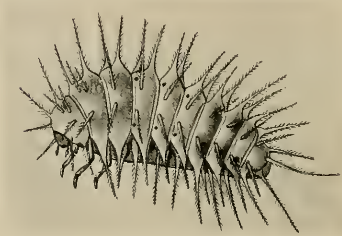


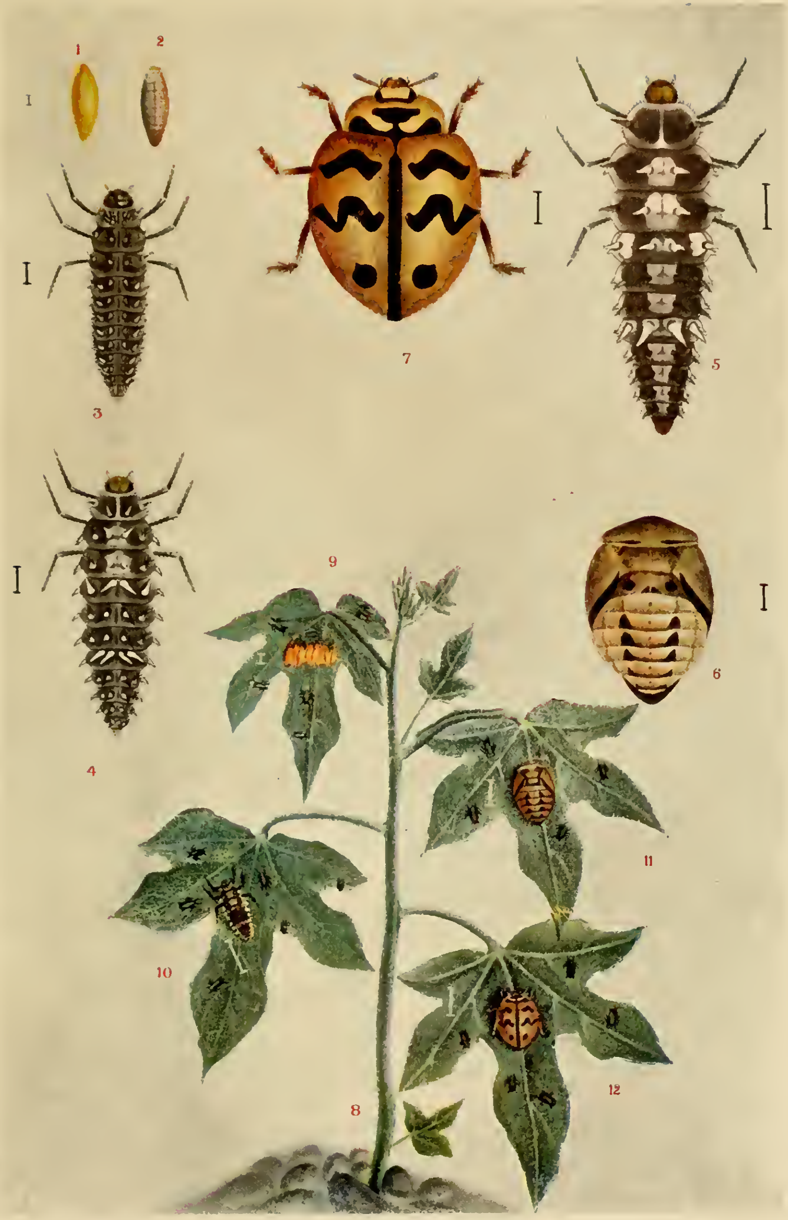
Fig. 184.—CHILOCORUS NIGRITUS LARVA × 8.

PLATE XVII.—Chilomenes Sexmaculata.

The Six-spotted Ladybird Beetle.

Fig. 1. Egg when laid.
,, 2. ,, just before hatching.
,, 3. Larva, first instar.
,, 4. ,, third ,,
,, 5. ,, fourth ,,
,, 6. Pupa.
,, 7. Imago.
,, 8. Cotton plant with aphides.
,, 9. Egg cluster on leaf slightly magnified.
,, 10. Larva ,, ,, ,,
,, 11. ,, ,, ,,
,, 12. Imago ,, ,, ,,

The black hair-lines show the actual size of the figures 1—7, and the white ones on the plant those of 8 to 12 on the plant.


1
2
7
5
3
4
6
9
11
10
12
8

Hibernation or periods of scarcity are universally passed in the imago stage, the beetles living for long periods without food and awaiting the proper conditions for egg-laying. The imago is protected by the exudation of oil, in some cases, an acrid yellow fluid being excreted at pores on the margin of the prothorax or at the joints of the legs. With the exception of *Epilachnides*, nearly all are predaceous upon scale insects, mealy-bugs, aphides and similar small forms of life. Many species are known though no complete list of Indian forms is available. The most important of the plains forms are described below; this by no means exhausts the common species, and much has yet to be learnt of the species which prey upon the less evident forms of pests. Each species appears to have a well defined series of prey, which it exceeds only when it must, and we know little of what preys upon the rarer species of Aphides and Coccides.

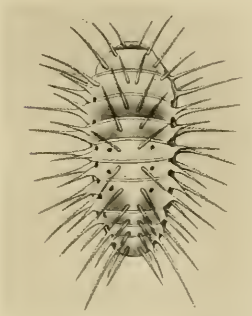


Fig. 185.—CHILOCORUS NIGRITUS LARVA × 8.

A great deal has been written about the value of introducing lady-bird beetles to destroy scale insects and the like; hundreds of trials have been made, a regular exchange of *Coccinellids* was established and, as a result, there was one real case in which good resulted. Unfortunately, the idea has been taken up by the Press at different times and still crops up. Ladybirds, like parasites, do their best where nature puts them, but cannot be moved about the world to eat indiscriminately. The species of this country play an essential part in maintaining an equable balance of life, and we have a large number of useful species which would repay more careful study. *Coccinellids* are divided into two series those with simple or bifid mandibles which feed on insects, and those with many toothed mandibles which feed upon plant tissues. All of the species mentioned are confined in the first series, excepting *Epilachna*. Crotch revised the family in 1874 and since then Gorham has described numerous species (Ann. Soc. Ent. Belge, 1892, 1894, 1895, 1903) as has also Weise (Ann. Soc. Ent. Belge, 1892, 1895 and

Stettiner, Ent., Zeit. 1908). We may divide the family into the *Coccinellinæ* insectivorous, *Epilachninæ* herbivorous; the former may be divided again. Of the *Coccinellini*, 84 species are recorded, of the *Chilocorini* 33, of the *Scymnini* (*Scymnus*) 29, *Exoplectrini* (*Vedalia*, etc.) 10, and of the *Rhizobiini* (*Aulis*) five species. In the *Epilachninæ* 38 species are described. These beetles are extremely variable in size, colouring and markings; climate exerts a marked influence on them, and it is possible the number of distinct species is not really so large.

Coccinella includes three common species, two of which are widespread in our limits. *C. septempunctata*, Linn., is the abundant Seven-spotted Ladybird which is found on wheat and mustard. The larvæ are slate coloured with yellow spots, very active and feeding voraciously on the wheat aphis (*Macrosiphum granarium*, Kby.) and the Mustard aphis (*Aphis brassicæ*, Linn.). The beetle is red with three black spots on each elytron and a joint one at the scutellum, with some white on the prothorax and head. In the hills, as in Europe, the size of the black spots is constant; in the plains it varies immensely and some beetles have them so large that they fuse and almost cover the elytra. Like their prey, this species is found only in the cold weather in the plains; the beetles have been found to go into dense grass and other sheltered spots in March where they *apparently* remain until the following cold weather. This species is a very important check on the increase of the Aphides it feeds on and one of the most economically valuable insects in India. In the Punjab (and rarely further South), we find also the Eleven Spotted species, *C. undecimpunctata*, Linn., with a similar life-history and habits. Both are palearctic insects which have spread into the Punjab and further south and adapted themselves to the conditions by a prolonged period of rest; the evidence points to this period of rest being passed in the imago stage. This species has only once been found in Behar while it is very common in the Punjab. Its usual southern limit appears to be in the United Provinces.

C. repanda, Thunb., is a widespread insect in the plains, the spots in the form of three black curved bands and a small central spot; it is found abundantly in the cold weather feeding on mustard aphis, (*Aphis brassicæ*), and is reported to feed on *Aleurodes bergi*, Zehn., in Java.

Thea cincta, Fabr., is a round yellowish insect found feeding on the fruiting bodies (Perithecia) of the fungus that attacks mulberry leaves (*Phyllactinia corylea*, Karst.). Larvæ were reared upon this material and a great number of individuals were found on the mulberry bushes. It presumably has other food also.

Chilomenes sexmaculata, Fabr., is the commonest species in the plains. It is a small rounded beetle, varying in colour from red to canary yellow, usually yellow. It deposits eggs on the leaves of the cotton plant, among or near an aphis colony. Each egg is oval, almost cigar-shaped, about one-twentieth of an inch long, light yellow in colour. (Plate XVII.) In captivity a beetle lays about 90 eggs in clusters of about 9 each. These eggs hatch in four to five days, a small spinose larva appearing which at once begins to feed on aphis; it runs actively about seeking aphides and crushed skins of the victims testify to its rapacity. In captivity each larva required about 200 aphides a day and lived thus for 10 to 13 days. The young larva is black, with long legs, the body tapering to the hind end; as it grows older, white spots appear and the full-grown larva is black with yellow and white blotches. Pupation takes place on the leaf, the larva fixing itself by the tail, the pupa only partly emerging from the cast skin in some cases. The beetle emerges after four to six days and also feeds on aphis. Besides the Cotton Aphis (*Aphis gossypii*, Glov.), this species feeds on *Aphis cardui*, Linn., and on *Aphis adusta*, Zehnt. When food is not available, the beetle waits, hiding in shelter until food is again forthcoming and eggs can be laid. These periods of rest may be of many weeks' duration, but if food is available, the species goes on breeding except in the very cold weather.

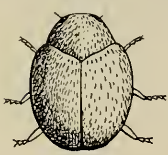


Fig. 186.—SCYMNUS XERAMPELINUS, × 8.

Scymnus includes the smallest species, round pubescent beetles of usually dull brown or black colour. *Scymnus xerampelinus*, Muls., is common, feeding on cotton aphis (*Aphis gossypii*, Glov.): the larva is clothed in white waxy processes which make it look like a mealybug: a single larva required 75 aphides daily for its food and lived 7 to 10 days. The pupa remains in the cast larval skin, emerging as a beetle after a week. This species occurs with

S. nubilans, Muls., throughout the plains, feeding also on cotton mealybug. We figure *Aulis vestita*, Muls. (Pl. LXXXIV, Figs. 7, 8, 9), found feeding upon *Monophlebus*. This beetle and its larva are found on trees infested by this mealybug and would readily escape notice. Like its prey the beetle appears only from February or earlier to May, and breeds freely at that time; the beetle is found during the rains in concealment on the bark, awaiting the return of *Monophlebus*. (Mem. Agric. Dept., India, Vol. II, No. VII.)

Chilocorus nigritus, Fabr., is a moderate-sized round black beetle, very shiny, which feeds on *Aphis cardui* as well as several scale insects (*Asterolecanium*) and aphides. It is widely distributed but rarely found abundantly. *Brumus suturalis*, Fabr., is yellowish with black stripes on the elytra. It feeds on cotton aphis, cotton mealybug and probably other small sucking insects. The larva was reared on *Phenacoccus insolitus*, Gr.; it is a sluggish insect, grey covered with a fine white bloom, measuring about five millimetres in length, two and a half in breadth the abdomen being the thickest part. It eats the mealybugs in all stages and pupates among them in the usual way. *Clanis soror*, We., is a small round beetle found feeding upon the Castor Mealy Wing (*Aleurodes*, Sp.). The stages are figured. (Plate LXXXI, Figs. 9, 10, 11.)

Epilachna is herbivorous and is universally distributed. The beetles are comparatively large for this family, of a dull red-brown colour with black markings. The variability of the markings has led to the species having many names and it is not clear how many species there are. Our common ones fall into two types, *E. dodeca-stigma*, Muls. with 12 spots, *E. vigintiocto-punctata*, Fabr., with 28. These vary in colour, in size and number of spots, in extent of pubescence, and in the extent to which the colour is obscured by dark suffusion. So far as can be seen the life-history is the same throughout the common Indian forms; eggs are laid in clusters on the leaves, which hatch to oval yellow grubs with spiny processes; these feed on the epidermis of the leaf and pupate there when full grown, in the ordinary manner.

Fig. 187.—EPILACHNA VIGINTI-OCTO-PUNCTATA.

Cucurbitaceous and Solanaceous plants are their food and they may be destructive when abundant.

Fig. 188.—EPILACHNA DODECA-STIGMA.

Collecting.—Coccinellids are of such importance that no opportunity of collecting should be lost. Above all, when collecting, it is useful to search carefully for their food; the value of each species depends wholly upon their food and while some are restricted to one or a very few insects, others are probably less restricted. The question of food also determines the times at which they are prevalent and we are still largely ignorant of how these insects pass through the year. Coccinellid larvæ are very easy to rear if given sufficient food and the adults, if well fed, lay eggs freely in captivity.

ENDOMYCHIDÆ.

Antennæ moderately long with a three-jointed club. Tarsi apparently three-jointed but really four-jointed; the basal two joints broad.

These beetles are distinct from all but the preceding (*Coccinellidæ*) in the peculiar tarsi; the longer clubbed antennæ further separate them from *Coccinellidæ*. The family is not a large one; all known are apparently feeders on lichens and fungi, and are found in concealment often gregariously. They are characteristic of moister warm areas than the plains of India. The transformations of several species have been recorded in America and Europe, but much remains to be learnt. The student should consult Gorham's papers; the species of Ceylon are described (Proc. Zool. Soc., 1886, p. 154) and some new Indian species (loc. cit. 1897, p. 456, Ann. Soc. Ent. Belge. 1895, p. 328, 1903, p. 323). Nineteen Indian species are recorded.

Fig. 189.—EUMORPHUS PULCHRIPES.

Dermestidæ.

Tarsi with five-joints ; antennæ short with a club, and received under the prothorax in a cavity. Head retractile.

These small beetles are not readily separated from those which come nearest to them unless the life-history is known, the commonest species, which are household pests, having characteristic larvæ. The beetles are often clothed with fine hair or scales. The head in some bears a median ocellus. The apical joint of the antennæ in the males may become enlarged.

Fig. 190.—Dermestes vulpinus F. × 4½.

The life-history is known in general but of no Indian species except the household ones. The larvæ are predaceous or feed upon dried animal matter. The free-living larvæ are found under the bark of trees and in similar situations where there is a quantity of insect larvæ on which they can feed. Household species feed upon skins, horns, wool and similar dried animal matter. The larvæ are characterised by the development of tufts of long hairs (Plate XVIII), which in some cases reaches an extraordinary development, especially in the predaceous free-living species. The reader should consult the figure in Sharp's Insects for a typical free-living Dermestid larva, such as is found under the bark of trees. Other larvæ are provided with small terminal and lateral tufts of hairs, capable of being moved and extended. These larvæ eat into their food, making holes in skins or horns and completing their metamorphosis there. The length of the life-history is not known but it can be very greatly extended in every stage, if food is scarce. It is known that the eggs are capable of remaining unhatched for long periods, that larvæ will starve and that the pupal stage may be a very long one. The pupa is commonly found almost wholly enveloped by the larval skin which is not shed but only splits along the dorsum. Several household species are likely to be found, having been recorded several times ; these are cosmopolitan insects spread by commerce.

PLATE XVIII.—ANTHRENUS VORAX.

THE WOOLLY BEAR.

Fig. 1. Larva, dorsal view. x 12.
,, 2. Young larva, feeding on a bristle. x 12.
,, 3. Pupa, in the larval skin, which is open along the dorsal line. x 10.
,, 4. }
,, 5. } Imago. x 16
,, 6. Egg. x 20.

PLATE XVIII

1

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The recorded species are less than twenty, including the cosmopolitan *Dermestes cadaverinus*, F., and the species mentioned below.

Dermestes vulpinus, F., whose larva feeds upon the cocoons of silk worms, is common in India, as elsewhere. It is curiously fond of these cocoons eating through the silk to reach the pupa within, on which it feeds. Cleghorn mentions it as a destructive insect to silk in India, the cocoons having to be quickly reeled off to avoid loss. (Indian Mus. Notes, I, p. 47.) Silkworm cocoons (containing pupæ) must be so packed that the beetle cannot get access to them or the cocoons on arrival will probably be infested and partly spoiled. *Dermestes* larva is elongate, cylindrical, tapering behind; the prothorax is large, the hind end bears two dorsal hooks and a ventral anal tube. Each segment has a dorsal plate, behind which is an erect row of long hairs and a backwardly directed row of stiff hairs; there are longer hairs on the sides, and a third row on the prothorax. *Aethriostoma undulata*, Motsch., is found in wheat. Its larva is broad, with short hairs, with no anal tube or hooks. The part it plays in wheat is not ascertained but it is likely to be predaceous upon the other insects there or to feed on their dead bodies. The larva of *Attagenus* is similar but the segments are completely hardened above and each segment fits over the next; there are no hooks or anal tube, and each segment is clothed in scales, with also a row of hairs which extend on to the sides; the hind end bears a bundle of hairs. *A. gloriosæ*, Fabr., probably occurs in India. The larvæ of *Anthrenus*, *Tiresias*, *Trogoderma*, are provided also with bundles of long hairs on the posterior segments, these hairs being moveable and erectile, often of peculiar form; in *Anthrenus* the bundles are on the three posterior segments. *A. vorax*, Wat., is known to attack skins and horns in India, as well as woollen clothes and the bristles used in making brushes, and is constantly reported as destructive. (Plate XVIII.)

BYRRHIDÆ.

Antennæ clubbed. Head retracted, tarsi five-jointed, a prosternal spine fits a mesosternal cavity.

Small oval beetles, convex and short, of dark colour, found under stones and on the soil in temperate regions. They are vegetarian, one genus (*Chelonarium*) living also on the leaves of trees. *C. indicum*, Gr., lives in the plains of India but is rare. Motschulsky described five Indian and one Burmese species of *Byrrhinus*. Four other species are described, *Chelonarium indicum*, Grouv., being the most widespread.

Georyssidæ.

Antennæ nine-jointed, three forming a club. Tarsi of four joints.

A tiny family of beetles distinguished on the above characters and chiefly found burrowing in soil in the Northern Hemisphere. Two species of *Georyssus* occur in Ceylon.

Heteroceridæ.

Antennæ with a long seven-jointed club. Tarsi four-jointed.

Semi-aquatic beetles found burrowing in the mud of river-banks and tanks. They are capable of stridulating and on being seized, emit

Fig. 191.—Heterocerus sp.

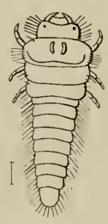


Fig. 192.—Heterocerus marginatus larva. (*From Chapuis.*)

a sound. The life-history of the European species is known, the pubescent larvæ burrowing in mud. Little is known of the Indian species six species being recorded. They are common in freshwater in India and come freely to light. The beetle is probably predaceous, feeding on the insect life of its habitat which is abundant and having its body and strong expanded legs formed for burrowing in the wet mud in which it lives.

Parnidæ.

Antennæ variable. Tarsi five-jointed, the last joint large; prosternum produced in front to protect the mouth, behind to fit into the mesosternum. Aquatic.

Small beetles clothed in fine pubescence, found in water. They are seen clinging to plants, stems and other objects in running water for which purpose they have the enlarged tarsal joint and claws, and the pubescence holds a sufficiently large bubble of air to supply the needs of respiration. The pubescence in *Parnus* covers the whole body, which is thus set in a bubble of air, but in *Elmis* extends only along the ventral surface, to carry air to the spiracles. The family are possibly simply clavicorn beetles which have, from feeding on decaying vegetation near water, become aquatic and retain the same food habits. Their larvæ are also aquatic,wholly unknown as yet in India.

Less than ten species are recorded, in the genera, *Dryops*, *Parygrus*, *Stenelmis* and *Sostea*. *Dryops opacus*, Grouv., is the common species found frequently at light in the plains and hills.

Cioidæ.

Antennæ of eight to eleven joints, with a three-jointed club. Tarsi usually of four joints, the first small, the last long. Abdomen of five segments, first longest.

Small insects of cylindrical form, uniformly coloured in deep brown or yellow, with small impressed points on the elytra. The beetles are found in corky mushrooms, usually in all stages of development together. *Lyctoxylon japonum*, Reitt., is recorded from the Himalayas and Japan.

Bostrychidæ.

Antennæ with a three-jointed club. Tarsi five-jointed, basal joint small, second and fifth long.

The family is recognisable most easily by the cylindrical form, the produced and tuberculate prothorax in many cases, and the general resemblance to *Scolytidæ*, from which they differ in the straight (not elbowed) antennæ, in which the apical joints are often expanded on one side only, and in their tarsi, which are five-jointed. They are small insects, scarcely as much as a quarter of an inch long and nearly always the dull black or deep brown of wood-boring and light-shun-

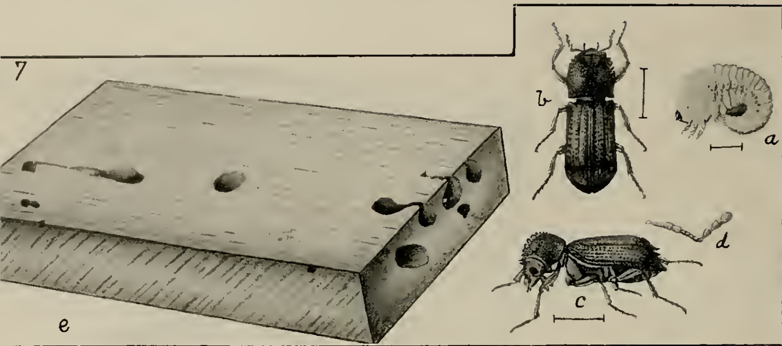


Fig. 193.—Bostrychus æqualis larva, imago and bored wood. [I. M. N.]

ning insects. The body is cylindrical, the integument thickened and hard, the structure compact and the insect well fitted for boring tunnels in wood. The legs are short, the femora and tibiæ broadened, folding up under the body, the trophi are well developed and powerful. In many the front of the prothorax overhangs the head and is toothed and roughened, while in some the body terminates behind in a flat slope in which are tubercles, as if the hind end had been cut off obliquely and tubercles put in for the beetle to get a purchase on the sides of the tunnel. Males and females are alike in appearance, the former the smaller.

The life-history of some species is known and details must be sought in the literature of forest insects. In general, the beetles bore tunnels in wood, depositing eggs in these tunnels; the larvæ are white, the body white, soft and tapering behind, the apex curled round underneath. Thoracic legs are usually present, eyes are absent and there are small four-jointed antennæ. The larval food is the same as that of the imago; pupation takes place in the larval tunnel, no cocoon being formed. In the known common plains species there are at least two broods yearly, the beetles emerging after the cold weather, a brood being completed before the rains and a second brood commencing then; this may be a hibernation brood or may emerge and yield a third or hibernation brood. In warmer parts of the plains there is no hibernation but it is not known whether there are then more than three broods.

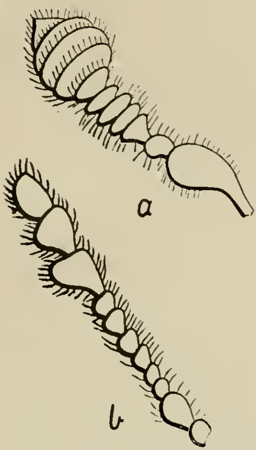


Fig. 194.—A. Scolytid, B. Bostrichid antenna.

The family is of importance as it contains species which destroy cut timber or dry wood, as well as bamboos; in one species at least, stored grain and food products are attacked. The function in nature of these beetles is to clear away dead wood; when these beetles attack furniture and cut wood, as well as bamboos, they are serious pests. The bamboo-boring species are extremely common in the plains but the remainder are almost wholly forest insects and only found outside forest limits in dry wood. There are two special points about the bamboo-boring species that are worth note; there is a general belief, not confined to India, that bamboos must be cut at certain phases of the moon or they will be attacked by Bostrychids; this is probably connected with the rise and fall of sap, bamboos cut at one time containing less sap than those cut at another; secondly it is a general custom to soak bamboos in water for a number of days, after which they are not attacked; any one may observe the effect of this by using unsoaked bamboos in a roof; they are attacked very heavily and almost at once, while soaked bamboos are not; the explanation probably is that soaking removes not only sugar and soluble carbohydrates but also albumens, and leaves the bamboo without nutritious content.

These beetles suffer from a considerable number of enemies, small beetles which invade their tunnels and attack them or their young. *Histeridæ* of the genera *Teretriosoma* and *Teretrius* are found in their burrows and Lesne mentions a *Colydiid* beetle (*Bothrideres*) which lives upon *Sinoxylon crassum*. *Cleridæ* attack them also (*Cylidrus, Denops, Tillus, Opilo*, etc.), and a *Melyrid* (*Axinotarsus*) is also recorded. Hymenopterous parasites are known but are uncommon.

The family has recently been monographed by Lesne (Ann. Soc. Ent. France, 1896, p. 95; 1897, p. 319; 1898, p. 438; 1900, p. 473; 1906, p 445). He divides it as follows :—

I. *Psoinæ*.
II. *Polycaoninæ*.
III. *Dinoderinæ*.
IV. *Bostrichinæ*.

1. Bostrichines. — Bostrichi. Xyloperthi.
2. Apatines.
3. Sinoxylonines.

Of the *Polycaoninæ*, one Indian *Heterarthron* is recorded. The *Dinoderinæ*, *Bostrichines* and *Sinoxylines* are alone of any importance in India. In the first, five species of *Dinoderus* and one of *Rhizopertha* occurs in India. Of the *Bostrichines*, there are nine *Bostrichi*, and seven *Xyloperthi* recorded. In the *Sinoxylines*, 17 Indian species are recorded.

Dinoderus distinctus., Le., attacks the branches of mango. *D pilifrons*, Le., is bred in bamboos, both green and dry, as in wood. *D. minutus*, Fabr., is smaller than the preceding and is common also in bamboos. It was also found in cut sugarcane. *Rhizopertha dominica*, Fabr. (*pusilla*, F.), is a household pest boring into biscuits and other dry stored produce, as well as grain. It is apparently common in Indian houses and we have reared it from wheat flour. *Bostrichopsis parallela*, Le., is mentioned by E. P. Stebbing as boring in bamboos. *Bostrychus aequalis*, Wat. (fig. 192), was found in tea-boxes from Calicut. *Sinoxylon indicum*, Le., has been captured in many localities in South India and Burmah, but

Fig. 193.—DINODERUS DISTINCTUS. [I. M. N.]

does not appear to have been reared. *S. anale*, Le., has a length of one-eighth to a quarter of an inch and is commonly found boring in cut

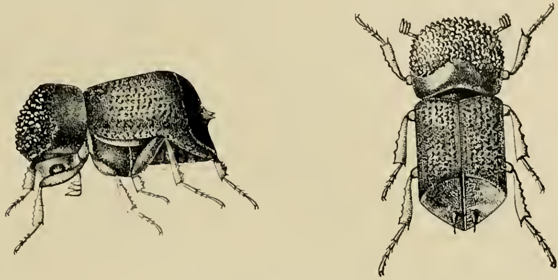


Fig. 196—SINOXYLON ANALE, × 6.

and dead wood. A number of trees it infests are recorded, as well as bamboos; apart from its significance as a forest pest, it is likely to be found anywhere in the plains. It is the species twice referred to in Indian Museum Notes (III, p. 123, V, p. 113) and we have reared it from ordinary dry wood in Behar. *S. conigerum*, Gerst., is recorded in South India, and is widespread in the tropics. *S. crassum*, Le., is referred to by de Niceville (Indian Mus. Notes, V, p. 106) as boring in *Acacia catechu* and is known to attack the cut or dead wood of other trees.

PTINIDÆ.

Tarsi five-jointed. Antennæ often with a feeble three-jointed club. Head retractile into the prothorax.

Small beetles, often of cylindrical form, the integument hard: the tarsi are of five joints, the basal two subequal in length (c. f. Bostrichidæ). The colours are sombre, dark brown or black predominating. The antennæ are often feebly clubbed.

The larvæ are well-known as borers in wood, furniture, dried farinaceous matter, books, drugs and tobacco. These larvæ are of a form similar to the *Lamellicornia*, the body white and thickset, set with fine hairs, and curved back on itself; the head is small, with distinct eyes and small antennæ usually of two joints, the body is finely wrinkled, and there are three pairs of legs. These larvæ eat tunnels and are very destructive; pupation takes place in a cocoon in the tunnel. The beetles on emergence couple and lay eggs soon after.

The family, which is a large one, is divided into two, the *Ptinides*, with the antennæ inserted on the frons, *Anobiides* with the antennæ inserted on the anterior margin of the eyes. *Ptinus* includes the cosmopolitan *P. fur*, Linn., a museum pest, and *P. nigerrimmus*, Boi. *Gibbium* contains a cosmopolitan species, *G. scotias*, Czen., a small shiny brown insect with swollen and united elytra, and no wings. It is a household pest and is recorded (Indian Mus. Notes, I, p. 106) as feeding on the outer shells of opium cakes; the larva makes a hard whitish cocoon of anal secretion; we have reared it from the rubbish found in the bottom of a cupboard of papers in an office in Dharwar; the insect is common in Egypt and the East, feeding on all manner of dried animal and vegetable matter and is recorded from a box of cayenne pepper.

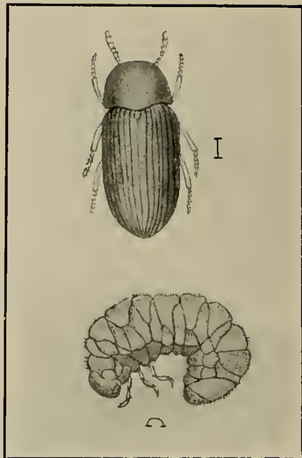
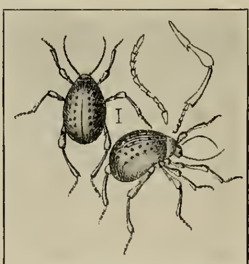


Fig. 197.—Sitodrepa panicea—larva and imago.



98.—Gibbium scotias. [I. M. N.]

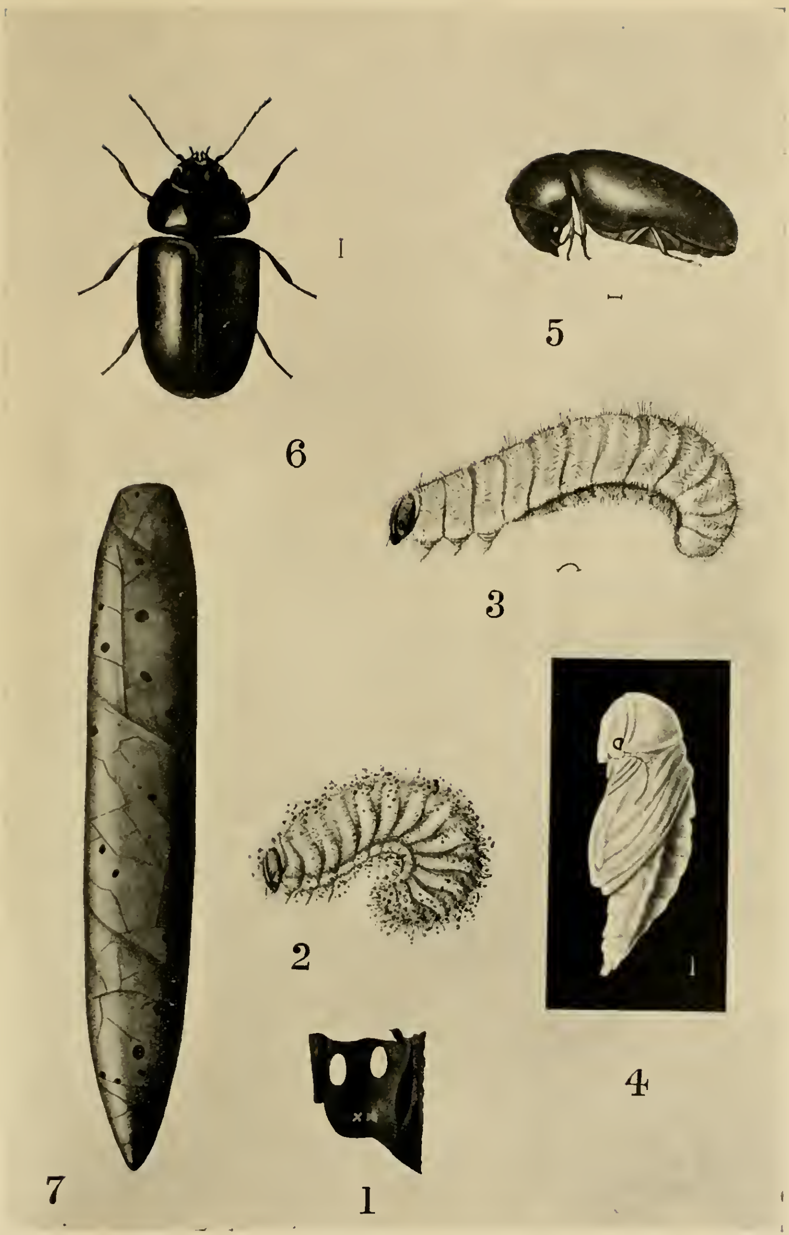
Of the *Anobiides*, *Anobium* is the best known, the larvæ boring in dry wood and furniture, the beetles in the tunnels producing the knocking noise known in England as the "Death Watch." *Anobium* (Sitodrepa) *panicea*, Linn., is found attacking books, papers, dry wood and similar dried vegetable matter. The beetle and grub are both borers, making neat cylindrical tunnels in which they live. The

PLATE XIX.—LASIODERMA TESTACEUM.

THE CHEROOT BEETLE.

Fig. 1. Two eggs on a piece of tobacco leaf. x 10.
,, 2 Larva, as it is usually covered with particles of leaf. x 12.
,, 3. Larva divested of the covering. x 16.
,, 4. Pupa. x 16.
,, 5. Imago, dorsal view. x 12.
,, 6. ,, resting attitude. x 16.
,, 7. *Bored cheroot.*

PLATE XIX.



beetle is said to knock with its head in the tunnels, as a signal presumably to others of its kind. This is a cosmopolitan insect and is common in books in this country. *Lasioderma testacea*, Duft. (Plate XIX), is slightly broader but otherwise similar in appearance, pubescent brown with five lines on the elytra. It bores in cheroots and cigarettes, the larva also boring in the same place. This insect is a serious pest in cured tobacco and any form is liable to become infested. The larva pupates in a case in the tobacco or between the cheroots and the life-history is a short one. It is recorded as attacking opium in the Gazipur Factory (Indian Mus. Notes, I, p. 57) and is a well-known insect in South Indian tobacco factories. It may also be found in turmeric and probably other drugs sold in the bazaars. In addition to the above household species, nine species have been described from this country. No details of the lives of these free-living species are available.

MALACODERMATA.

This group may be divided as follows :—

Lycidæ.
Lampyridæ.
Telephoridæ (*Cantharidæ*). — Here treated as *Malacodermidæ*.
Drilidæ,
Melyridæ. (*Malachiidæ*.)
Cleridæ.
Lymexylonidæ.
Rhagophthalmidæ.

Amongst important recent papers are Gorham's on the Andrewes collection (Ann. Soc. Ent. Belge, 1895, p. 294 ; 1903, p. 323 ; Proc. Zool. Soc., London, 1889, p. 96) and Bourgeois' papers (Ann. Soc. Ent. Belge, 1892, p. 7 ; 1905, p. 46 ; 1906, p. 99 ; 1891, CXXXVII ; Bull. Soc. Ent. France, 1896, p. 117 ; Ann. Soc. Ent. France, 1903, p. 478 ; 1905, p. 127). For *Lycidæ*, Waterhouse's Illustrations of Typical Coleoptera, Vol. I, is valuable and the *Lampyridæ* are listed by Olivier in Genera Insectorum.

Malacodermidæ.

Tarsi five-jointed. Integument soft. Six, seven or eight ventral segments.

This family is a large assemblage of forms which are difficult to define accurately but which are, as a general rule, easily recognised.

The colours are often sombre, though many are yellow and a few a vivid red. They vary in length up to nearly half an inch. The body is flat-

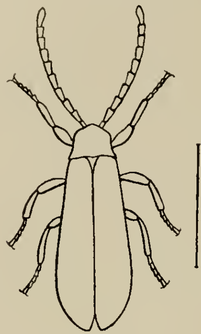


Fig. 199.—MACROLYCUS BOWRINGI.

Fig. 200.—MALACODERMID LARVA, × 3.

Fig. 201.—MALACODERMID LARVA, × 3. THE LIGHT PATCHES ON THE APEX OF THE ABDOMEN ARE LUMINOUS.

Fig. 202.—LUMINOUS MALACODERMID LARVÆ OR FEMALES, × 1.

tened, the integument soft, the body without that hardness and rigidity which is a feature of most beetles. The head is generally concealed under the prothorax ; the antennæ are often pectinate, sometimes moniliform, serrate or vaguely clubbed. The large flat pronotum fits loosely to the elytra, the latter lying over the abdomen but not accurately adapted to it. The mouth-parts are usually feebly developed. Sexual differences are marked in a number of characters (most easily in the larger eyes which are often contiguous in the males) and some females never attain to the winged form but remain as incompletely matured insects or are of the form of the males but with incompletely developed wings. The females of many species are unknown.

Though these beetles are among the most abundant of Indian insects, little is known of their metamorphosis. They are themselves found in the moist warm parts of India in great abundance, in the drier parts of India in the rainy season only and less abundantly. The beetles are found during the day on plants, the brightly coloured ones openly, others in concealment, and they come out at night, only for a short time at a regular hour. Some are probably vegetable feeders, some predaceous, and their larvæ are, in some cases, known to be predaceous on molluscs. One appears to have been reared in India ; the larva of *Lamprophorus nepalensis* is mentioned and figured :—(Ritsema. Tijdschr, Ent. XXXIV, p. CXIV, and Notes Leyden Mus. XIII, pl., X, 1891).

In moist localities, as in the submontane forest areas, are found the peculiar flat larvæ (Fig. 201) of the sub-family Lampyrinæ. These insects are often over one inch long, the segments flattened, the notum forming a flat plate which covers the segment ; the head is concealed under the large pronotum and is protrusible, with small antennæ, slender curved mandibles and inconspicuous mouth-parts. There are three pairs of short legs, and the ventral surface of each segment has a brush of short stiff hairs ; from the apex of the abdomen are protruded a bunch of soft slender filamentous processes which act as a sucker and give a firm hold on the soil. These are retractile and are normally completely retracted into the rectum. On each side of the eighth abdominal segment is an oval white patch which becomes luminous at the will of the insect. The reduced spiracle occupies the middle of this patch, the remaining spiracles being larger. This luminosity is very striking, a bright greenish white light being emitted. The light is evidently under the control of the insect and can be quickly produced, though on the cessation of stimulus it fades only slowly. The luminous patches are on the ventral surface and though the overlapping dorsal plate is to a large extent transparent, the light is emitted principally upon the ground. These insects are nocturnal, are dependent upon moist conditions and feed upon snails. A large specimen required at least six small snails daily and with sufficient moisture and enough snails throve in captivity. The luminosity is not used in feeding; the insect seizes a snail, curls over on its back with the snail held in its legs and slowly devours the muscular part, leaving the alimentary canal. This has been observed frequently and the luminous organ is not functional. What purpose this organ serves in a larval insect is not clear unless it be defensive. Quite young specimens exhibit it and though none of these larvæ have been reared, all that have been observed in India are sexually immature and evidently larval. It is to be hoped that these curious insects will be investigated by an observer situated where they are abundant and that the species to which they belong may be determined by rearing them to maturity. Olivier states that while the larvæ are well known, in no single case has a larva been reared and the imago identified. A larva, apparently of this group, was found in Behar (Figs. 199, 200), an elongate, slightly flattened insect, of a dull reddish tint with soft integument ; the legs were well developed, and at the apex of the abdomen below were two light-emitting patches. Apparently this was a mature larva seeking a place in which to hibernate or pupate.

The nature of the luminosity of these insects has been much discussed ; certain tissues of the bodies of these beetles have the power of giving off light, just as other tissues exert a mechanical action or emit electrical energy. The luminosity is under the control of the insect and heat is not produced. It has been remarked that these insects can convert a quantity of energy into its full equivalent of light without loss due to the production of heat ; no means are known of doing this artificially and even the most modern devices for light production convert only a fraction of the energy into light. The precise object of this luminosity is not clear ; while most of the beetles are nocturnal, a few are actually diurnal in habit and the luminosity would not appear to have any value. In the case of nocturnal species, the emission of light may serve as a "warning signal" to bats and nocturnal birds but there is little to support this view. It is more likely that this property is connected with sex, but it is also possible that it is a part of the vital activity of the insect which has no function but an ornamental and pleasing one. It is worth noting that the luminosity is greatest in those species which have the least developed antennæ ; forms with long pectinate antennæ are the least luminous.

in India the Lampyride division of this family includes the only luminous insects; the only other light-emitting insects in which the light is the direct production of the insect's tissues are the species of *Pyrophorus* (*Elateridæ*), which are confined to the Neotropical Region.

This large family is divided into sub-families (tribes) as follows :—

I. Antennæ inserted on the frons or at the base of the rostrum dorsally.		
(*a*) Intermediate coxæ separated.	1.	*Lycinæ*.
(*b*) ,, ,, contiguous, antennæ sub-contiguous.	2.	*Lampyrinæ*.
Antennæ distant.	3.	*Telephorinæ*.
II Antennæ inserted laterally in front of the eyes.		
(*a*) Clypeus not distinct.	4.	*Drilinæ*.
(*b*) Clypeus separated by a suture.	5.	*Melyrinæ*.

Lycinæ.—Over fifty species are recorded from India, largely from hill forest localities. Red and orange are prevailing colours in our species; the beautiful *Lycostomus præustus*, Fabr., is found in the plains, a deep orange insect with the elytra tipped with black. We have seen bushes so clustered with red *Lycostomus* as to appear to be covered with red blossoms. *L. rufiventris*, Wat., is another of our species, the colouring bright red; it rests by day openly on a plant or grass stem, and is active at night only.

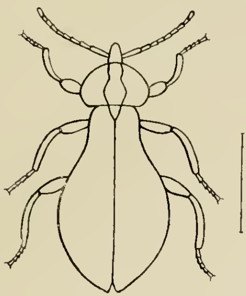


Fig. 203.—LYCOSTOMUS THORACICUS

Lampyrinæ are monographed by E. Olivier in Genera Insectorum (1907). Indian species are as follows :—

Lucidotini	..	.. *Lucernuta* 9.
Lamprophorini	..	.. *Lamprophorus* 10.
		Diaphanes 17.
		Lampyris 1.

Megalophthalmini	..	.. *Harmatella* 2.
Luciolini	..	.. *Luciola* 31.
		Pyrophanes 1.

Diaphanes marginella, Ho., *Luciola Gorhami*, Rits. and *L. ovalis*, Ho., are the light-emitting species so abundant in trees at night during the rainy months. The males have a larger luminous area (three segments) than the females (two segments) and are extremely bright and vivid in some cases.

Telephorinæ.—Over fifty species are described from the continent, but one of which occurs in the plains. This is *Tylocerus bimaculatus*, Ho., a yellow insect with a black blotch on each elytron, the male with the basal and apical segments of the antenna dilated. In *Silis*, the male antennæ are beautifully pectinate, the beetle flying or walking with the antennæ stretched out, each branch very long and erect, giving the appearance of a frond of a delicate plant. Insects with such specially developed antennæ are not uncommon in deep forest and presumably these structures are associated with special senses.

By some authors, the name *Cantharis* is associated with an insect of this family, which would then be known as the *Cantharidæ ;* this would create profound confusion in the mind of the student, who associates the term, in all literature up to now, with the blister-beetles below. To such authors, the *Scolytidæ* are *Ipidæ*, the *Bruchidæ* are *Lariidæ* or *Mylabridæ*, the *Trogositidæ* are *Temnochilidæ* or *Ostomidæ*, the *Parnidæ* are *Dryopidæ*, the *Ptinidæ* are *Anobiidæ*, the *Cistelidæ* are *Alleculidæ*, and so on. It is to be hoped that such alterations in the nomenclature will, by the general consent of Entomologists, be barred ; the tendency to change names long in use on account of some purist's discoveries in priority is deplorable ; the work of practical and teaching Entomologists is being burdened with an immense nomenclature constantly increasing in complexity, and the difficulties of the student are greatly increased. To convert *Heliothis armigera* to *Chloridæ obsoleta*, to call *Locustidæ Phasgonuridæ*, to change the significance of such names as *Mytilaspis*, *Dactylopius*, *Lecanium* and *Coccus*, (each with a clear significance to the practical worker) are instances of this practice referred to elsewhere in these pages and which the student should clearly understand.

Drilinæ.—This sub-family includes less than twenty Indian species. *Selasia laticeps*, Pasc. and *Dodecatoma bicolor*, Westw., are to be found during the rains, delicate yellow and black insects, with pectinate antennæ.

Melyrinæ. (*Malachiinæ*).—These beetles are of small size and bright colouring, active by day in some cases and found occasionally in great abundance at flowers. The larvæ are not known. Over thirty species are described and several are common in the plains. *Hapalochrus fasciatus*, F., is a small beetle, coloured in orange and metallic blue, found running on crops and small plants. *Laius jucundus*, Bourg., is smaller, an equally brightly coloured insect, which runs actively about in grass and on soil. *Prionocerus bicolor*, Redt., is a large yellow insect, with the appearance of the typical members of the family. *Melyris* is represented by a small pubescent black insect found abundantly on the flower heads of *Artemisia* in the hills. It is quite unlike most *Malacodermids*, more compact and chitinised, and much smaller. *Idgia* includes the typical forms, brightly coloured insects which are active by day and feed on the anthers and stigmas of plants. *Idgia cardoni*, Bourg., has been found to be destructive in this way, though not on any scale, destroying the flowering parts of cereals and preventing fertilisation.

CLERIDÆ.

Antennæ clubbed, dentate or flabellate. Lamellæ under the tarsal joints. Tarsi five-jointed, but basal joints of posterior legs often very small.

Brightly coloured insects, of small size, the majority with warning colouration. Many are banded in bright colours, some uniformly blue or other metallic colours. The shape is characteristic, the head and thorax narrower than the elytra, the sides parallel, the body cylindrical. The antennæ are feebly knobbed, moderately long. The head is prominent, the prothorax distinct, the elytra covering the abdomen. The legs are of moderate length, formed for running.

These little beetles are active in flight and are found in the open on flowers, on trees, in grass, on fallen wood, at carcases. Some are predaceous upon other insects, notably those that bore in wood and bamboos. The bamboo boring *Bostrichids*, as also wood-boring

Scolytids, are their prey and the larvæ have the same habits. Little is known of the habits of the larvæ as a whole, some being predaceous,

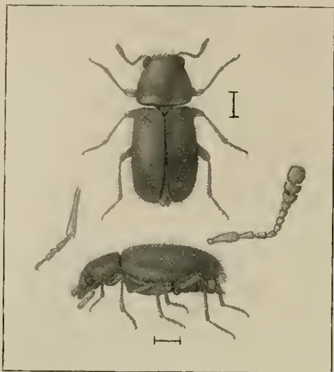


Fig. 204.—Necrobia rufipes.

Fig. 205.—Callimerus decoratus.

some scavengers and some being known to live in the nests of bees and in locust egg masses. With the exception of those that prey upon wood-boring beetles none appear to have been reared in India.

The family is a large one, the latest monograph (Genera Insectorum) giving nearly 2,000 species, of which 109 are Indian. They are less common in the cultivated plains than in the hill forest areas and the warmer moist parts of India. Gorham describes Doherty's Indian and Burmese species (Proc. Zool. Soc., London, 1893, p. 566), and Fea's (Ann. Mus. Genova, 1892).

Few are likely to be found unless they are specially looked for, and there are probably many species to be found in the plains. The following are noteworthy :—*Necrobia rufipes*, F., a bright blue insect, is cosmopolitan and is, with *N. violacea*, L., a household pest feeding on animal produtcts (horn, etc.). *N. ruficollis*, F., in which the thorax and base of the elytra are red, is known to be destructive to the dry cured fish prepared in Sylhet. *Corynetes cæruleus*, de G., is also cosmopolitan and carried by commerce. *Ommadius indicus*, Cast., is a larger dark-banded brown insect, found in Southern India. *Tillus notatus*, Klug., is found in abundance in the burrows of bamboo-boring

Bostrichids and, in bamboo-roofed buildings, is at times extremely abundant. Its larvæ are supposed to live in the burrows, feeding on the larvæ of the *Bostrichids*; it is probably an important factor in checking this pest. We figure *Callimerus decoratus*, Gorh., as an example of the vividly marked species so common in forests; the ground colour is deep blue, the spots are dense white and the legs are yellow. *Opilo subfasciatus*, Westw., *Orthrius bengale*, Westw., and other species of *Orthrius* are found in the plains, brown and black species that frequent flowers and which suggest small longicorns.

LYMEXYLONIDÆ.

Tarsi of five joints, first and fifth long, remainder short. Antennæ short, serrate.

Elongate cylindrical beetles, whose larvæ are cylindrical and bore galleries in dead or dying trees. They are a very small family and doubtfully distinct from both *Malacodermids* and *Melandryids*. They are extremely widespread and occur in tropical forests in the East. *Atractocerus* occurs in Ceylon and is likely to occur in India.

RHAGOPHTHALMIDÆ.

This family includes two Indian species *Rhagophthalmus brevipennis*, Fairm., from Nagpur and *R.* (Ochrotyra) *semiusta*, Pascoe, from the Nilgiris.

DASCILLIDÆ.

Tarsi five-jointed. Abdominal segments five.

A small group, near to the *Malacodermidæ* and doubtfully homogeneous or distinct. Most are American and European. Less than twenty species are recorded from localities in India; of their habits nothing appears to be known.

RHIPICERIDÆ.

Antennæ flabellate or pectinate in the males. Tarsi five-jointed, the fifth joint with a well-developed setaceous onychium. Anterior legs with trochantin.

A family, closely related to the *Malacodermidæ*, of small numbers and but little known. The antennæ in one genus, *Rhipicera*, have more than the usual eleven segments, as much in some cases as forty. The beetles are not common and are essentially tropical. Three species of *Callirhipis* occur in India.

STERNOXI.

Schwarz gives the following classification of the *Sternoxi* :—

Buprestidæ.	*Elateridæ.*
Throscidæ.	*Dicronychidæ.*
Eucnemidæ.	*Plastoceridæ.*
Cerophytidæ.	*Cebrionidæ.*

The *Eucnemidæ* are monographed by Bonvouloir (Ann. Soc. Ent., France, 1870) and the *Cebrionidæ* in the same publication, 1874. The student will also find Maindron's *Elateridæ* in this publication for 1905, p. 319. *Elateridæ* are listed by Schwarz and *Buprestidæ* by Kerremanns in Genera Insectorum.

Buprestidæ.

There is a prosternal process extending back into a mesosternal cavity. The antennæ serrate, short. Tarsi five-jointed, basal four joints with pads.

These beetles resemble *Elateridæ* superficially but have not the hind angles of the prothorax produced backwards. They include tiny

Fig. 206.—Psiloptera fastuosa.

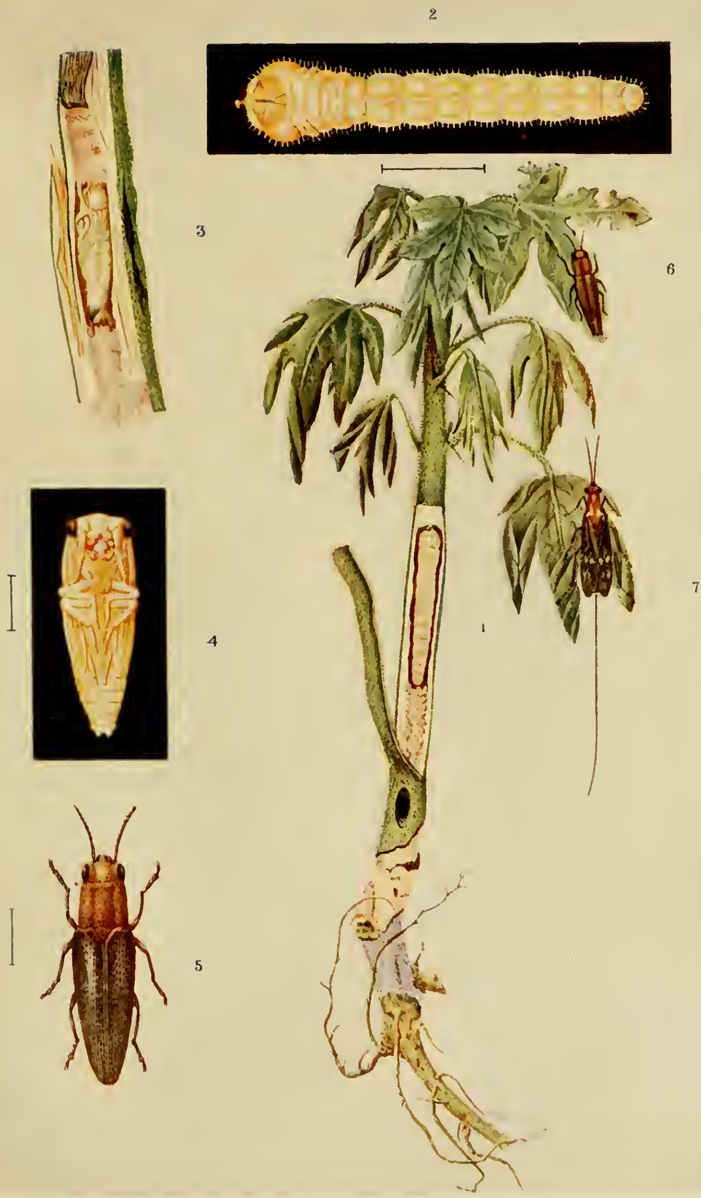
Fig. 207.—Julodis atkinsoni.

beetles less than one-quarter of an inch long as well as large robust forms nearly one inch in length. The colours are usually metallic, from dul

PLATE XX.—Sphenoptera Gossypii.

Cotton Stem Borer.

Fig. 1. Larva in stem of Cotton plant.
,, 2. Larva, magnified.
,, 3. Pupa in stem, x 3.
,, 4. ,, magnified.
,, 5. Imago magnified.
,, 6. Imago.
,, 7. Parasite.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bronzy black to bright green with red reflections. Some species are covered with an efflorescence produced from a secretion in the skin. Warning colouration is not usually shown and the exact significance of the colour schemes is perhaps doubtful. The integument is hard and strong, the head partly sunk in the thorax, which is strongly fixed to the abdomen, the elytra accurately adapted to the body ; the antennæ are readily concealed under the head. The mouth-parts are short and of the herbivorous type. The legs are short and fold under the body when at rest. The wings are large and functional in flight. Males and females are similar in appearance and usually also in size. The life-history of a few species has been worked out in India and agrees with that of the group as a whole. The larvæ are borers in the tissues of plants, some mining in the leaves, others boring in the twigs, the branches, the woody stems or beneath the bark of trees. The larva is of a characteristic form, legless with the thoracic segments swollen into a distinct bulb (Plate XX), the abdomen very long and slender. The swelling fits the bore made in the plant and gives the larva the necessary hold to move along the bore or to work with its mandibles against the hard tissues. Pupation takes place in the bore, the pupa lying naked in a chamber made by closing the bore with debris, as a rule ; the larva prepares the hole of exit for the pupa, leaving only a thin covering of bark through which the beetle can readily emerge. The beetles feed on leaves, eating the parenchyma and leaving the veins only. They fly actively and are diurnal.

The large species have a life-history lasting one year at least, and the beetles are seen at one season in the year only. Some at least of the smaller species have several broods in the year depending upon their foodplants. Hibernation appears to be passed in the larval and in the imaginal states. A few are pests, those which breed in cultivated plants such as guava, cotton, jute, groundnut and citrus trees. The family is of more importance in Forestry than in Agriculture. Hymenopterous parasites attack these larvæ just as they do other boring larvæ, and birds are known to feed on the beetles.

This family is a very large one and widely spread, with nearly 300 recorded "Indian" species. Kerremanns divides the family into 12 sub-families, which need not be touched on here (see Ann. Soc. Ent., Belg., XXV, p. 165); he has recently listed the known species in Genera Insectorum and is monographing the species of the world. By far the larger number of recorded Indian species are Himalayan or Burmese. A very small number are common in the plains with a small number that have been occasionally recorded.

Sternocera includes large brightly coloured species, of somewhat oval shape, with smooth elytra and deeply punctate pronotum, the sternal process prominent. They are rarely found outside the hills and forest areas, *S. chrysidioides*, C. & G., and *S. nitidicollis*, C. & G., being occasionally captured.

Julodis is of similar form but without a marked sternal process, the elytra pointed at the apex. *J. atkinsoni*, Kerr., was reported (in error) as an injurious insect in the Punjab but is rarely found in North-West India. It appears to be a genus characteristic of sandy desert areas.

Chrysochroa includes 17 Indian species, of which *C. mutabilis*, Oliv., is found in the plains. This is a metallic green insect with red reflections especially at the margin of the elytra. *C. chinensis*, C. & G., is the beautiful green and red beetle sold as a curiosity in the hills and very common in some forest localities, while *C. edwardsii*, Ho., is the big yellow-blotched species abundant in the Khasi hills and also a source of income to the Khasi insect collector.

Fig. 208.—*Chrysochroa chinensis.*

Psiloptera cupreosplendens, Saund., is occasionally caught in the plains, a smaller green and red metallic insect, the elytra much punctured.

Sphenoptera is the most abundant in cultivated areas, several species being found breeding in wild or cultivated plants. They are deep metallic bronzy insects, not of large size and by no means easy to discriminate. Kerremanns gives 20 Indian species. *S. gossypii*. Kerr. (Plate XX), is the cotton stem borer of the cotton areas, apparently widespread over India, and, as a rule, very common but only once found in

Behar. Its life-history is elsewhere described (Indian Insect Pests, p. 100). Another *Sphenoptera* is a serious enemy to groundnut (*Arachis hypogea*), the larvæ boring in the underground rootstock. It is abundant in South India. *Belionota prasina*., Thunb., is found boring in guava and mango trunks and is found commonly. It is a very dark metallic blue-black, the pronotum with a lateral indentation and red blotch, the elytra with four fine longitudinal ridges.

Fig. 209.—BELIONOTA PRASINA.

Fig. 210. AGRILUS GRISATOR.

Kerremanns lists nearly 1,100 species of *Agrilus*, 38 of which are Indian. A species that is probably *A. grisator*, Kerr., has been reared from lemon trees and another species breeds in the same plant. They are small linear beetles of varied colouring.

Finally, we have the still smaller, more oval forms included in *Trachys*, 41 out of 260 of which Kerremanns records as Indian. So far as is known, the larvæ of these beetles are leaf miners and one has been reared from the leaves of Jute, another from Beal. Several species are common.

THROSCIDÆ.

Represented by *Throscus* (Trixagus) *proprius*, Bonv., found in North India.

EUCNEMIDÆ.

Twelve species are recorded from different localities in the hills.

ELATERIDÆ.—*Click Beetles.*

The hind angles of the thorax usually produced backwards. A prosternal process received in the mesosternum. Antennæ often serrate or pectinate.

A very large family of small or large beetles recognizable usually at sight from the very striking general facies peculiar to the family. The large forms, which are half an inch and more in length, are in many cases brightly coloured, the small forms, of which there are a great number, in dull tints of brown or yellow. The antennæ are moderately long and of varied form. The head is small and embedded in the solid prothorax. The prothorax is remarkably large and powerful, fitting loosely but accurately to the elytra, the lateral angles prolonged backwards. On the ventral surface is a process, which passes into the mesosternum in which is a cavity fitted to it. The abdomen is long, covered by the hard elytra ; the legs are moderately long and formed for running. The striking structure of the prothorax is associated with the faculty many of the beetles have of leaping up with a click when placed on a flat surface with the venter upwards.

Fig. 211.—AGRYPNUS FUSCIPES.

Although these beetles are common everywhere in India, and there is an abundance of species, practically nothing is actually on record as to the life-history. We figure from Westwood a larva possibly that of *Agrypnus fuscipes*, the commonest large *Elaterid* of India. We are not aware that any species has actually been reared, though larvæ that are probably of this family can be found commonly enough. The known

Fig. 212.—LARVA OF AGRYPNUS FUSCIPES.
(*From Westwood.*)

larvæ elsewhere are cylindrical and elongated, the segments smooth and fitting closely to one another, the whole head and body forming a smooth flexible cylinder. There are three pairs of legs, and the hind end terminates in hooks and chitinised processes which probably give the larva leverage on the soil or other medium in which it lives and facilitates rapid locomotion.

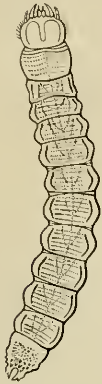


Fig. 213.—Larva of alaus oculatus. (*After Chapuis.*)

On the analogy of known European forms there can be no doubt that these brown shiny larvæ are those of *Elateridæ* but the difficulty is to rear them. It is uncertain whether they feed on roots or other vegetable matter or whether they are predaceous on other insects and so on those which really injure the roots of plants (e.g., *Melolonthidæ*). They are associated with damage to roots but may not cause it. and we are not aware of any instances of damage to roots by Elaterids in India. In the known species, the development is slow and several years are occupied in the metamorphosis. Nothing is known as to their enemies. none are known to be pests in India, and there are as yet no data as to their hibernation or seasonal occurrence, save the very general observation that, like most insects, they are found most abundantly in the rainy season.

The family is so large and complex that the preliminary difficulty of identifying or even separating the distinct species is at present insuperable. Practically all the known Indian species were described by Candeze, whose works must be consulted. Schwarz has listed the *Elateridæ*, as apart from the *Eucnemidæ*, etc., in Genera Insectorum (1906), enumerating 503 species as occurring in India and Burmah alone. This cannot be more than a part of the actual species and new species are found in quantity.

Of the 28 sub-families, 21 are represented by Indian forms. The light-emitting *Pyrophorini* are confined to the new world and do not occur in India. *Agrypnus* (13 spp.) includes the large forms, *A. fuscipes*, Fabr. (fig. 210), being the common large black click-beetle of the plains. *Lacon* (44 spp.) is a common genus, with several plains species, smaller forms, with somewhat expanded prothorax. *Campsosternus* (30 spp.) are large insects of metallic colouring, usually green, abundant in hill forests and of striking appearance. The extremely common small click-beetles which come so abundantly to light in the plains during the rainy months are species of *Heteroderes* (16 spp.): nothing is yet known of their life-history or habits, in spite of the numbers in which they occur; they are wholly nocturnal, the beetles found by day in hiding on plants, in bark, under dry leaves, etc. *Cardiophorus* (75 spp.) is widely spread over the plains and abundant; *C. stolatus*, Er., is a small beetle, the elytra chestnut with a black fascia, also very abundant at light. *Cardiophorus quadrimaculatus*, Motsch., has yellow blotches on the elytra and is conspicuous. *Melanotus* (23) includes larger dark brown species, *M. fuscus*, Latr., common in Kanara and the hills, other species occurring in the plains. *Penia eschscholtzi*, Cost., is a broader rounder beetle of a bright brown colour with ochreous fasciæ, common in the Himalayas. *Plectrosternus rufus*, Lac., is the large red beetle with black longitudinal grooves, in which the prothorax is small and the antennæ conspicuously serrate. *Hemiops crassa*, Gylh., is smaller, the ground colour yellow but equally conspicuously coloured.

Dicronychidæ.

These are separated as a distinct family by Schwarz on account of the absence of penis. Two species of *Dicronychus* occur in India, of which *D. cinnamomeus*, Cand., is not uncommon in the plains, a small brown beetle with the typical facies of the *Elateridæ*.

Cebrionidæ.

A single species is described as Indian, *Sandalus orientalis*, Bourg.

HETEROMERA.

A distinct series of beetles, whose classification into families is not clear. Four families are easily distinguishable as far as Indian forms are concerned.

Tenebrionidæ include a large number of the species, the tarsi not lobed, the claws smooth, the body compact with close fitting elytra.

Mordellidæ have the head peculiarly formed and inflexed, the hind coxæ with sharp plates.

Canthariddæ have the head with a neck, the tarsal claws with appendages, and the elytra not fitting the abdomen closely.

Trictenotomidæ are large, with long antennæ often serrate at the tip, long curved mandibles and resemble *Cerambycidæ*.

The remaining eleven families are of less importance and less easily recognisable. For papers on this group, see Fairmaire's papers on the Kurseong and Andrewes' collections. (Ann. Soc. Ent., Belge, 1894, p. 17 ; 1896, p. 6).

TENEBRIONIDÆ.

Antennæ of eleven joints, under a projection of the side of the head. Tarsi heteromerous, simple. Abdomen of five segments.

A large family of beetles generally of sombre colour, found most abundantly in deserts and dry places. They are of moderate size, many of some bulk and weight. The antennæ are short and of varied form; the trophi are of the biting herbivorous type. The body is hard, often flattened, often globular, the elytra fitting closely and in the apterous forms soldered together. Sexual differences occur in a few, as in the erect horns on the head, the dilation of the tarsi, or the presence of the tuft of hair on the abdomen of the males.

Fig. 214.—OPATRUM DEPRESSUM. [I. M. N.]

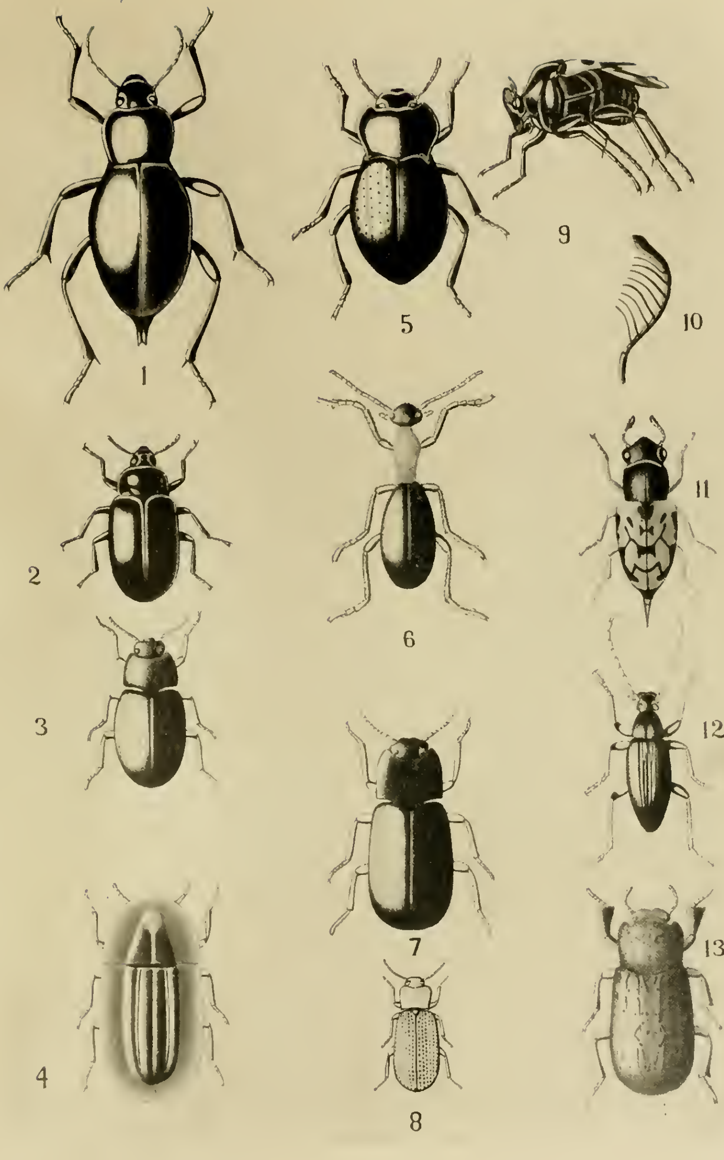
Little is known of the life-history and but few species have been reared in India. The larvæ are elongate, cylindrical, the segments with brown thickened integument; the hind end bears often two dorsal hooks and a ventral retractile process ; the legs are present and functional in running. The larvæ are extremely difficult to find ; *Opatrum* is in some places found literally in millions but its larva never ; larvæ have been obtained first in captivity and then in the field only after prolonged searching. The known larvæ, like the known beetles, feed on dead vegetable matter such as decaying leaves ; this also appears to be their food in desert places where there is a layer of leaves below each bush ; we have seen these desert forms come out in numbers and feed on locust hoppers. The function of the family essentially is that of scavenging the dead vegetable matter that falls in such abundance and, excluding the household pests, none are injurious. The prevalence of deep black as a colour is to be expected since they are insects which shun light and which live in dark places where they are well hidden; the colouring strikes one when one sees these beetles in sandy deserts as in North India, but the colouration is of use since the beetles rapidly recover from the torpidity due to the chill of the air at night by coming out into the sunlight at sunrise for a short time before going into the bushes to feed. These beetles are a striking feature of the sandy wastes of North India where insect life is so scanty and these species are very imperfectly known and probably peculiar to such localities. Not all Tenebrionids live on the soil in concealment, though most do so ; they really fall into two series, the light-seeking and the light-shunning species, the latter predominating. They are found among decaying vegetation, among fallen leaves, under bark, in thatched roofs, between the timbers of a house and generally in concealment. Practically nothing is known as to the length of their life-histories or their seasons ; a yearly feature is the emergence of numbers of the very common beetle *Mesomorpha villiger*, which breeds in dry leaves and wood and which emerges abundantly to fly in the warm evenings in March in the plains. In the warm winter of 1907, these beetles emerged on February 25th, an exceptionally early date. *Opatrum* appears to have no season, nor do most of those which we have found abundantly in the plains, though *Blaps* is found only in the cold weather and probably has a yearly period.

The family is a very large one with a great number of species. The geographical distribution is wide, but the ground species appear to be most abundant in Africa, the Mediterranean and Caspian littoral, and

PLATE XXI.—HETEROMERA.

Fig.	1.	Blaps orientalis.	x $1\frac{1}{4}$.
,,	2.	Ceropria induta.	x 3.
,,	3.	Mesomorpha villiger.	x 4.
,,	4.	Cossyphus depressus.	x 3.
,,	5.	Platynotus perforatus.	x $1\frac{1}{2}$.
,,	6.	Formicomus sp.	x 8.
,,	7.	Opatrum elongatum.	x 4.
,,	8.	Doliema plana.	x 4.
,,	9.	Emenadia ferruginea.	x $2\frac{1}{2}$.
,,	10.	,, ,,	male antenna.
,,	11.	Othnius delusus.	x 7.
,,	12.	Allecula sp.	x 2.
,,	13.	Scleron orientale.	x 4.

PLATE XXI.



in certain centres in the New World. India possesses but a small number of the large total of species and but few come into our plains fauna.

About 300 Indian species are recorded, of which perhaps fifty are found in the plains. The individual species are difficult to discriminate and no comprehensive work on the Indian species is in existence. The Cardon and Andrewes collections have been described (Ann. Soc. Ent., Belge, 1894, 1896) and a number of species added lately, but the literature is scattered and the family requires revision. We are not aware of any records of life-histories or habits.

Polposipus herculeanus, Sol. is a large species covered with hair, whose characters are so odd that Lacordaire states that he thought the original describer might have had before him a "faked" insect, the head, legs and body belonging to three distinct genera. *Tenebrio* contains *T. molitor*, whose larva is so common in meal and flour and which is bred in large numbers as food for cage birds. It is now cosmopolitan. *Rhytinota*, *Pachycera*, *Hyperops* and *Himatismus* include rather elongate beetles of a dead black colour and small size, found sometimes in great abundance. The beetles have been collected at all times of the year and seem to have no distinct seasons. *Blaps* is the large "black beetle" of the plains, with *B. orientalis*, Sol. (Plate XXI, fig. 1), common and *B. indicola*, Bot., rarer. The former is very common and striking; the elytra are soldered together and, in the females, produced into a process behind, which varies much in length. This beetle on being handled exudes an unpleasant liquid which stains a permanent dull red. Nothing appears to be known as to its life-history and all our specimens were captured between December and May. *Platynotus perforatus*, Muls. (Plate XXI, fig. 5), is also very common, a flatter beetle, more distinctly punctured. *Scleron denticolle*, Fairm., and *S. orientale*, F. (Plate XXI, fig. 13), are small retiring beetles, characterised by the curiously flattened and expanded fore femur and tibia, apparently for the purpose of digging.

Opatrum is perhaps the commonest of all the genera, occurring sometimes in enormous numbers. There are a variety of species, including *O. elongatum*, Guer. (Plate XXI, fig. 7), which is narrower and has the prothorax slightly tuberculate, *O. dorsogranosum*, Fairm., in which the upper surface is somewhat granulose, and *Opatrum. depressum*, Fabr., which is figured here. These species occur sometimes in incredible numbers ; we have seen a field of six-foot-high indigo so infested that every stem was black ; the beetles always shun light and in the dense indigo crop they live in shade and feed on the abundant dry leaves that fall. When the crop is cut they are brought in with it to the vats and sometimes cover the surrounding masonry, etc. A number of beetles were confined in the insectary and fed on these leaves ; larvæ were eventually found which were reared without difficulty but which lived wholly on the surface of the soil under the covering of leaves. On first seeing the multitudes of these beetles that exist. one is tempted to wonder where their larvæ could have been ; we realise it after having reared them and it is possible then to dimly see how vast may be the fauna hidden away like this on the soil and how important their work of disposing of plant refuse is. *Opatrum* apparently like most of its family, is wholly a feeder on dead or decaying vegetable tissue and the beetles have been found to even eat planks laid on the soil.

The genus *Toxicum* is marked by the erect horns of the males : these beetles are found under bark ; the function of the horns is unknown. The two species of *Tribolium* occur widely spread, *T. ferrugineum*, Fabr., *T. confusus*, Duv. Both are pests of stored produce and occur frequently in dried insect collections. The latter is stated to be abundant in America, but we have been unable to recognise it in our long series. We reproduce the figures illustrating the differences in the two species in Chittenden's paper (U. S. Dept. of Agri. Ento. Bull., N. S. 4). It is, however, recorded from rice in Rangoon

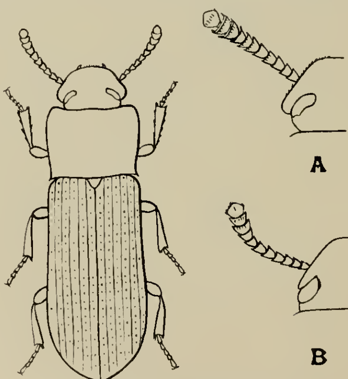


Fig. 215.—TRIBOLIUM CONFUSUM, A. HEAD OF T. CONFUSUS, B. FERRUGINEUM. (*After Chittenden.*)

(Indian Mus. Notes V, 139). The former is common and has been reared from wheat grains, wheat flour, and oat meal, as well as dried insects.

One of the more striking insects of the plains is the curious flattened *Cossyphus depressus*, Fabr. (Plate XXI, fig. 4), in which the elytra and pronotum are produced into a curved thin lamella surrounding the body after the manner of a Cassid beetle. What object this serves is uncertain, but it may give it a resemblance to a seed which is of use as a protection. *Derosphærus nigricollis*, Bot., is a larger beetle, the elytra deeply punctate and shining, with long legs, which is found on the soil in the plains. *Platydema* includes small oval brown beetles found eating the inner portions of the flakes of tree bark. *Mesomorpha villiger*, Bl. (Plate XXI, fig. 3), is a cosmopolitan beetle found among decaying leaves, in thatched roofs, in old trees, wherever there is decaying vegetable matter. It is a small dull brown or black beetle, rarely seen or noticed, but probably to be found everywhere if searched for. *Ceropria* (Plate XXI, fig. 2) includes a few brightly coloured species with tints of shiny purple or blue.

Collecting, etc.—It is probable that only a small part of the Tenebrionid fauna of our area is actually recorded, and the collector will find much that is new. These beetles can be easily kept in captivity and breeding experiments are required to determine life-histories, etc., with much field observation. The beetles themselves are not difficult to find under bark, amongst fallen leaves, in thatched roofs, among cut timber and in similar situations. The Desert fauna of North India especially requires investigation and much interesting work waits to be done on the life-histories and habits of these species.

CISTELIDÆ.

Characters as in the previous family but the tarsal claws pectinate, not simple.

A small family of unimportant beetles, rarely found. They have long antennæ ; the elytra do not fit the abdomen very closely ; the males have longer antennæ and larger eyes than the females. In a few the head is prolonged into a distinct short blunt rostrum. The known species live in decaying trees or under bark, as do their larvæ.

About thirty species are Indian, including *Allecula* (Plate XXI, fig. 12), *Cistela* and *Cistelomorpha*.

LAGRIIDÆ.

Interior coxæ projecting, conical and contiguous. Anterior coxal cavities closed behind; claws simple, ventral segments five, penultimate tarsal joint bilobed and pubescent.

These are Tenebrionids with different coxæ and having anterior coxal cavities closed behind, and will not, by the close coleopterous student, be confused with other *Heteromera*.

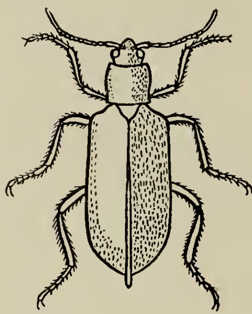


Fig. 216.—LAGRIA SP. × 2.

About forty species are described from India alone; *Lagria* is the most important genus, widespread and with several common Indian species; the body is hairy, the head has a thick neck, the tarsus has the penultimate joint expanded and pubescent as in the *Chrysomelidæ*.

OTHNIIDÆ.

This family is represented in India by a small species, *Othnius delusus*, Pasc. (Plate XXI, fig. 11), found in the hills of South India.

MONOMMIDÆ.

Represented in India by a single species, *Monomma brunneum*, Thoms. (fig. 216), found under the bark of trees. This is a dark

Fig. 217.—MONOMMA BRUNNEUM.

Fig. 218.—HEAD OF M. GIGANTEUM. (*From Thomson.*)

brown insect, with clubbed antennæ fitting into grooves of the lower side of the prothorax. The group is monographed by Thomson (Ann. Soc. Ent., France, 1860).

PYTHIDÆ.

Anterior coxal cavities open behind (c.f. *Tenebrionidæ*). *Prothorax narrower at the base than the elytra. Eyes entire.*

A small family of unimportant insects separated on minute characters from its allies. The family is small with few representatives. None are common in the plains, and *Doliema plana*, Fabr. (Plate XXI, fig. 8), is the species most likely to be found.

MELANDRYIDÆ.

A family distinct from all allies by a variety of characters; the claws are not pectinate (*Cistelidæ*), the anterior coxal cavities are open behind (*Tenebrionids*); they are not hemispherical (*Nilionidæ*); the prothorax is as broad as the elytra (*Pythidæ*); there is no neck (*Mordellides*); and finally the pronotum does not extend laterally on the prothorax (rest of Heteromera).

So far as our fauna is concerned they are of no importance whatever. They are dull coloured insects found in decaying wood in temperate regions. *Penthe rufopubens*, Mors., has been described as Indian.

PYROCHROIDÆ.

Antennæ flabellate or pectinate. Prothorax narrower than the elytra. Head with a neck. Elytra longer than the body. Penultimate tarsal joint broadened.

Beetles of small to moderate size, found with their larvæ under the bark of trees. *Pyrochroa* is the common genus, with the antennæ toothed (or nearly pectinate in the males), the body finely pubescent. Three species have been described, *P. deplanata*, Pic., from Malabar, *P. subcostulata*, Fairm., from Cashmere, and *P. cardoni*, Fairm., from the Himalayas (North Bengal).

Anthicidæ.

Head with a neck. Antennæ filiform. Prothorax narrower at the base than the elytra. Claws simple.

This family includes four sub-families recognised by many authors as families. The *Pedilinæ* include less than ten species of *Macrataria*.

Anthicinæ.—These are small slender beetles with a distinct resemblance to ants, common in grass, and sometimes very abundant. They are to be found running actively on grass and plants just as ants do, and they appear to be predaceous on small insects and Aphides. Nothing is known of their life-history.

Mons. Maindron obtained 19 species during his tour in India (Ann. Soc. Ent., France, 1903, p. 348). Laferte monographed the *Anthicinæ* in 1848, listing 31 species of *Anthicus*. Cardon's collections are described by Fairmaire and Pic. (Ann. Soc. Ent., Belge, 1894). *Formicomus* (19 species) and *Anthicus* (62 species) include the species found in the plains (Plate XXI, fig. 6).

Hylophilinæ.—Small beetles, less than one-eighth of an inch long with the basal two abdominal segments united and four segments beyond free. Basal tarsal segment long, penultimate bilobed. These small beetles are but little known and their life-histories scarcely at all. They are stated to live in dead wood. None have been reared in India and only a few collected.

The most recent monograph (M. Pic. Ann. Soc. Ent., France, 1906, p. 190) records *Hylobænus indicus*, Pic., and eight species of *Hylophilus* as Indian.

Scraptiinæ.—*Scraptia pulicaria*, Fairm., is the sole recorded species

Œdemeridæ.

Head narrowed behind, produced in front into a short rostrum. Antennæ usually filiform, eleven or twelve jointed. Prothorax narrower than the elytra. Penultimate tarsal joint bilobed.

These are somewhat elongate beetles, of thin integument, found on flowers or decaying wood, some diurnal, some nocturnal. So far as known, the larvæ are feeders in or on wood or decaying timber and are occasionally injurious. The beetles resemble Longicorns on the one hand, or Malacodermids on the other. Five species are described by Fairmaire with *Asclera indica*, from Bengal, and *Oncomera* (Dryops) *indica* from Kanara.

MORDELLIDÆ.

Head short, bent down over the legs, with a narrow neck, antennæ filiform, dentate or, in the males, pectinate.

Small thickset short beetles with, in our common species, a characteristic facies. They fall into two series, partly regarded as distinct families (*Rhipiphorina* and *Mordellinæ*). Our common species belong to the former and, so far as known, are parasites in the nests of Aculeate Hymenoptera. Horne figures *Emenadia ferruginea*, F. (*flabellata*, F.), which he reared from the nests of *Eumenes* in India. This and other species are common on the wing in the plains and are readily recognisable: the elytra are pointed, the body very thickset, vertical in front, the colouring black and yellow brown (Plate XXI, figs. 9, 10). This genus is practically world-wide. *Rhipiphorus pectinicornis*, Thunb. (*blattarum*, Saund.), is parasitic, the female wingless and larviform, living on cockroaches. Of the two genera, nine are recorded as Indian. Of the *Mordellinæ*, none appear to be recorded; we have reared one species from larvæ found boring in the stems of *Dicliptera*.

CANTHARIDÆ.—*Blister Beetles.*

The head is joined to the prothorax by a distinct neck. The elytra are not closely applied to the abdomen: the integument is weak. The claws have appendages.

These beetles are easily recognisable from the above characters and have a distinct facies. They are rarely over one inch long, usually about half an inch, moderately robustly built. The colours are varied, in some cases typically warning, in others blue, brown or dull coloured. The antennæ are long and simple, rarely of less joints than eleven in the *Mylabrinæ*; the head is of moderate size, the compound eyes large, the biting mouth-parts not conspicuous. The prothorax is narrower than the head and the two are not broadly united but joined by a neck

Fig. 219.—MYLABRIS PUSTULATA.

The elytra neither meet accurately in the median line nor fit closely to the side of the abdomen and only loosely cover the upper surface of the body. The wings are ample and used in flight; *Melæ* is wingless with abbreviated elytra. The legs are long, the tarsi long, the claws with a closely fitting appendage below, which resembles a duplicate claw. Males are similar to females but smaller; size is often very variable in both sexes. An acrid oil is excreted from openings in the apices of the femora in *Mylabris*, *Cantharis* and *Melæ;* this oil contains an active principle, Cantharidin, which has irritant properties rendering it commercially valuable.

Almost nothing is known of the life-history of Indian species. Large masses of small yellow eggs are deposited on grass or soil, from which hatch small active larvæ of the usual Coleopterous form. The further history of these larvæ has not been traced. The student should consult the account of the life-history of the known species of *Melæ* and *Epicauta,* details of which are given in Sharp's Insects. These insects are parasitic upon the larvæ of Aculeate *Hymenoptera* or upon the egg masses of *Acridiidæ.*

The beetles are diurnal, the winged species flying readily. They are herbivorous, feeding on leaves and flowers and, when abundant, form a conspicuous part of the diurnal fauna. Each species appears yearly and there is but one brood. They are often very abundant and occasionally appear in large numbers with great suddenness and in an apparently mysterious fashion. Owing to their herbivorous habits and frequent abundance, the beetles may be injurious to cultivated plants. The flower-eating species of *Epicauta* (*Cantharis*) destroy the anthers and pistils of cereals and thus cause serious damage to the crops. The latter form of damage is of frequent occurrence. *Andropogon sorghum* (juar, great millet) being specially affected. (Compare the habits of *Chiloloba,* the *Cetoniid* beetle.) *Cantharis hirticornis,* Haag., is destructive to *Amaranthus* and vegetables in Assam, the beetles being abundant in May and devouring the leaves.

The family is a large one, found principally in the tropics. Over 70 Indian species are described and less than ten are common in the plains, these being apparently widely spread over the Indian region. There are four principal genera, *Cantharis* (*Epicauta*). *Mylabris, Zonitis,* which are winged, and the wingless *Meloe*. There is considerable confusion in the nomenclature of the recorded species, and the specific names adopted here are liable to revision when the nomenclature of the family is revised.

Meloinæ.—Wingless. Metasternum very short, middle coxæ covering the hind coxæ. *Meloe* is the important genus, of which 2 Indian species are recorded.

Mylabrinæ.—*Mylabris* is winged but has the antennæ short, curved and thick. Marseul monographed the sub-family in 1873 (Mem. Soc., Liege (2) III, pp. 363—662).

The common form is *Mylabris pustulata*, Thunb., doubtfully distinct from *M. sidæ*. *M. rouxi*, Cast., is a similar but smaller, black and yellow species, while 16 other species are recoided.

M. pustulata, Thunb., is a conspicuous beetle, measuring about one inch in length, coloured black with large orange marks on the wings and prothorax. The wings and body are softer than in many beetles, the typical head and antennæ are those characteristic of the *Cantharidæ*, and the yellow fluid exuding from the joints of the legs further characterises this common insect. The life-history is unknown, and the life-histories of those *Cantharidæ* which have been studied are so various that there is no indication as to what the life-history of this insect is likely to be. The fluid exuded from the joints of the legs, with its blistering properties and probably unpleasant flavour, serves as a protection from birds and other enemies; the colouration is that known as "warning," that is, it serves to plainly advertise the unpleasant nature of this insect, so that birds, etc., may not eat it. In its habits this insect is, as would be expected, conspicuous; it may be seen on plants, fully exposed, so that its warning livery is clearly seen. It feeds upon the flowers of plants, notably *Cucurbitaceæ* such as the melon, pumpkin, cucumber, white gourd, etc. It is common in the plains and occurs throughout India where vegetation is abundant. There is one brood in the year and these beetles appear sometimes in great numbers and are very destructive.

Cantharinæ.—The antennæ longer, not curved, filiform. *Cantharis* (Epicauta) contains a number of common species of which little is as yet known. *C. violacea*, Makl., is a small deep-blue form found in Western India. *C. actæon*, Cast., is the very common large blue species, found for a short time in the rains. *C. tenuicollis*, Pall. (? *C. ruficollis*, Pall., *C. ornata*, Cast.), is a green form with a slender reddish prothorax, which, with the dull brown *C. rouxi*, Cast., is destructive to cereals by devouring the stigma and anthers, no grain being formed. When the flowering of rice, millets or juar coincides with the emergence of these beetles, widespread loss may occur. *C. hirticornis*, Haag., is a black species with red head found abundantly in Assam in May where it feeds on Amaranthus and other vegetables. *Illetica testacea*, Fabr., is the more robust and densely chitinised red-brown species found in the rains. This has robust mandibles; the shiny black thorax and lined elytra are hard and strong, giving the beetle more the appearance of a *Cerambycid*.

Fig. 220.—CANTHARIS TENUICOLLIS.

Cissites Debyi.—Green has observed that the eggs of this species are laid in the galleries of *Xylocopa tenuiscapa*, Westw., in Ceylon; some of the larvæ, he imagines, migrate on the bees to other colonies, (? *viâ* the flowers visited by the bees) and those that remain in the original nest (and presumably attack the bee-larvæ) pupate in side tunnels which they make off the main bee-tunnel (Ent. Mo. Mag., 1902, 232).

COLLECTING.

Collecting.—The beetles are readily captured with the hand and require to be carefully dried. They lay eggs freely in captivity, the eggs hatch and, in captivity, nothing further can happen. The further elucidation of the life-history requires either the extremely careful observation of the larvæ when hatched in the open or prolonged investigation into the egg masses of *Acridiids* or the nests of Aculeate *Hymenoptera* in the hope of finding larvæ. Any opportunity of doing either should be seized, as no progress can be made till more is known and we can at present only estimate their directly injurious effect as adults.

Trictenotomidæ.

Antennæ long, serrate inside at the apex. Tarsi heteromerous.

These are large beetles, practically heteromerous Longicornia with slightly serrate antennæ. They have long bodies, the dark colours

Fig. 221.—Trictenotoma childreni, × 1.

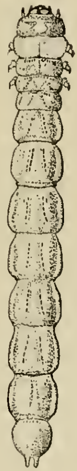


Fig. 222.—Trictenotoma childreni larva. (*After Gahan*).

(except *Autocrates ænea*, Westw., which is metallic blue), the general facies of many Cerambycid beetles and are found in the same habitat. These insects are characteristic of the Indo-Malayan region, particularly of forest areas.

Autocrates has the prothorax spined, the scutellum blunt. *Trictenotoma* has the prothorax only angulated, scutellum longer and sharper. Very little is known of the life-history of these insects ; they are probably predaceous in the adult stage. The larva of *T. childreni* has recently been described and figured by Gahan from Java specimens (Trans. Ent. Soc., London, 1908, p. 275) ; we reproduce one figure in the hope that it may assist in the recognition of larvæ of this family in South

India where they must occur. The structure of the larvæ is held to support the view that this family is more nearly related to the *Pythidæ* or *Pyrochroidæ* than to any other *Heteromera*. Besides the metallic blue *Autocrates ænea*, Westw., of the Himalayas, *Trictenotoma Grayi*, Sm., occurs in South India, *T. childreni*, Gray, in the Khasis, and *T. mniszechi*, Deyr., in the Himalayas (Ann. Soc. Ent., France, 1875, p. LIX). Westwood (Cab. Or. Entom., 1847) figures *T. childreni*, Gray, *T. templetonii*, Westw., and *T. ænea*, Parry, and discusses the characters on which he separates these as a distinct family.

PHYTOPHAGA.

The tendency in classification at present is to a complexity of families, especially in *Coleoptera*, and while this is possibly justified from structural characters, it is certain that there is not as yet sufficient material available to define so many families; to all but the student of systematic entomology, the old broad families embracing insects allied in structure and habits are still the most natural and the simplest in actual working. We have accordingly adhered to the three families composing this series, the plant-feeding beetles; the Bruchids are seed-eating, the Chrysomelids live on green plants, the Cerambycids in the woody tissues of plants. This makes but three families and to place an insect in one of these three, places it as far as these habits go. Modern classification makes two or more of Bruchids, 13 or more of Chrysomelids, and two of Cerambycids, with a great tendency to make more.

The series is distinguished by the apparently four-jointed tarsi usually with at least one joint expanded and pubescent beneath, and the absence of a prolongation of the head as a rostrum. It is, in practice in the field, a peculiarly homogeneous series, the three families sharply distinct in all our common species. It is easy to put a *Scelodonta* down as a weevil however, though it has no distinct beak, because it resembles the leaf-eating smaller weevils in which the rostrum is not much developed and actually the limits of these two series do, as they should, shade into each other.

BRUCHIDÆ.—*Pulse Beetles.*

Small thickset beetles, the hind legs thickened, the prosternum vertical. Tarsi apparently four-jointed, pilose below, third joint bilobed. Antennæ eleven-jointed, often dentate or pectinate.

These small beetles have a characteristic facies which distinguishes them from other *Phytophaga*, but confuses them with *Anthribidæ*.

Fig. 223.—BRUCHUS CHINENSIS; EGG ON PEA, × 2; LARVA, × 12; IMAGO, × 10.

They are small, rarely exceeding one-quarter of an inch in length Their colours are sombre and inconspicuous, the body clothed with hairs. The head is small with a blunt rostrum, with short antennæ, often pectinate or serrate. The prothorax is well developed and accurately adapted to the mesothorax. The elytra are truncate, not covering the pygidium. The legs are short, the hind femora thickened. The abdomen is peculiarly thickset, giving the beetles a characteristic appearance.

These beetles are commonly reared from the seeds of leguminous plants. The beetle lays a number of small oval eggs, of a yellow colour; they are apparently laid in a semi-liquid condition, so that they adhere to the seed or pod and then harden, (they have a curious resemblance to Scale insects of the genus *Asterolecanium*). In the field they are laid in the pod and in the case of *Bruchus obtectus*, Say, they are often dropped loosely among the seeds (Chittenden). These eggs hatch, the larva eating through the inner wall of the egg-shell into the seed-coat and so into the seed itself where it feeds upon the tissues. The larva is white, curved and with a close resemblance to larvæ of weevils. Riley showed that, in the first instar, the larva is provided with three pairs of incomplete but functional legs, as well as a series of thoracic spines and a pair of toothed thoracic plates which enable the larva to bore into the pod or seed and so establish itself. When it has reached the seed, it moults and appears without the legs and the thoracic plates. As a rule, one seed, if full grown, is sufficient for a larva (or for many), but in the case of growing seeds the larva may eat so fast that the seed cannot develop and it has to move into a fresh one. When full grown, the larva cuts a disc in the seed-coat almost through and pupates below. When the beetle is ready to emerge, the disc readily opens, letting out the perfect insect. In *Caryoborus gonagra* the larva comes out of the seed and pupates outside in an excrementitious cocoon. The beetles are found in the field visiting flowers of leguminous plants or on the leaves of plants. They appear to take no food, as do the household species also. There is no information available on the question of the hibernation, etc., of the free-living species. None are pests to crops in India but the household species are destructive to stored pulse. Bruchid larvæ are the hosts of Chalcid parasites, which lay their eggs in the larvæ in the seeds. These insects are sometimes found in abundance in infested pulse.

The family is not a large one and, with the exception of the cosmopolitan household species, is principally found in the tropics. No list of Indian species exists and there is room for work on this family. Including cosmopolitan insects, 37 species are known from India and the number of species recorded from the plains is a very small proportion of those there are. The family is divided into two tribes : *Urodontides* with clubbed antennæ represented by *Urodon* in Ceylon; *Bruchides* with dentate or pectinate flattened antennæ. The following six species of *Bruchus* include the known or recorded species found in stored pulse in India :—

(1) *B. chinensis*, Linn., in *Pisum sativum* (peas), *Dolichos lab-lab* (val), *Dolichos biflorus* (moth), *Cicer arietinum* (gram), *Cajanus indicus* (pigeon pea), *Ervum lens* (lentil), *Vigna catjang* (cow pea).

(2) *B. affinis*, Froll., in imported beans.

(3) *B. emarginatus*, All., in peas (*Pisum sativum*).

(4) *B. quadrimaculatus*, Fabr., in peas (*Pisum sativum*) and in "beans."

(5) *B. pisorum*, Linn., in peas (*Pisum sativum*).

(6) *B analis*, Fabr., from cow pea (*Vigna catjang*).

Chittenden (Yearbook, Agric. Dept., U. S. A., 1898, p. 240) states that *B. obtectus*, Say, also occurs and it is likely to be found The life-histories of *B. pisorum*, *B. chinensis*, *B. obtectus* and *B. quadrimaculatus*, are fully described by Chittenden (loc. cit.). Short accounts occur in most general works on entomology. We are not aware that any of these species have been reared in India, except from harvested seed ; elsewhere the beetles lay eggs in the pods on the plant, as well as on the stored seeds, but we have seen no instance where Bruchids attacked any cultivated pulse in the field, though many other insects are known which do so. We may presume either that these cosmopolitan species originated elsewhere or, if native to India, breed in wild plants; a very small number of species have been bred from wild leguminous pods in India, and these species do not occur among them. We believe all our destructive Bruchids to have originated elsewhere.

Caryoborus gonagra, F., is a larger grey-brown insect, found in tamarind seeds and is the commonest free-living species in India. The larva when full grown emerges from the seed and prepares a cocoon of very coarse and gummy white threads, within which it pupates; this cocoon is oval and attached to some part of the seed or pod. The imago feeds on the leaves of the tamarind tree. The life-history was described in a German paper by Elditt in 1860, he having reared it from pods of *Cassia* obtained from India (Indian Mus. Notes, III, p. 15).

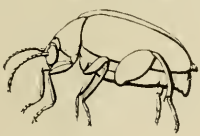


Fig. 224.—CARYOBORUS GONAGRA, × 4.

CHRYSOMELIDÆ. *Leaf-Eating Beetles.*

Antennæ moderately long, their insertion distinct from the eyes. Upper surface bare.

The *Chrysomelidæ* are readily distinguished as they are *Phytophaga* without long antennæ as in the *Cerambycidæ*, and without the peculiar form and hind legs of the *Bruchidæ*. They are also neither bred from pulse nor in trees and are on the whole a distinct and easily re-

Fig. 225.—AULACOPHORA EXCAVATA, × 3.

Fig. 226.—AULACOPHORA EXCAVATA, × 3.

cognised family. Individual species approximate on the one hand to the *Bruchidæ* and on the other to *Cerambycidæ*, and there is no really sharp line of distinction, but the very great majority are clearly recognisable. These beetles comprise a very large and varied assemblage, including a greater number and variety of forms than any other family of *Coleoptera*. All are herbivorous, the beetles are smooth, not being hairy as a rule or at least without the pubescent hairiness of Bruchids and Cerambycids. All are diurnal. It is impossible to discuss them as a whole and would serve no useful purpose ; they are divisible into a large number of divisions, some of which are extremely characteristic and without going deeply into the dry details of classification, we can readily distinguish the more important of these.

There are first the *Eupoda*, in which the prothorax is much narrower at the base than the elytra. The *Camptosomes* have one distinctive character, the lines of the abdominal segments not going straight across but curving, making the middle of each segment narrower than the sides, and leaving a large space in the middle for the fifth.

The *Cyclica* have not the above characters, but the prothorax is often a little narrower than the elytra and usually has the edges distinct, not rounded off.

PLATE XXII. GALERUCELLA RUGOSA.

Fig. 1. Eggs on leaf. x 3.
,, 2. Larva on leaf. x 3.
,, 3. ,, 48 hours after hatching. x 20.
,, 4. ,, full grown. x 6.
,, 5. Pupa. x 8.
,, 6. Female. x 8.
,, 7. Male. x 8.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2
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7

Finally the *Cryptostomes* are very characteristic, the head being bent down so that the mouth is below, the antennæ inserted close together at the front of the head. They include the very distinct *Cassidinæ* in which the head is hidden, and the *Hispinæ*, which have a characteristic outline and are often spiny. Actually if a Chrysomelid has not the narrow prothorax, nor the curved ventral abdominal sutures, nor the deflexed head and the contiguous antennæ, it must be one of the *Cyclica*, the largest division of this large family.

Prothorax narrowed, rounded. Head constricted behind eyes, produced anteriorly. *EUPODA.*	*Sagrinæ.* *Donaciinæ.* *Criocerinæ.*	
Ventral abdominal sutures curved. *CAMPTOSOMES.*	(Megascelinæ). *Megalopinæ.* *Clytrinæ.* *Cryptocephalinæ.* *Chlamynæ.* (Sphærocarinæ).	
Prothorax a little narrowed but laterally acute. *CYCLICA.*	(Lamprosominæ).	
	Antennæ separate.	Feet bilobed. *Eumolpinæ.* Feet simple. *Chrysomelinæ.*
	Antennæ approximate, elytra soft. *Galerucinæ.* (Trichostomes).	Posterior coxæ grooved. *Halticini.* Posterior coxæ not grooved. *Galerucini.*
Antennæ approximate Head deflexed. *CRYPTOSTOMES.*	Head exposed. *Hispinæ.* Head concealed. *Cassidinæ.*	

The following is a synopsis of the larval habits as far as they are known :—

Sagrinæ.—Roots of trees.

Donaciinæ.—In aquatic plants.

Criocerinæ.—On aquatic plants above water, or on land plants with excrement over.

Camptosomes.—In cases, on plants or in ants' nests.

Eumolpinæ.—In roots or in soil.

Chrysomelinæ.—Free, leaf-feeding.
Halticini.—Mining in leaf or plant, or tree.
Galerucini.—Free, exposed, or in underground parts of plants.
Hispinæ.—Mining.
Cassidinæ.—Exposed, carrying excrement or having anal process.

A great number of species have been described both in the older publications of Hope, Oliver, Illiger, Baly (Chennell's Assam Collection, etc.), and more recently by Jacoby, whose descriptions of the Cardon and Andrewes' collections add many new species (Ann. Soc. Ent., Belge, 1895, p. 252; 1897, p. 420; 1898, p. 185; 1903, p. 80; 1904, p. 380). The late Mr. Jacoby's volume of the Fauna of India deals with the family as far as *Eumolpinæ*.

Eupoda.—The *Sagrinæ* are the first sub-family, with five species of *Sagra* in India. These are characteristic insects, of large size and brilliant colouring, of which the life-history is almost wholly unknown. The oval brown cocoons of *S. boisduvallii* were found at Buitenzorg in the hollow root of a tree (Rhizophora) in 1862, (Nederl. Tijdschrift V, p. 97), and it is known that in Java, *Sagra Buqueti* lays eggs on the bark of a tree, the larvæ living in the tree and causing gall-like hypertrophy of the wood. The beetles are found upon plants, *Sagra femorata*, Dy., a metallic green insect, being the common species in India, found in forests.

Donaciinæ are a small group, of which four species are Indian. The larvæ of *Donacia* live in aquatic plants, the beetles in water or in the air. None appear to have been reared in India. *Donacia æraria*, By., is found in the plains, though not commonly. *Hæmonia*, though not recorded as Indian, is also known from the plains.


Fig. 227.—Donacia recticollis.

Criocerinæ.—A larger group with 105 Indian species of which 80 are included in *Lema* and 19 in *Crioceris*. The Ceylon forms are distinct and are treated by Jacoby as Malayo-Australian, only one occurring apparently also in South India.

The life-history of none of these is definitely recorded *Crioceris impressa*, F., was reared by de Niceville on kham-alu (*Dioscorea alata*)

Fig. 228.—Lema signatipennis.

Fig. 229.—Crioceris fasciatipennis.

(Indian Mus. Notes, V, p. 134). In general the larvæ are either semi-aquatic, living on the leaves of aquatic plants in cases made of their own excrement, or live on plants on land in the same way. These larvæ have the anus on the upper surface so that as their excrement is voided, it covers the body and makes a protective covering. They are extremely characteristic in appearance and are likely to be found on aquatic plants. The beetles are common in grass and on plants: they are usually brightly coloured and warning: several species are common, *Lema coromandeliana*, F., and *Crioceris impressa*, F., being widely spread in the plains.

Camptosomes.—A large division divided into several sub-families, some of which are not represented in India. The *Clytrinæ*, *Chlamynæ* and *Cryptocephalinæ*, are the most common, with many species of small cylindrical beetles, coloured often in orange or yellow and black. The larvæ of *Cryptocephalus* are of peculiar form and live in small cases formed of their excrement: they are white larvæ, with the abdomen tapering and doubled back under the body so that the apex reaches the thoracic legs; the case made is a small oval one, in which the larva lives with the head and thorax at the opening, the anus in such a position that the excreta can be ejected. (In a Himalayan species living on Artemisia, the cases very closely resemble the excreta of the larger grasshoppers and this is possibly a protective device.) The cases of *C. corrosicollis*, Jac., are common on long grass and those of *C. Pusaensis*, Jac., on "Jhau" (*Tamarix gallica*), and the little larvæ can be readily reared. Donnisthorpe has described the life-history of the European *Clythra quadri-punctata*, L., in Trans. Ent. Soc., London., 1902, p. 11. We reproduce his summary :—

Fig. 230.—CRYPTOCEPHALUS PUSAENSIS. LARVA, IN AND OUT OF CASE, DIAGRAM OF CASE, IMAGO.

"To recapitulate the foregoing facts : The life-history of *Clythra quadri-punctata* is briefly as follows :—When the beetle has emerged from the pupa in the nest, it escapes with caution 'feigning death,' and holding on to twigs, when attacked by the ants. It then seeks its mate, and copulation takes place. The beetles are generally to be found on birch shrubs, the young shoots and leaves of which they eat, biting the top shoots right through. The female then seeks a tree or shrub above or close to a nest of Formica rufa, and drops the eggs on to the ground beneath. The eggs are covered by a case, or capsule, which is placed around it by the female, and consists of her own excrement. This covering is placed in position with the posterior tarsi, the egg being held in the depression of the abdomen. The covered egg looks exactly like a small bract, and is exceedingly like the end of a birch catkin. The ants pick up the covered egg and carry it into the nest. The young larva, which hatches in about twenty-one days, uses the egg-case as a nucleus on which to build the larval case ; thus very young larval cases have the egg-case still attached to their posterior end. The egg-case has a threefold *raison d'être*—to protect the egg and newly hatched larva, to make the ants believe it is a bit of useful vegetable refuse, and to give the larva a foundation on which to start the larval case. When the larva case grows larger the egg-case breaks off and the larva fills up the hole thus formed with the same material as that with which it builds the rest of the case. This material consists of its own excrement mixed with earth, which it prepares with its mandibles. To enlarge the case the larva removes particles from the inside, and plasters them on to the outside. The larva feeds on vegetable refuse in the nest. When changing its skin it fastens the case to some object in the nest. When full-grown it fastens the case to a piece of wood or twig, and turning completely round, changes to a pupa, facing the broader end of the case. When hatched the beetle gets out of the case at this broader end, by biting a circle round inside it, thus forming a cap, which it forces off."

The student should refer to this account and read the bibliographical remarks especially. There is nothing to show that our species have this habit, but it is worth bearing in mind when searching ants' nests for insects.

The *Megalopinæ* include *Temnaspis* (4), and *Colobaspis* (4), rare insects found in the hills. The *Clytrinæ* are listed by Jacoby and

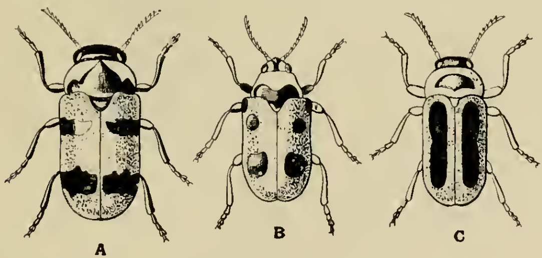


Fig. 231.—A. DIAPROMORPHA PINGUIS, B. ASPIDOLOPHA THORACICA, C. GYNANDROPHTHALMA SUBDIVISA.
(*After Jacoby.*)

Clavareau in Genera Insectorum, with 90 species from the Indian region of which less than fifteen are found in India proper. Jacoby describes 125 species in the Fauna of India. *Titubœa bimaculata*, Jac., *Clytra succincta*, Lac., *Clytra conformis*, Lac., *Coptocephala nair*, Lac., and *Diapromorpha turcica*, Fabr., appear to be common species of the *Clytrides*, and *Cryptocephalus senarius*, Suff., *Cryptocephalus sehestedti*, Fabr., *Cryptocephalus corrosicollis*, Jac., among *Cryptocephalides*. Of the latter genus nearly fifty Indian species were recorded forty years ago and a larger number have been since described. *Exema*, *Chlamys* and *Hymetes* represent the *Chlamynæ*, which are almost wholly American.

Cyclica.—The largest division with the greatest number of species. There are three main sub-divisions of which two, *Eumolpinæ* and *Chrysomelinæ*, have the base of the antennæ separated widely, whilst the third, *Galerucinæ*, has the bases of the antennæ drawn together though not touching. The latter are separated by Jacoby under the term *Trichostomes*. In all, the beetles are of small to moderate size, usually brightly coloured. They constitute the immense majority of the family, the typical leaf-eating beetles. Colours are usually warning, bright blue, bright red, a great variety of tints.

Eumolpinæ.—Practically nothing is on record as to the life-histories of our forms, but the larvæ probably are miners in roots or live in the soil feeding on roots. Jacoby records 414 species from the Indian region. *Scelodonta* includes small dull coloured beetles

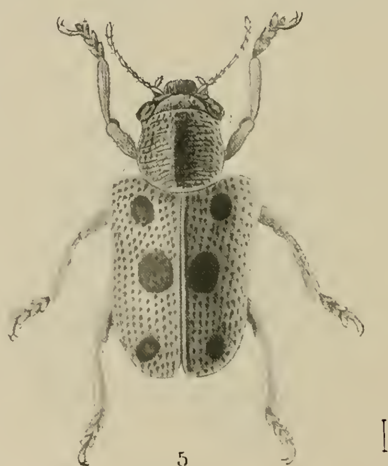


Fig. 232.—Scelodonta strigicollis.

found abundantly on grass and on plants. *S. strigicollis*, Mots., is common on grape vines and where this plant is cultivated, is a serious pest. The late Mr. Jacoby wrote in the Fauna that this species could no longer be recognised, but he labelled a series of specimens from the Pusa collection with this name and omitted to record the localities in the volume. (It will probably be found to have a similar life-history to its ally the American grape vine rootworm, *Fidia viticida*, whose life-history has been described.) *S. vittata* is a larger form, found on Panchanjuria (*Vitis trifolia*), which shams death extremely effectively and falls to the ground on its back, the brown lower surface and white patches making it very difficult to distinguish.

Colasposoma is a large genus of moderate-sized metallic-coloured beetles, *C. metallicus*, Clk. and *C. ornatum*, Jac., being common in the plains. *Corynodes peregrinum*, Fuesl., is a deep blue beetle, very abundant feeding on Ak and other wild plants and found throughout the plains. *Nodostoma*, *Nodina*, *Heteraspis*, *Pseudocolaspis*, *Colaspis* and *Colaspoides*, are the other common genera.

Fig. 233.—Larva of Corynodes peregrinus. × 6.

Pachnephorus bretinghami, Jac., and *P. impressus*, Ros., take the place in India that *Myochrous* takes in America, as being destructive to the young shoots of cane and cereals: they are small dust-coloured beetles, with the appearance of weevils, found in numbers in the expanding leaves of the young cane shoots which they destroy; hidden in the heart of the shoot, they are difficult to find and usually escape observation, the destruction of the young shoot being assigned to some other cause.

Chrysomelinæ.—Though these beetles occur in all parts of India, very little appears to be known beyond the mere description of such species as have reached European collections and been described. Nor is there any complete list at present available and the recorded Indian species are buried in a voluminous and scattered literature. It is the least represented division with less than 70 recorded species. We are not aware of any species being of economic importance to agriculture in India and the larvæ apparently feed wholly upon trees, uncultivated shrubs and herbs. The group is characteristic of the temperate regions and only a few come into our limits, the majority being Himalayan. A large number of larvæ of exotic species have been described and these are known to feed openly upon the leaves of plants as do the *Galerucini*. *Phædon brasicæ*, Baly., is a steel-blue beetle found feeding upon mustard in Golaghat (Indian Mus. Notes, Vol. III, p. 44). *Plagiodera* is represented by several species and *Lina* is represented by the European *L. populi*, Linn., which occurs in the Himalayas. *Chrysomela* includes a variety of moderate-sized beetles, some of bright colours, the commonest plains species of a dull black colour; two are abundant, the spotted *Chrysomela*, *C. guttata*, Geb., and the unspotted species *C. Pascœi*, Jac. *Paropsides hieroglyphicus*, Gebl., breeds freely on pear trees in the hills and is a pest in Shillong.

Galerucinæ. Halticini.—A large group with over 150 described Indian species and many more to be recorded. *Podontia* is common in the hills and moister plain areas, *P. affinis*, Grond., and *P. 14-punctata*, Linn., being the familiar species. The latter is recorded as breeding in Calcutta on *Spondias mangiferæ*; the larva is covered in excrement and pupates in a rough cell of earth in the soil, the imago appearing yearly in August (Indian Mus. Notes, Vol. IV, p. 68). *Clitea picta*, Baly., is a small oval brown and black species found feeding, as an imago, on the leaves of Bael (*Aegle marmelos*). The beetles jump freely as do most of this group. The larva is found boring in the shoots of this plant, the slender twigs being tunnelled down the centre but little harm being done. The

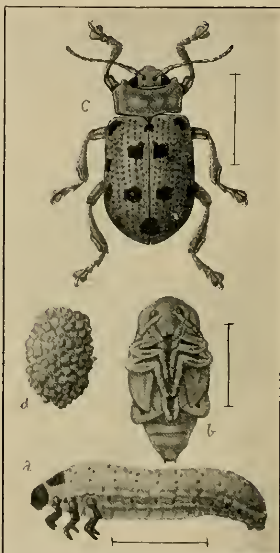


Fig. 234.—Podontia 14-punctata. (I. M. N.)

PLATE XXIII.—Phidodonta Modesta.

Sugar-cane Hispa.

Fig. 1.	Eggs ...	A. B.	A day after laying.	
		C.	Before hatching.	
,, 2.	Newly hatched larva. x 3.			
,, 3.	Larva in mine in cane leaf.			
,, 4.	Full-grown larva. x 3.			
,, 5.	Pupa ...	A.	Ventral aspect.	x 3.
		B.	Dorsal aspect.	x 3.
		C.	Just before emergence.	x 3.
,, 6.	Imago ...	A.	Just after emergence.	x 3.
		B.	15 minutes after emergence.	x 3.
		C.	30 ,, ,, ,,	x 3.
		D.	60 ,, ,, ,,	x 3.
,, 7.	Imago, to show disposition of spines.			

1


2


3


4

5


7

6

larva is soft, whitish with few very short hairs, the head brown, the tiny round spiracles on the dorso-lateral line. Behind the head is a distinct prothoracic shield, and over the anus is a flat black plate with short hairs round ; this plate is at an angle to the long axis of the body, facing dorsally and posteriorly and may be for the purpose of enabling the larva to exert pressure by placing this against the wall of the tunnel. *Chætocnema basalis*, Baly., is the flea beetle of rice, a small active beetle that leaps readily. This and other genera include the common flea beetles known as destructive to crops in all countries. Several species are found in Indian crops attacking wheat, sann hemp, mustard and brinjal. The larvæ of these small beetles are miners in the tissues of the plant. *Luperomorpha weisi* is recorded as attacking mango trees in Purulia (Indian Mus. Notes, Vol. V, p. 125). *Haltica cyanea*, Web., is a common steel-blue beetle of moderate size. It breeds freely in the rains and until December, the black larva feeding on a very common weed, *Ammannia rotundifolia* (*Lythraceæ*) which comes up abundantly after the rains. This species is curiously plentiful in some years, but is very localised and swarms have been observed clustered in a patch in a single field ; they are gregarious when abundant, a patch of ground sometimes black with them. The winter is spent normally in pupation in the soil, the beetles emerging in March and waiting till food can be obtained. This is one of the perfectly harmless insects so often reported as injurious, owing to its presence in large numbers in crops. Its ally, *H. cærulea*, is the prey of the bug *Zicrona cærulea* as is probably also this species (see Pentatomidæ below).

Fig. 235.—HALTICA CYANEA LARVA, × 4.

Galerucini.—Over 250 species are recorded and this number will probably be doubled when the Fauna volume comes to be prepared.

Oides occurs plentifully in forest localities and occasionally in the plains in the form of *O. bipunctata*, F., an oval orange beetle with a black blotch of varied size on each elytron. The larva is yellow and feeds on the leaves of the common wild creeper *Vitis trifolia* ; when full-grown it pupates on the leaf under a few coarse threads.

Aulacophora is the commonest beetle genus in the plains with three common species. *A. foveicollis*, Kust. (= *abdominalis*, G. et H.), is

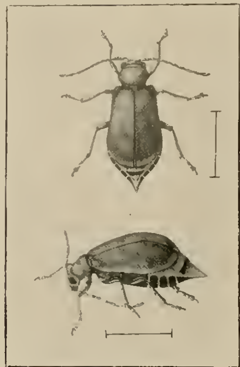


Fig. 236.—AULACOPHORA FOVEICOLLIS. [I. M. N.]

Fig. 237.—MIMASTRA CYANEA.

deep orange above, while *A. excavata*, Baly., has the elytra deep blue, *A. atripennis*, Fabr., the elytra black, and *A. downesi*, By., the elytra black with a yellow basal patch. The last is rarer than the first three. There are a number of species of this genus and the whole classification of these beetles is in confusion. Though *A. foveicollis*, Kust., is extremely common, nothing is known of its life-history and all attempts to solve the problem hitherto have failed. It is a destructive insect to young cucurbitaceous plants, eating the leaves. (The larva of its ally *Diabrotica* in America, mines in the stem a little below ground, while the beetle behaves as our species does.) *Hoplasoma* also includes several common species whose life-histories appear to be unknown. *Mimastra cyanea*, Ho., is principally a defoliator of forest trees and occasionally occurs in numbers. The beetle emits an acrid yellow fluid from the head. Several other species are common in jungle but not in cultivated areas. We figure all stages of *Galerucella rugosa*, Jac. (Plate XXII), whose larva feeds on *Polygonum ;* this genus and *Haplosonyx* are abundantly represented even in the plains. Another *Galerucella* is destructive (in its larval and imaginal stages) to the Waternut or Singhara crop (*Trapa bispinosa*), destroying the leaves of this valuable plant.

Hispinæ.—Cryptostome beetles, in which the antennæ are set closely together on the front of the head, but without the produced

Fig. 238.—Gonophora bengalensis.

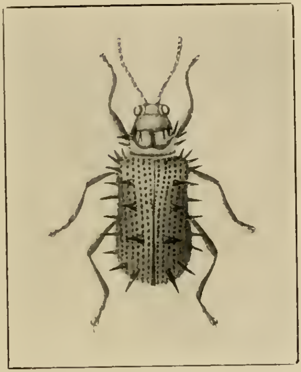


Fig. 239.—Hispa ænescens, × 7.

prothorax covering the head, which characterises the next sub-family.

These beetles have a characteristic facies of their own, being usually flattened, the sides of the elytra parallel, the prothorax narrow, the integument either much pitted in lines or with regularly arranged spines. The antennæ project in front of the small head; the legs are short, the elytra often have truncate ends. The colouring is varied, browns, metallic blacks and occasionally brighter metallic tints predominating. Some species are evidently cryptically formed and coloured, escaping notice when resting motionless on a young leaf tightly pressed to the surface.

The life-history of several species in India has been worked out (Plate XXIII). The essential features are that the egg is laid in the tissues of a leaf or plant, the resulting grub mining in the tissues, and producing a "blotch" mine. Moults take place inside the mine and the larva is much flattened, though in some cases provided with legs. Pupation takes place in the leaf. The beetles are similar in appearance in both sexes. So far as known, all *Hispinæ* have such a life-history and the larva lives concealed in the tissues of plants. Hibernation and other periods of rest take place in the imago state.

One species, *Hispa æneseens*, By., is a serious major pest, and another *Leptispa pygmæa*, By., occasionally rivals it. Others are minor pests or live in uncultivated plants. Hymenopterous parasites are the only known check on the increase of these insects. H. Donckier de Donceel's Catalogue (Ann. Soc. Ent. France, 1889, LXVIII, p. 540), enumerates 111 Indian species, chiefly of the following genera :—*Callispa* 14, *Anisodera* 12, *Gonophora* 9, *Downesia* 10, *Platypria* 7, *Hispa* 42. A few, including plains species, have been described since. Gestroi's papers (Ann. Mus. Civ. Genova). Baly's catalogue of *Hispidæ*, and Weise's recent papers (Deutsche Entomologische Zeitschrift) describe the majority of our species.

Fig. 240.—Leptispa pygmæa.
(I. M. N.)

Leptispa pygmæa, Baly., is a narrow steel-blue species destructive to rice in Malabar and occasionally found elsewhere in the plains. Its life-history is unknown. *Amblispa lævigata*, Guer., is a spineless black insect found on the leaves of the high grass in Canara and the Himalayas. *Gonophora bengalensis*, We., is a pretty yellow-brown species with black spots found abundantly during the rains in submontane localities.

Platypria includes *P. Andrewesi*, We., described from specimens reared from ber (*Zizyphus jujuba*) and common in widely spread localities in the plains. The larva does not remain in one mine but moves about, eating into the leaf, eating out a kind of pocket and then emerging to commence a fresh pocket. The larva (fig. 241) is flat, the head large and hard, with short antennæ and a lateral cluster of ocelli; the prothorax bears a dorsal and a ventral shield ; the segments are produced laterally and bear a terminal backwardly-curved process ; the spiracles are on the dorsum ; the legs are well developed and the larva runs actively; the abdomen terminates in a flat chitinous plate with a lateral process, the anus being ventral. It pupates in a special pocket in the leaf. The pupa is similar, but the fourth abdominal segment is

Fig. 241.—Platypria andrewesi. Larva on ber leaf; old and pupal mines, × 3.

drawn out laterally into a strong backwardly-directed process on the dorsum.

Fig. 242.—Platypria andrewesi.

P. echidna, Guer., is a common form in the Western Ghauts and Nilgiris. *Hispa* (*Phidodonta*) *modesta*, We., has been bred in sugarcane: its life has been fully described (Mem. Agri. Dept. Ent.), as has also that of *Hispa ænescens*, By. This last is a very important pest in rice-growing tracts and may be distinguished by the form and position of the prothoracic spines, the small tooth at the lower edge of the basal antennal joints, the absence of spines on the antennæ above and the metallic black-green colour. The discrimination of Hispids is not difficult if attention be paid to such points, but the student may be cautioned against hasty identification without very careful examination.

Cassidinæ.—Tortoise Beetles. The characteristic of these beetles is the flattening of the body and the extension of the pronotum over the head. The form is oval or rounded, the outline of the extended prothorax continuous with that of the elytra and giving the insect the appearance of a tortoise. The colouring is either dull green or dry grass colour, or is peculiarly brilliant, the living insect having a glittering golden hue with a ground tint of red, pink or green. In appearance these are perhaps the most striking of all insects, living jewels of the most delicate beauty. The object of this colouring is not clear, though the dull green ones are evidently cryptic, in conjunction with their form and immobile attitude on the plant.

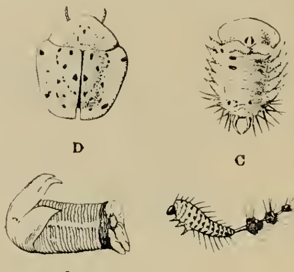


Fig. 243.—Aspidomorpha miliaris, A. Egg mass, B. Larva, C. Pupa, D. Imago.

Few details are available as to the life-history. Eggs are of two types, single eggs laid on the leaf (*Coptocycla*), egg masses containing many eggs (*Aspidomorpha*); larvæ are flattened, with processes bearing spines, with three pairs of legs and having an anal process which can be turned over the dorsum and bears the dried excreta. We figure such a larva (Plate XXIV). These larvæ are found on the leaves of their foodplants and, in the moist tropical zones where they are of large size, they are extremely striking. Their food is the epidermis or tissues of the leaf and they are nocturnal in habit as a rule. Pupation takes place on the leaf and the processes on the body are a marked feature of these

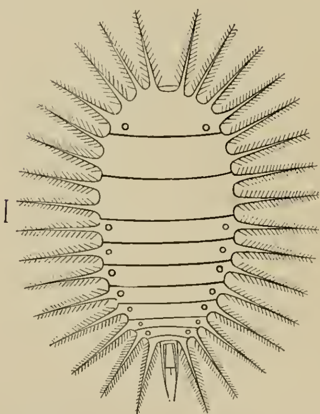
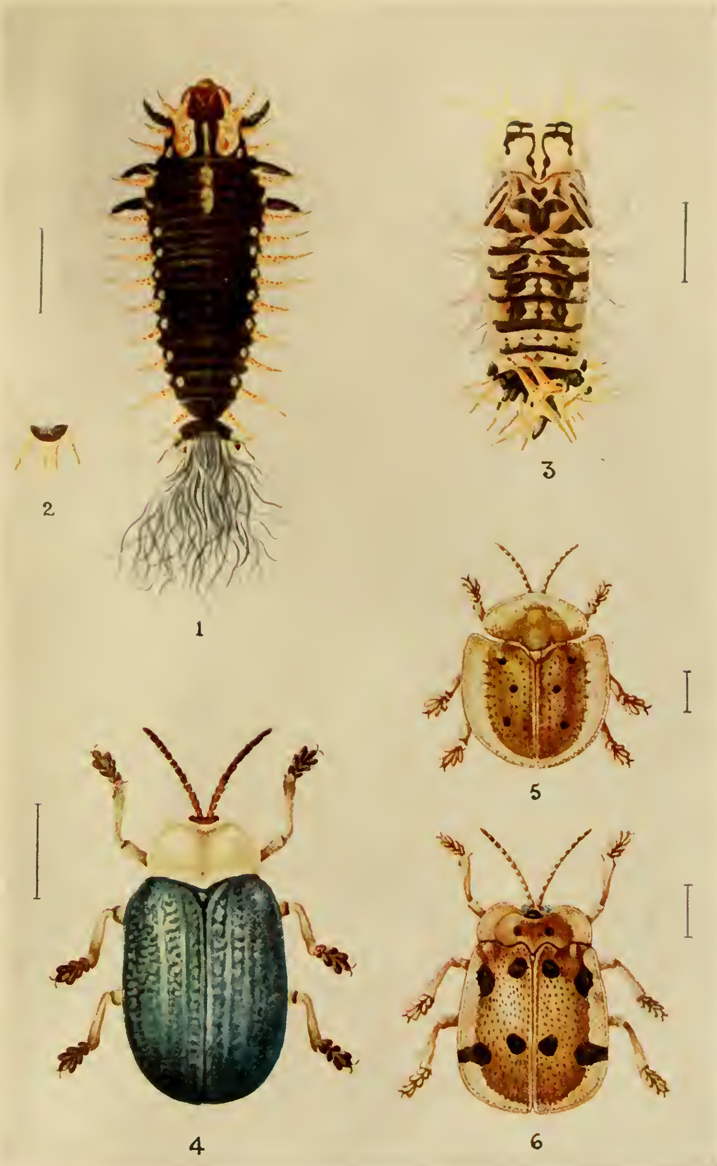


Fig. 244. Larva of Metriona circumdata.

PLATE XXIV.—Cassidinæ.

Fig. 1. *Calopepla hexagona*, larva from above, with its attached moult.
,, 2. Anal segment with the moult removed.
,, 3. Pupa, from above.
,, 4. Beetle.
,, 5. *Coptocycla sexpunctata.*
,, 6. *Prioptera* 10 *maculata.*



CASSIDINAE.

insects. None can be reckoned as pests since none occur abundantly; *Convolvulaceæ* are their food especially, several feeding on sweet potato (*Ipomœa batatas*) and on garden creepers. The majority breed only in the rains since there is then only a sufficiency of food. Apparently the imago goes into hiding for the intervening seasons, but accurate data on this and other points in the life history are not available.

The species are described by Bohemann in his Monograph, dated 1850-1862, and a number of species have been described since. *Hoplionota* (6), *Prioptera* (8), *Calopepla* (4), *Epistictia* (3), *Chirida* (4), *Aspidomorpha* (14), *Cassida* (26), *Laccoptera* (4), *Coptocycla* (13), are the genera. The larger and more brilliant species of *Calopepla*, *Aspidomorpha*, etc., are wholly hill or forest forms, and only the duller green *Metriona* and *Coptocycla* and the smaller *Aspidomorpha* occur in the plains. *Aspidomorpha miliaris*, Fabr., was reared in Calcutta on Convolvulus; it commonly attacks sweet potato also. The life-history has been worked out in the Philippines by W. Schultze, who figures all stages. (Philippine Journal of Science, III, p. 261.) The duration from the egg to the emergence of the adult was 38 days, there being four larval moults before the pupal moult. He remarks that the larvæ feed and pupate in groups. The student should consult this paper, as also Muir and Sharp's (Trans. Ent. Soc., London, 1904, p. 1), and Muir and Kershaw's (Loc. Cit., 1907, p. 249), for interesting notes on the eggs and transformations of this group.

Metriona circumdata, Hbst., is the commoner green form breeding on the same plant, as also does the common six-spotted *Chirida sexnotata*, F., both of these laying eggs singly on the leaf. *Cassida dorsonotata*, Boh., is common in the moister areas, while *Coptocycla varians*, Hbst., is found in abundance breeding on the wild Ipomœa on sand dunes (*Ipomœa pes-capræ*); the single oval egg is laid on the leaf and is fastened with short brown filaments from the side of the egg on to the leaf; the green larva is flattened and very difficult to see, resting by day motionless on the plant.

Collecting.—The beetles are easily collected and preserved; their food-plants should in all cases be noted. Whenever possible they should be kept alive with food till eggs are obtained and the larvæ studied. This is not always possible and the life-histories of some of our commonest species still remain unknown. For this reason every larva found deserves careful rearing; larvæ are preserved in formalin. The student may be cautioned against hasty identification of specimens that look extremely alike, more especially in the *Hispides*. There is no group that requires more careful scrutiny before pronouncing two specimens to belong to the same species, and this is of great importance in the economic species. There is also no group that offers such scope to the inquirer, especially in the bionomic aspect. To the naturalist living in a forest or hill district there is immense scope and the fauna of any one place will take years to procure and work out properly.

CERAMBYCIDÆ.—(*Longicornia*).

Antennæ long, their bases partly encircled by the eyes. Upper surface pubescent.

This large family of large insects is readily recognisable from their general form and their long antennæ. They range from under half an

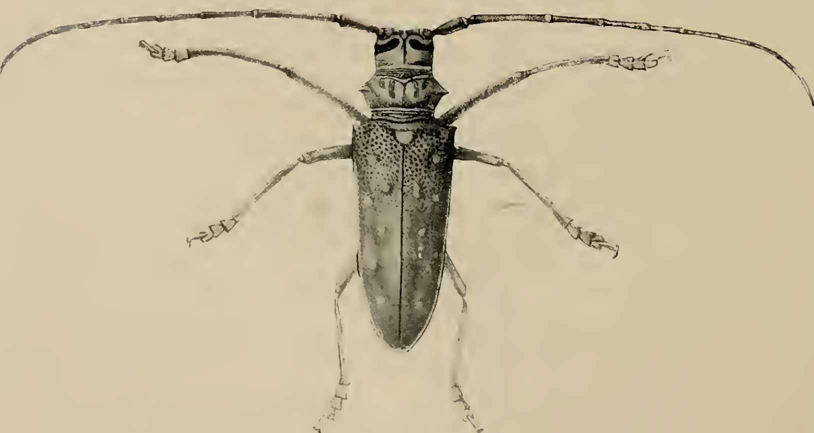


Fig. 245.—BATOCERA RUBRA.

inch to over one inch in length, the body robustly built and the integument hard. The colours are sombre or bright, many being cryptically coloured, others exhibiting Mullerian mimicry, imitating the colouring of warningly coloured insects.

The head is distinct and well developed, with large eyes and powerful trophi, the heavy biting mandibles being prominent. Antennæ are long, dentate in some forms, in others with tufts of hair. The prothorax is powerful, accurately adapted to the body. The elytra cover a pair of ample wings and are closely applied to the abdomen. In some cases they are abbreviated or narrowed and do not wholly cover the abdomen. The legs are long, the tarsi pubescent. Males are similar to the females, the former having larger mandibles and distinctions in the antennæ and forelegs and, as a rule, the antennæ are longer. They stridulate by moving the prothorax against the body, the posterior edge of the prothorax rubbing on a corrugated surface on the mesothorax and so producing an audible squeak.

Fig. 246.—Cœlosterna scabrata larva.

The life-history, so far as known, is uniform throughout the group. The females lay large eggs singly in cracks of the bark of trees or on bamboos. These eggs hatch to legless larvæ which tunnel in the hard woody tissues, eating out large galleries in which they live. The larva is characteristic in form, generally similar to that of Buprestidæ but with the abdomen more developed and the swollen prothorax less marked. The head is small, with powerful biting mandibles. The thorax is slightly swollen, with a broad dorsal plate, without legs; the abdomen often has dorsal plates on each segment. The pupa is found in the tunnel, in a chamber formed by closing up the tunnel at its head and tail, or in a cocoon of white hard material derived from the excrement. The length of the life-history is known in few cases but in species investigated elsewhere, has been found to be very long, as much as three years being spent in the larval stage. This is due possibly to the lack of nutrition in the food of the larva, the dry woody material not containing much nutriment; a great amount of it must pass through the alimentary canal in order to supply the necessary food and a long period is apparently consumed in obtaining this. The larval galleries are often very large and extend to a great length through the trunks of trees.

The family is a very large one, principally confined to forest areas and of no importance in Agriculture except in special cases. Few are found in the cultivated plains and the bulk of the species are purely forest haunting insects. The Indian species are being described by Gahan in the Fauna of India.

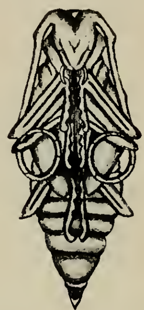


Fig. 247.—BATOCERA RUBRA PUPA.

The family is divided into two sub-families :—

Cerambycinæ.—Head in front oblique or sub-vertical, last joint of palpi not pointed in front. Fore tibiæ not grooved beneath.

Lamiinæ.—Head in front vertical or bent inwards well below the thorax. Last joint of the palpi pointed at the end. Fore tibiæ generally with a groove beneath. (Gahan).

Cerambycinæ.—Gahan makes four sub-families :—

Prionini.—Distinguishable as a rule by the sharp lateral margins of the prothorax. *Disteniini.* Ten hill forms. *Lepturini.* Twenty-three hill forms. *Cerambycini.* Embraces most of our forms but is not readily distinguishable in the case of hill forms, except from *Prionini.*

Prionini.—An assemblage of 53 Indian species, of which two only are common in the plains. They are large dark brown insects, the an-

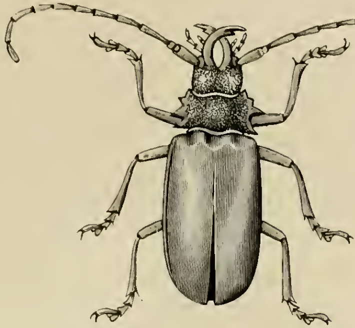


Fig. 248.—Priotyrannus mordax.

tennæ long, the prothorax usually spined, the mandibles often very long, curved and powerful. *Dorysthenes montanus*, Guer., is stated to come out of the soil in the Nilgiris in such numbers as to cover the soil; this occurs in April, May and June, the observer (Mr. Perrotet) further remarking that the bears eat these beetles. (?) (Guer. Men., Rev. Zool., 1840, p. 40.) The large brown beetle that flies into lights in Southern India and bites so freely is *Priotyrannus mordax*, Wh. The less formidable *Paraphrus granulosus* Thoms. comes into houses at night in Behar. *Macrotoma crenata*, Fabr., is a common plains species, wide-spread over India, found under fallen leaves and at light. *Aegosoma, costipenne*. Wh., is recorded as boring into teak trees in Assam. (I. M. N. 11, p. 12.) *Acanthophorus*

Fig. 249.—Hypoeschrus indicus.

serraticornis, Oliv., occurs in South India where it bores in mango and has been found as far North as Amballa, and *A. modicus*, Gah., is known only from Lahore.

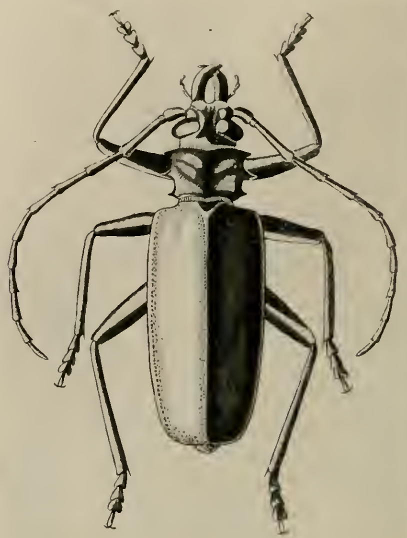


Fig. 250.—ACANTHOPHORUS SERRATICORNIS.

Cerambycini.—Gahan lists 309 species from the Indian region, divided into 20 groups. It is impossible to discuss so large a number of forms here; about 12 may be considered as common in the plains. We figure *Hypoeschrus indicus*, Gah., which bores in the Sal tree.

Xystrocera globosa is a reddish brown beetle, of about one inch length, with a conspicuous longitudinal band of metallic green along the elytra, found very widely. It represents the third group *Œmini*. Mr. Willcocks states that it is, in Egypt, a serious enemy of the Siris tree (*Albizzia lebek*).

Stromatium barbatum, Fabr. (*Hesperophani*), is perhaps the most abundant Cerambycid beetle in the plains, and is known to breed in Khair (*Acacia catechu*), teak, sissu and other dry timber; it is a dull brown insect, whose most interesting feature is the patches of silky hair on each side of the prothorax of the males; these are so placed and set that they catch the light in a very marked way, reflecting it towards the front, so that looked at from in front the insect appears to have two large shining eyes; this may be mere fancy or may serve a useful purpose in courtship or defence. This beetle is known to emerge yearly in early June.

Fig. 251.—SAL WOOD ATTACKED BY HYPOESCHRUS INDICUS.

The Cerambycines contain a large number of forms common or injurious. *Plocederus obesus*, Gah., is the insect recorded as destroying sal (I. M. N. I, p. 91); its cocoons, which are large, hard and formed apparently wholly of calcium carbonate, are striking objects. *Æolesthes holosericea*, Fabr., is recorded (I. M. N. I, p. 89) as breeding in sal wood (*Shorea robusta*). It is an extremely handsome beetle of rather over an inch length, covered with fine pubescence that gives beautiful silky reflections. It is one of the common plains species. *Diorthus simplex*, Wh., is another common and widespread species, of a dull brown colour, resembling the preceding generally but with a distinct scar at the apex of the basal antennal joint bounded by a little ridge. *Derolus demissus*, Pasc., is a smaller brown species without the antennal scar and with a fine ridge along the ventral face of each femur.

Fig. 252.—AEOLESTHES HOLOSERICEA.

With the *Callichromini*, we leave the dull brown species and come to metallic blue and green species of larger size and more slender build.

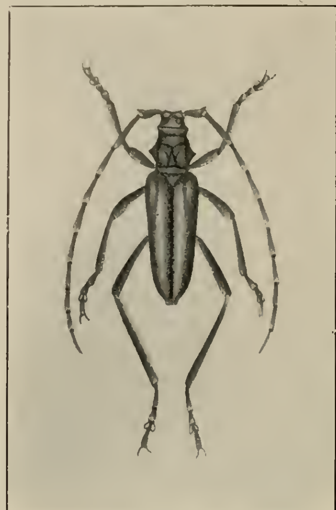


Fig. 253.—Chloridolum alcmene.

Chloridolum alcmene, Thoms., is the species found boring in the trunks of orange trees in Coorg (see Agri. Journ., India, Vol. I, p. 129). It is a deep blue insect, the legs dark coloured; it is recorded also from Assam, Andaman Isles, and Burmah, while Mr. Andrewes found it in the Nilgiris. No other species is notable and none occur in the cultivated plains; some are known to emit an odour which is pleasant and possibly connected with sex.

The *Clytini* include a large number of hill forms, chiefly slender insects with a cylindrical or globose prothorax and marked in bright colours. *Xylotrechu* has the antennæ wide apart and the front with ridges; it includes the White Borer of Coffee, *X. quadripes*, Chevr., whose larva lives in the stems of the coffee plants. Much has been written about this pest which occurs in the coffee districts of South India and is most destructive to coffee grown under too dense shade. It is found also in Assam, Sylhet and Burmah and is an example of an ordinary indigenous insect which finds abundance of a cultivated plant in which it can breed and thus becomes

Fig. 254.—Xylotrechus quadripes. The White Borer of Coffee.

a pest. The reader should consult the account of Dunning (Tr. Ent. Soc., London, 1868, p. 105), of Bidie (Report on the Ravages of the Borer, 1869, Madras), and that of Taylor (The White Borer, 1868, Madras).

Caloclytus is a large genus of yellow banded beetles, one of which is occasionally extremely abundant in the plains. This is *C. annularis*, Fab., a slender beetle clothed in yellow pubescence, with dark bands on the thorax and elytra; it lays its eggs on bamboos, the larva living in the bamboo and gradually destroying it; the life-history occupies one year, the beetle being easily reared in captivity; large numbers have been found to emerge from a thatched roof in which new bamboos were used, their emergence taking place in May. Other species are extremely common in the hills, as are also some species of *Clytus* and *Demonax*.

Fig. 255.—CŒLOSTERNA SCABRATA.

Lamiinæ.—The revision of this sub-family is not yet complete and we can only mention the common species of the plains, with the caution that the publication of the revision in the Fauna Volume will inevitably alter the nomenclature of the species named. *Batocera rubra*, Linn. (figs. 245 and 247), is the large beetle found throughout the plains, whose larva is common under the bark of trees; it appears to occur chiefly in decaying bark and the trees felled in Pusa contained abundance of the large larvæ and pupæ. It is an extremely handsome insect, the largest of the common plains species. It is common also in mango, and E. P. Stebbing has described its occurrence in the Duki fig (Ind. For. Bull. 10). *Cœlosterna spinator*, F., is a common beetle, breeding in babul (*Acacia arabica*); the beetle has been found to eat the bark of cotton plants and, when abundant, as it occasionally is, to do harm in this way. *C. scabrata*, F. (figs. 246 and 255), has been reared from *Casuarina equisetifolia* in South India, where it is very destructive to young trees, and also from mulberry. *Sthenias grisator*, F., is a smaller beetle reported to girdle *Tabernæmontana alba* branches in South India, as well as to cut down rose bushes (Ind. Mus. Notes III, p. 40). *Olenecamptus bilobus*, F., is common in the plains on pakur, gular and other fig trees; it is conspicuous by the round white spots on the smooth brown elytra and is likely to be found everywhere in the plains. *Apomecyna histrio*, F., and *A. pertigera*, Thoms., are common among cultivated crops; both are of small size, dull brown in colour, with many small white spots disposed over the elytra. The latter have been reared from the stems of the common pumpkin (*Cucurbita pepo*) in which it occurs abundantly (Plate XXV).

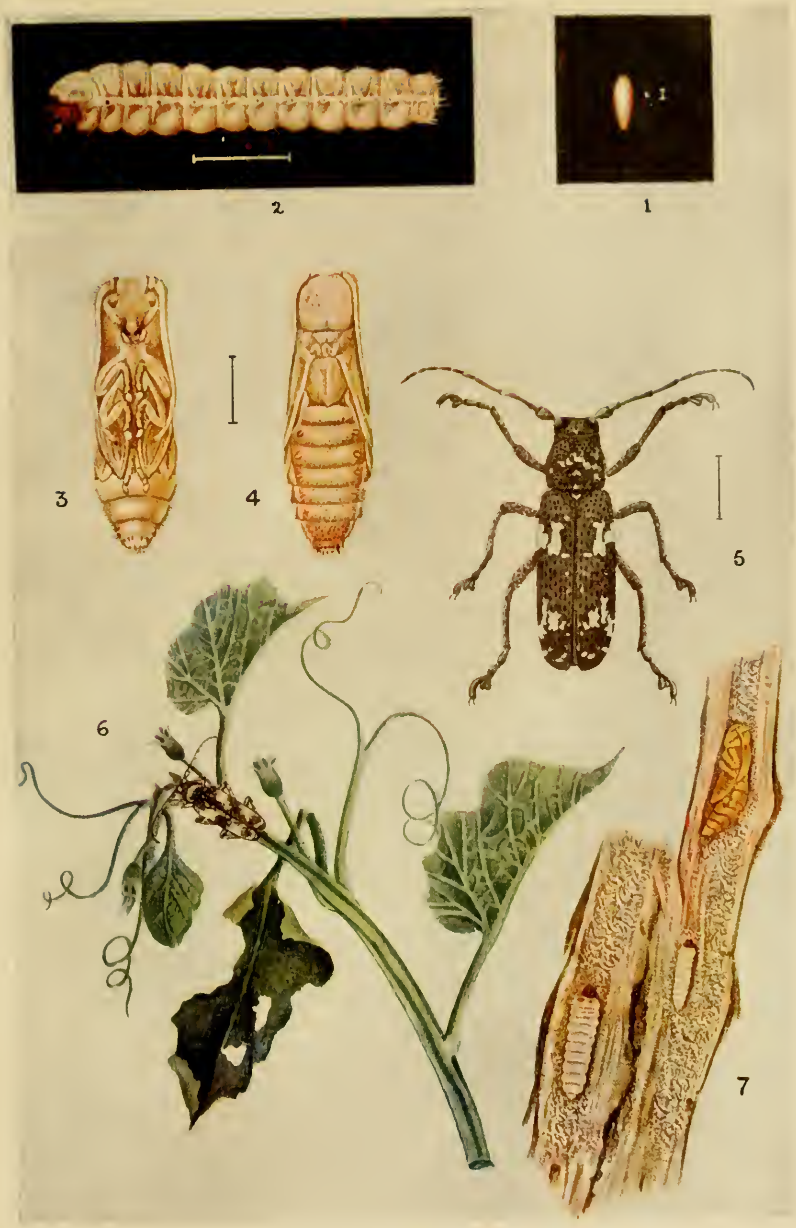
Amongst the many species of *Glenea*, *G. spilota*, Thoms., is known to breed in the trunk of the silk cotton tree (*Bombax malabaricum*), the larva being found abundantly in the decaying trunk after the plant has dried, in common with a host of other insects. *Monohammus nivosus*, Wh., is the commonest representative of this immense genus, an insect found on the Ak plant (*Calotropis* spp.) in the plains. Its larva is found in the stem of the plant, tunnelling up the centre and the beetle is to be found practically wherever this plant grows.

Fig. 256.—Monohammus versteegi.

The following list of plants bored by Cerambycidæ is compiled from Indian Museum Notes (I.M.N.), the reports of the Forest Zoologist (E.P.S.), of the Entomologist, Indian Tea Association (C.B.A.), and our own records. We have included borers of other groups such as the Arbelidæ, Cossidæ, Buprestidæ, etc., but the records are extremely meagre and show how little this subject has been investigated. The borers in dry wood, etc., of the Bostrichidæ,

PLATE XXV.—Apomecyna Pertigera.

Fig. 1. Egg.
„ 2. Full-grown larva.
„ 3. } Pupa, ventral and dorsal.
„ 4. }
„ 5. Beetle.
„ 6. Beetle feeding on growing plant.
„ 7. Larvæ and pupæ in the stem.



APOMECYNA PERTIGERA.

etc., and the larvæ living in the branches, etc. (as the Curculionidæ), are omitted.

Fig. 257.—Neocerambyx paris.

	Plant.	Bored by.
Akh.	*Calotropis gigantea.*	*Monohammus nivosus.*
Asan.	*Terminalia tomentosa.*	*Æolesthes holosericea* (I. M. N.).
Babul.	*Acacia arabica.*	*Æolesthes holosericea* (I. M. N.).
,,	,, ,,	*Cœlosterna spinator* (I. M. N.).
Ber.	*Zizyphus jujuba.*	(*Arbela tetraonis.*)
Bamboo	*Dendrocalamus strictus.*	*Stromatium barbatum* (E. P. S.).
.	*Bambusa* sp. (dry).	*Caloclytus annularis.*

Casuarina.	*Casuarina equisetifolia.*	(*Arbela tetraonis*).
,,	,, ,,	*Cœlosterna scabrata.*
Coffee.	*Coffea arabica.*	*Xylotrechus quadripes* (I. M. N.)
,,	,, ,,	(*Zeuzera coffeæ*) (I. M. N.).
Gular.	*Ficus glomeratus.*	*Batocera rubra.*
Guava.	*Psidium guava.*	(*Arbela tetraonis*).
,,	,, ,,	*Æolesthes holosericea.*
,,	,, ,,	(*Belionota prasina*).
Khair.	*Acacia catechu.*	*Stromatium barbatum* (I. M. N).
Lime.	*Citrus medica.*	*Chloridolum alcmene.*
Orange.	,, *aurantium.*	(*Agrilus grisator*).
Litchi.	*Nephelium litchi.*	(*Arbela tetraonis*).
Mango.	*Mangifera indica.*	*Acanthophorus serraticornis.*
,,	,, ,,	*Stromatium barbatum.*
,,	,, ,,	*Batocera rubra.*
,,	,, ,,	(*Arbela tetraonis*).
Pumpkin.	*Cucumis melo.*	*Apomecyna pertigera.*
Sal.	*Shorea robusta.*	*Plocederus obesus* (I. M. N.).
,,	,, ,,	*Hoplocerambyx spinicornis* (I. M. N.).
,,	,, ,,	*Cœlosterna scabrata* (I. M. N.).
,,	,, ,,	(*Chrysobothrys sexnotata*) (I. M. N.).
,,	,, ,,	*Æolesthes holosericea* (E. P. S.).
,,	,, ,,	*Acanthophorus serraticornis* (E. P. S.).
,,	,, ,,	*Dialages pauper* (E. P. S.)
,,	,, ,,	*Hypæschrus indicus* (I. M. N.).
Sandal.	*Santalum album.*	(*Zeuzera coffeæ*).
Simul.	*Bombax malabaricum.*	*Plocederus obesus* (I. M. N.).
,,	,, ,,	*Glenea spilota.*
Sissu.	*Dalbergia sissu.*	*Stromatium barbatum.*
Tea.	*Camellia theifera.*	(*Arbela dea*). (C. B. A.).
,,	,, ,,	(,, *quadrinotata*). (C. B. A.).
,,	,, ,,	(*Phassus malabaricus*).

Teak.	*Tectona grandis.*	*Batocera rubra* (I. M. N.).
,,	,, ,,	*Stromatium barbatum* (I. M. N.).
,,	,, ,,	*Stromatium longicorne* (I. M. N.).
,,	,, ,,	*Aegosoma costipenne* (I. M. N.).
,,	,, ,,	*Æolesthes holosericea* (I. M. N.).
,,	,, ,,	(*Psiloptera fastuosa*) (I. M. N.)
,,	,, ,,	(*Cossus cadambæ*) (I. M. N.)

RHYNCHOPHORA.

A series of beetles recognised by the tarsi, which are similar to those of the Phytophaga (fig. 183), by the antennæ, usually clubbed and often elbowed, and by the rostrum, the head being drawn out more or less distinctly, so that the mouth, instead of being ventral, is anterior to the eyes, and often at the apex of a distinct beak-like prolongation of the head. It is difficult to place a few forms and to distinguish exactly between this series and some of the Phytophaga, but such cases occur very rarely. The Rhynchophora are on the whole a distinct series, all phytophagous, with leg-less larvæ usually living concealed (pace *Cionus*) and including a large number of boring insects found as larvæ in plants.

Anthribidæ.

Rostrum short and blunt. Antennæ straight, usually clubbed, eleven joints. Tarsi of four joints, third small and hidden.

Dull coloured beetles of small size and not often found, the body clothed in pubescence. These beetles are found on tree trunks, on mushrooms, on dead wood ; few are very active, though a few can leap (*Aræcerus*). The larvæ are white grubs similar to those of *Curculionidæ* but sometimes with legs. They are found in seeds and in wood. Though few Indian species are known, many probably occur and their identification is not easy. Malaya is the head-quarters of the family. The student who specialises in this family will find a list of the known species with bibliographical references in Ann. Soc. Ent., Belge, XLIX, p. 218 (1905). Bovie here lists 91 species as occurring in India, Burma and Ceylon. Jordan has described the majority of the forms from our limits.

Eucorynus crassicornis, Fabr., is a dark coloured insect found not uncommonly in tree bark in the plains, while *Phlœobius alternans*, Wied., has been found on plants. *Aræcerus fasciculatus*, de G., is cosmopolitan and has been recorded as breeding in Areca nut in India. It is stated to have been distributed in coffee beans in which it breeds freely. This, or a very closely allied species, breeds freely in old dried cotton seeds (Plate XXVII) that remain on the plant after picking, and we have reared very large numbers from such seeds. Another has been reared in dry chilli pods and a third from the stem of parwar (*Trichosanthes anguina*). The cosmopolitan species feeds on a great variety of substances and is variable in appearance; the discrimination of species is not easy in this genus.

CURCULIONIDÆ.—*Weevils.*

Labium absent. Antennæ clubbed and elbowed. Head produced into a rostrum. Fourth tarsal joint reduced.

Weevils are recognisable by the rostrum and elbowed antennæ in almost all cases. They vary in size from one-eighth of an inch in

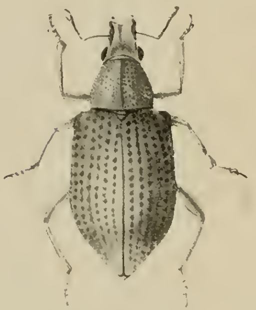


Fig. 258.—BRACHYASPISTES TIBIALIS. × 5. [I. M. N.]

Fig. 259.—BRACHYASPISTES TIBIALIS. × 5. [I. M. N.]

length to nearly two inches, and include a large number of forms a little more than a quarter of an inch long. The colours are commonly dull, browns and greys predominating, many black, a few a rich red brown and some green. In many species the body is clothed in scales, the actual integument being dark coloured, the delicate scales grey, buff,

PLATE XXVI.—CYLAS FORMICARIUS.

SWEET POTATO WEEVIL.

Fig. 1. Egg. x 10

,, 2. Small potato showing eggs laid on it. x 2.

,, 3 Larva.

,, 4. Attacked potato.

,, 5. } Pupa, magnified.
,, 6. }

,, 7. Imago.

,, 8. Antenna of female above, male below.

SWEET POTATO WEEVIL.

green or other light tints. When magnified these scales give the insects a very beautiful appearance, one that cannot be appreciated by the naked eye. In some species the body is not clothed with scales but with an "efflorescence," a delicate mealy covering produced by the insect itself, and suggesting that a strong alkaline solution has been excreted and evaporated, leaving a white floury coating. The body is often short and thickset, the head drawn out into a beak of very varied form. Small compound eyes are placed at the base, the antennæ projecting from the side of the rostrum. The antenna consists of a slender elongate basal segment, the scape, seven or six short slender segments forming the funicle and a club composed of three or four expanded segments (Fig. 137). The minute biting mouth-parts are situated at the apex of the rostrum; the latter may be short and thickset or long, slender and either curved or nearly straight. In a majority, there are the scars of the bases of temporary mandibles found in the newly hatched weevil, on the mandibles; these were used in emergence from the cocoon or ground and shed. The prothorax is well developed, the abdomen large and completely covered by the elytra which fit closely to the body and cover the folded wings. The legs are moderately long, the femur often swollen at the apex, the tarsi of four apparent joints, of which the basal three are usually flattened and densely pilose. Males and females are similar in appearance, the former often smaller and in some species readily distinguished by the form of the rostrum, fore-legs or antennæ.

Though the family is a very large one, the life-histories of only a very few are known. So far as known, the eggs are of two types; eggs laid in exposed positions on the outside of a plant are small oval objects, smooth, with a hard shell; those which are deposited in the tissues are soft, elongate and white. They are laid singly, and usually in considerable number spread over a number of plants. Larvæ are, as a rule, internal feeders and are white soft legless grubs (Plates XXVI, XXVII), with a distinct brown head and a much wrinkled body, which is fleshy and slightly curved. The majority of the known larvæ are found in the tissues of plants, in roots, stems, fruits, twigs and other parts. None are known to be other than herbivorous. Pupation occurs in the plant, and there is great variety in this respect. A few make cocoons of fibres; many pupate in the tunnel without covering, though in a distinct closed chamber. The larvæ which live exposed make a case of excrement or of gummy material derived from the anus.

The weevils which emerge are active insects, diurnal or nocturnal, feeding on leaves and other parts of plants or on plant sap. None are known to be predaceous, though at least one is probably so. The duration of each stage varies with the species. Some are one-brooded, hibernating as the imago and passing long periods in the imago form, until they are able to lay eggs in the tissues in which the larvæ can live. Others are many-brooded, and one brood succeeds another so long as food is available. In these cases hibernation appears to be passed in the larval or pupal form.

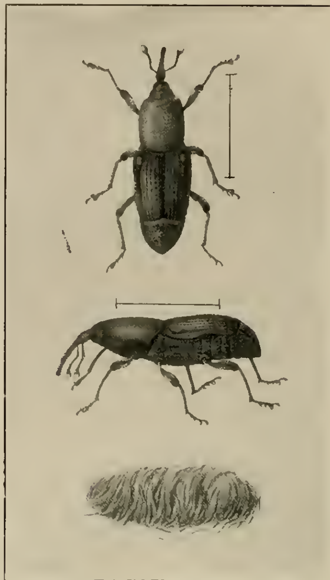


Fig. 260.—Odoiporus longicollis, imago and cocoon.

Weevils have the habit of "shamming dead;" when approached the legs and antennæ are folded close to the body and the insect drops to the ground. This is a valuable defence, especially in thick vegetation, the insect falling to the soil and being extremely hard to find. Since all are herbivorous and some abundant, the family includes many destructive species, whose ravages, especially in the larval stage, are of importance in Agriculture. Our knowledge of these insects is slowly growing and many yet remain to be worked out. Owing to their concealed lives and to the often nocturnal habits of the imago, they are difficult to check, no stage being exposed to any particular measures that can be adopted. A few are destructive, not in the larval but in the imaginal stage, the weevil living for long periods and destroying leaves. The mango weevil, the melon weevil and apple weevil attack fruits, the sweet potato weevil, tubers, the cane weevil the roots, the cotton stem weevil, palm weevil and jute weevil the stems, while the white and green weevil eat the leaves, and the rice and wheat weevils stored grains. The enemies and checks of these insects are little known; parasitic insects check the larvæ and the weevils are probably destroyed by birds and by predaceous insects.

The family is one of the largest, and though many species are known, no thorough account of the group is in existence. They occur

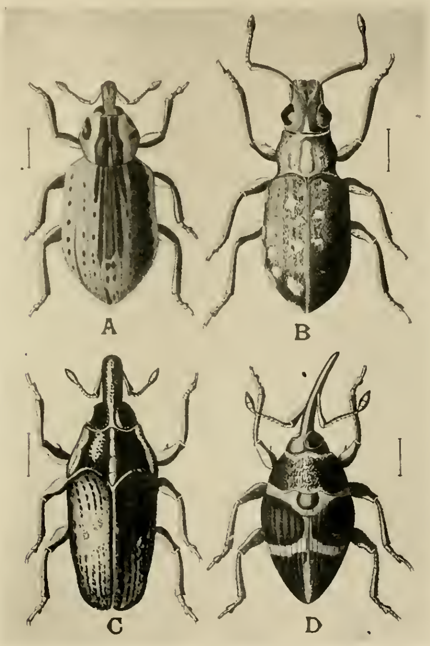


Fig. 261.—A. HYPERA VARIABILIS, B. MYLLOCERUS DISCOLOR, C. ALCIDES LEOPARDUS, D. BALANINUS C. ALBUM.

in all parts of the tropical and temperate regions. In India, the plains fauna is rich in species, though more are to be found in the submontane forest and jungle areas. The family as it occurs in India is being described in the Fauna of India by G. A. K. Marshall.

The classification of the *Curculionidæ* is too vast to be entered into here. One has but to glance at the vast array of groups, divisions, legions, cohorts, tribes, etc., into which the family has been divided to realise its complexity. A complete revision of the family in the light of new knowledge will have to be done when the monographs on the regional faunæ are more complete. As in other complex groups of Coleoptera, there seems to be no immediate prospect of any thorough revision owing to the complexity of the family and its vast number of species. About 1,500 Indian species are probably already described or recorded, but an equal number at least will probably be added now and new forms are found constantly.

Brachyderinæ.—Blosyrus asellus, Oliv., is a grey weevil, with thickset abdomen and elytra, found commonly feeding on leaves from August to December. *Astycus lateralis*, F., is the common green weevil of the plains of India, found feeding in abundance upon cultivated plants. *A. chrysochloris*, Wied., is the larger metallic green species common in Assam. *Tanymecus indicus*, Fst., is one of the many weevils which are so abundant on soil and eat young plants. It is extremely common in the Gangetic plain and appears regularly twice in the year at the commencement of the kharif and rabi seasons. *Tanymecus circumdatus*, Wied., is common on plants, a delicate green form with longitudinal stripes, and *T. chloroleucus*, Wied., is also abundant, uniformly clothed in almost white scales. The genus is a very large one, with many species in the plains. Their larvæ will probably be found in the roots or underground stems of plants. *Atmetonychus peregrinus*, Oliv., is also found, a grey much roughened weevil found on young plants (Plate XXVII, fig. 10).

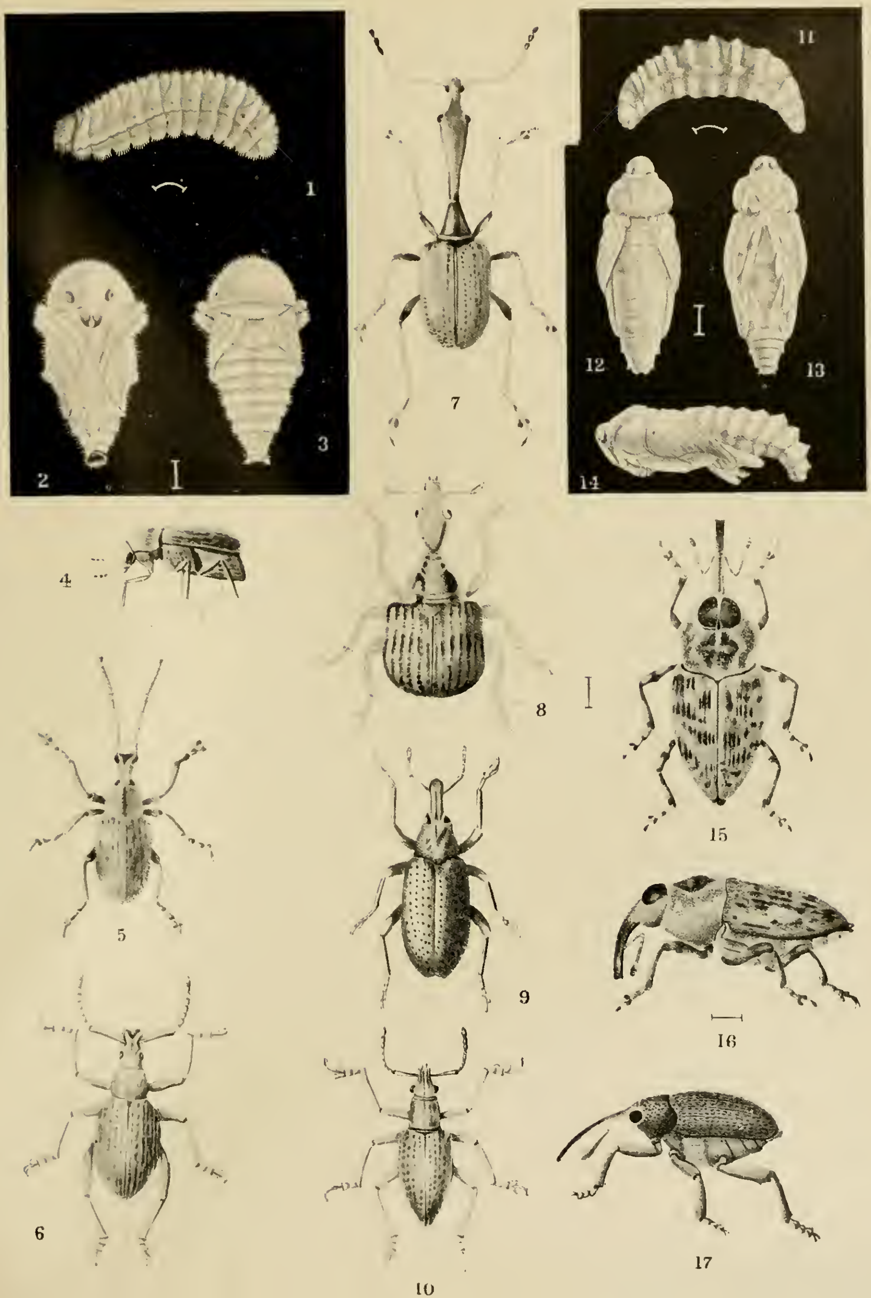
Otiorhynchinæ.—Episomus lacerta, F., is a comparatively large grey weevil that has been found in numbers on cotton plants, feeding on the bark (Plate XXVII, fig. 6).

PLATE XXVII.—CURCULIONIDÆ.

WEEVILS.

Fig. 1. Larva of Aræcerus sp. (Cotton seed weevil.)
,, 2. } Pupa ,, ,,
,, 3. }
,, 4. Imago ,, ,, x 6.
,, 5. Phytoscaphus triangularis. x 3.
,, 6. Episomus lacerta. x 2.
,, 7. Apoderus scutellaris. x 4.
,, 8. ,, tranquebaricus. x 4.
,, 9. Xanthochelus superciliosus. x 2.
,, 10. Atmetonychus peregrinus. x 2.
,, 11.
,, 12.
,, 13.
,, 14. Phylaitis sp. (Cotton stem weevil), larva, pupa, imago.
,, 15.
,, 16.
,, 17. Balaninus Bomfordi. x 6.

PLATE XXVII.



Mylloccrus is an important genus of weevils in India with several common species. The commonest is the "White weevil," *M. maculosus*, Desb., described from Cawnpore specimens (Ind. Mus. Notes, Vol. IV, p. 111). This is abundannt everywhere in the plains but its life-history is still unknown *M. setulifer*, Desb. (Fig. 262), described in the same publication, is found attacking flowers and is not strictly a plains species. *M. discolor*, Boh. (Fig. 261), has been reared from grubs found at the roots of cane plants, the grub and pupa in the soil, the former feeding on the cane roots. The adult feeds upon young mango leaves. It may be found sometimes in abundance hiding away for the winter under bark or in any sheltered crevices, and it emerges again in March. *M. blandus*, Fst., is a small dull grey species which feeds upon the young leaves of cane and maize and is very destructive to young plants (cf. *Pachnephorus*).

Fig. 262.—MYLLOCERUS SETULIFER. [I. M. N.]

Eremninæ.—Phytoscaphus triangularis, Oliv. (Plate XXVII, fig. 5), is a small brown weevil, with lighter markings found commonly feeding on leaves. *Amblyrrhinus poricollis*, Boh., is a similar and smaller insect, frequently found feeding upon the small leaves of mango, litchi and other fruit trees.

Hyperinæ.—Hypera includes two common species found breeding upon lucerne (*Medicago sativa*) and Senji (*Melilotus indica*). The green grub feeds exposed upon the leaf; a parchment-like cocoon is made on any part of the plant and from this the imago emerges. The weevil is far more destructive than the grub, eating into the shoots and causing them to wither. The species concerned are *H. varians*, Hbst. (Fig. 261), and *H. medicaginis*, Mshll.; they have an active season in the cold weather only, disappearing into hiding in March or April, the weevils living over until the next cold weather in concealment.

Cleoninæ.—Lixus brachyrrhinus, Boh., breeds freely in the cultivated Amaranths grown as vegetables, the grubs being found in the stems. The weevils can be found on the plants in the rains. *Atactogaster finitimus*, Fst. (*Leucomigus antennalis*, Fst.), is stated to be injurious to cotton and gram in South India (Ind. Mus. Notes, Vol. IV, p. 112), and is a common insect in Madras.

Xanthochelus superciliosus, Gylh. (Plate XXVII, fig. 9), is the large grey weevil found feeding abundantly upon the leaves of ber (*Zizyphus jujuba*).

Hylobiinæ.—*Paramecops farinosa*, Wied., is the weevil so commonly found on the Ak (*Calotropis* spp.). It is greyish in colour but is covered in a white mealy efflorescence. The eggs are laid in the rind of the Ak fruit, the little grubs boring into the soft tissues and feeding on the developing fibre and young seeds. The full grown grub reaches a length of half an inch, and pupates in a compact cocoon formed of the delicate fibre (known in commerce as "kapok"). Ten days after, the adult emerges, and feeds on the leaves of the Ak plant. The weevils are very common and widely spread where this plant grows.

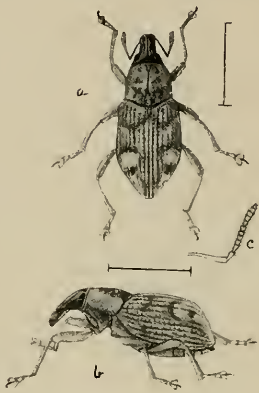


Fig. 263.—Atactogaster finitimus. [I. M. N.]

Cyladinæ.—*Cylas formicarius*, F.—The best account of this insect is found in the Queensland Agricultural Journal for August 1900 (page 176). Mr. Tryon there gives a thorough account of the species, with a complete bibliography. He discussed its origin, a matter still of doubt, but as the two first describers, Fabricius and Bohemann, both obtained it from India, there is some ground for believing it to be a native of South India, spread gradually over the tropics. A short account of this insect will be found in Indian Insect Pests. Eggs are laid on the sweet potato tuber or rootstock, the larvæ tunnelling into the tissues and boring through them ; pupation takes place inside and the weevil feeds also on or in the tuber. The stages are well shown in Plate XXVI, and the weevils may be found throughout India, being often destructively abundant.

Apioninæ.—The genus *Apion* includes a vast number of tiny beetles with straight antennæ and marked sexual differences, found almost over the globe. The colours are black, brown, blue, red or metallic. A number of Indian species are known, but the discrimination of species is very difficult. *Apion gagatinum*, Mots., is a common plains species on grass. *A. strobilanthi*, Desb., is described from seeds of *Strobilanthus* in Sikkim, an unusual habit for a member of this genus (Ind. Mus. Notes, Vol. II, p. 32). Another species lives in the stems of jute in India.

Attelabinæ.—The genus *Apoderus* contains the weevils in which the head and sometimes the prothorax is drawn out into a long neck (Plate XXVII, figs. 7, 8). These weevils prepare cases of green leaf; the leaf is cut across near the base, the cut reaching from each margin to the midrib or crossing the midrib from one margin only; the leaf is then folded longitudinally, and the tip rolled in; an egg is laid and the rolling process continued till the leaf, up to the cut, forms a compact cylindrical mass, consisting of tightly rolled and folded leaf blade, with the egg in the centre; no silk or gum is used and the insect works with legs and jaws in folding and packing the leaf; the roll is left adhering to the remainder of the leaf, the egg hatches and the grub feeds on the leaf inside the roll. The roll subsequently dries and falls off with the pupa inside. We figure the case of *Apoderus blandus*, Schonh., made on Sissu. Eggs laid on 25th June, hatched on the 28th, the larvæ pupated by the 30th and weevils emerged from the 3rd to the 7th July: the life-history is thus a very brief one and there are apparently two broods during the rains, the second being a hibernation brood in which the larva remains for the winter in the case. *A. tranquebaricus*, Fabr., in South India rolls the leaf of the country almond (*Terminalia catappa*) and the habit has been observed in a number of species in the sub-tropical zone of India. Over 30 species are known in India, in the genera *Apoderus*, *Attelabus*, and *Rhynchites*.

Fig. 264.—LEAF CASE OF APODERUS BLANDUS, MAGNIFIED.

Balaninæ.—Balaninus Bomfordi, Fst., eats into the unopened buds of the banyan tree and feeds on the inside; with their very slender curved beaks they make neat punctures and many buds wither. The larvæ are found in the fleshy receptacles of the fig, which they destroy so that the fig falls off. We figure this species, which represents the group in the plains, and *B. C. album*, Fabr., found in Eastern Bengal (Plate XXVII, fig. 17).

Cioninæ.—Cionus hortulanus, Fourc., Var. *major* is a "cold weather" species in the plains, breeding only on *Celsia coromandeliana*; the shiny grubs feed openly on the buds and look like caterpillars; they pupate in a delicate horny cocoon, made of anal secretion, on the plant. There are, as a rule, about three broods yearly in Pusa, from February to April, the weevils then seeking shelter. They are usually very abundant, one of the most noticeable of the cold weather forms. In the Himalayas at 7,000 feet this weevil breeds on *Celsia* from May to October. *C. albosparsus*, Fst., has been found in Bombay and others occur in the sub-tropical zone.

Alcidinæ.—A sub-family confined to the Old World and mainly occurring in the tropics. It consists of *Alcides* with 242 species recorded up to 1906 and *Acœrus* with one. The group has been listed by Bovie (Genera Insectorum 1907). Of the former 26 species are Indian. The species of which anything is known have been reared from larvæ boring in the shoots of plants. *Alcides leopardus*, Ol. (Fig. 261), is the species most commonly found, known throughout the plains; its larva bores in the shoots of cotton, destroying them, and pupating in the tunnel near the bark. The pupal period is short (4 days) and the weevil rests within the tunnel for some days after.

A. collaris, Pasc., is a larger species, the prothorax red-brown, the elytra black with white spots, which is found in sweet-potato fields in the plains. *A. fabricii*, F., has reddish-brown elytra with cream stripes, and a black and cream coloured prothorax; it has been found in widely scattered localities. *A. bubo*, F., is the weevil whose larva breeds in Agathi (*Sesbania*) in South India and is a serious pest. Its eggs are greenish white, flattened and of nearly round outline, laid in holes in the stems of the young plants and covered with gelatinous material.

The life-history occupies six weeks ; many larvæ are found in the same plant, which dies, and the loss in young plants is extensive.

Cryptorhynchinæ.—Pachyonyx quadridens, Chevr., is found breeding in the dhak plant (*Butea frondosa*) in Northern India. *Cryptorhynchus* contains the mango weevils of India, of which *C. gravis*, Fabr., is the common form in Eastern Bengal and Assam, *C. mangiferæ*, F., in South India and Ceylon. Both breed in the stone of the mango, the eggs being laid in the young fruit, the larva on maturity eating through the pulp and emerging to pupate in the soil. There is but one brood yearly of the former and the weevils remain dormant from July or August to the following March—April in concealment in the ground and in or on the bark of trees.

Fig. 265.—Cryptorhynchus gravis.

Desmidophorus contains several sub-tropical species, *D. hebes*, Fabr., also occurring in Behar, where it is occasionally found in abundance on garden Hibiscus.

Zygopinæ.—Phænomerus sundevalli, Bch., is a small linear beetle, resembling an elongate rice weevil, found in the plains. *Metialma* includes two species. *M. scenica*, Pasc., and *M. balsaminæ* Pasc., the latter having been reared from larvæ found boring in the stems of balsams : the larva tunnels in the soft tissues and pupates in a cocoon formed of fibres twisted into an oval shape.

We figure a *Phylaitis* (Plate XXVII), common in the stems of malvaceous plants, which attacks cotton severely and specially tree cottons. It was a serious enemy to tree cottons in Behar and is destructive in South India, the larvæ boring in the stems, forming a thick swelling and eventually so weakening the plants that they break off or die. Its distribution appears to be a limited one, as it is not a widespread pest of cotton.

Calandrinæ.—Rhynchophorus includes the common Palm Weevil of India *R. ferrugineus*, F. (*R. signaticollis*, Chevr.), which breeds in the toddy palm (*Phœnix sylvestris*) and in the cocoanut palm (*Cocos nucifera*). The eggs are laid in the soft tissues at the base of the leaf sheath, at a wound or at the cut made by the toddy drawer; the larvæ tunnel through the tissues in all directions and, when mature, make a cocoon of twisted fibres. This insect is one of the more important pests of India and much has been written of it in Ceylon where it is of still greater importance. (Figs. 268, 269.)

Fig. 266.—CALANDRA ORYZÆ. × 10.

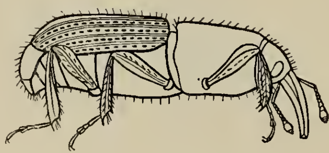


Fig. 267.—CALANDRA ORYZÆ. × 10.

Calandra (Sitophilus) is a genus of two species of world-wide occurrence. *C. granaria*, L., is of a uniform deep redbrown colour, the prothorax with oblong punctures; the metathoracic episternum is very narrow with a single row of punctures. It is wingless. *C. oryzæ*, Linn., has two fulvous patches on each elytron, the punctures on the prothorax are rounded and closer together, the metathoracic episternum is wider and has two rows of punctures. It is winged, the weevils flying readily. The latter is the common Indian species, of which much has been written, but little is known.

Odoiporus glabricollis, Gyll., is the common weevil whose larva breeds in the stems of the plantain (*Musa sapientum*). The black weevil is to be found on or in the plant and is quite common. (Fig. 260.)

Polytus mellerborgii, Bh., is a tiny dark coloured weevil found breeding in decaying plantain stems.

Cercidocerus bimaculatus, Boh., is a black species in which the antennæ have a very expanded truncate club ; it is found rarely in tropical India.

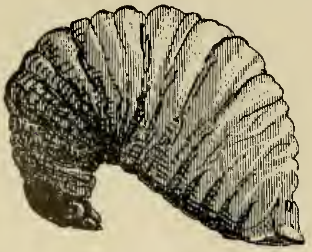


Fig. 268. - Rhynchophorus ferrugineus larva.

This family also includes the large forms such as *Cyrtotrachelus dux*, Boh., & *C. longipes* found in sub-tropical India, which are the most striking Curculionids of the Indian fauna. In the latter the male has very long forelegs ; they feed on the juice of bamboo shoots and the eggs are also laid there, the larvæ tunnelling in the shoots and making the usual fibrous cocoon of this group.

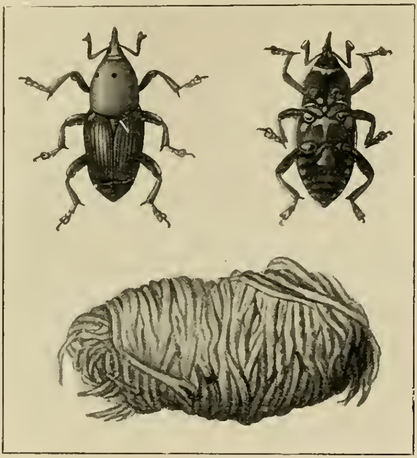


Fig. 269.—Rhynchophorus ferrugineus. [I. M. N.]

Collecting.—Weevils are simply collected on their foodplants and require no special methods. The rarer species are obtained by "beating" bushes, and it is advisable to remember that they often sham dead and fall to the ground when the plant is shaken. Larvæ are to be found in every possible part of the plant and practice enables the collector to discern swollen twigs or branches in which larvæ are found. They are not difficult to rear and almost any part of a plant is worth investigating for weevil grubs. The rarer species are obtained in this way and there is no better collecting method than to search systematically among wild plants. Benzene is the best killing agent and the weevils keep well until required to be set.

Brenthidæ.

Antennæ straight, nine or eleven-jointed. A horizontal rostrum, usually long. Tarsi pilose below. Body elongate.

A family closely allied to the *Curculionids* but usually of more elongate and linear form. They are usually bare, shining, of dull browns and ferruginous tints. The males in some cases have large curved mandibles or expanded and toothed fore femur and tibia. The habits of but few are known and none of these appear to be Indian. In general, they are wood-boring or found in decaying wood. They are chiefly tropical and well represented in the forests of the East. There are two sub-divisions :

Antennæ eleven-jointed. *Brenthinæ.*
,, nine ,, *Ulocerinæ.*

Fig. 270.—Orychodes sp. × 4.

There are about twenty recorded Indian species, but the family has been greatly neglected. Several species are common in the plains, in some of which there appears to be a considerable amount of sexual differentiation in respect of the head and rostrum. The family is listed by Von Schonfeldt in Genera Insectorum (1908), who enumerates 10 species from India exclusive of Burmah and Ceylon, the small number of species recorded being apparently due to errors of geography in the earliest describers of species.

Calodromus Mellyi Guer., *Callipareius foveatus* Senna, *Cerobates canaliculatus* Mo., *Symmorphocerus cardoni* Senna, *Prophthalmus delesserti* Pow., *P. obscurus* Pow., *P. potens* Lac., *Baryrhynchus miles* Boh., *Eupsalis truncatus* Boh., *Orychodes pusillus* Oliv., are the known Indian species.

SCOLYTIDÆ.

Rostrum short or absent. Antennæ short, elbowed, clubbed. Tarsi apparently four-jointed, filiform, third joint entire or bilobed, not elongated.

A family closely allied to some of the Curculionidæ in structure but distinct in the almost total absence of the rostrum and in their

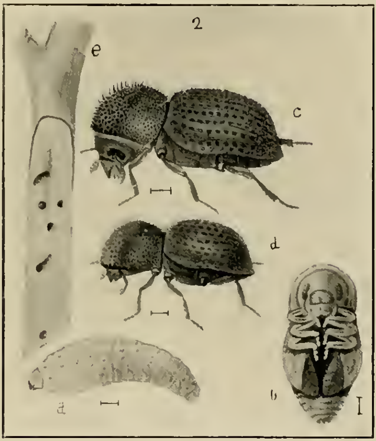


Fig. 271.—XYLEBORUS FORNICATUS [I. M. N.].

habits. Most are elongated and cylindrical, of small size and of the dull brown or black colour common to beetles which live in darkness. The antennæ are short, sometimes with twelve joints (funicle 1, scape 7 club, 4), sometimes with as few as three. (Fig. 193.)

Owing to their peculiar habits a great deal has been learnt of these insects since they are of extreme importance in forestry. Nearly all are borers in woody tissues, but few living in green tissues (the Scolytid that bores in the shoots of the common plant *Vinca rosea*, in the Western Hemisphere does not seem to occur in India though the plant does). Owing to the destruction they cause in forestry, the group has been extremely carefully studied elsewhere and the student will find full details in works on the forest insects of America and Europe. Their peculiar habits, especially in regard to sex, some being polygamous, some monogamous, the extreme ingenuity of their system of tunnelling and the fact that in some their food consists not of wood but of the fruiting bodies of certain fungi, which they themselves (hence called ambrosia beetles) cultivate with care, makes them a group of especial interest. They are, however, practically wholly forest insects, and occur almost entirely in the sub-tropical hill forest areas of India. No species are of agricultural importance, and the typical wood and bamboo borers of the plains are *Bostrichidæ* and not *Scolytidæ*.

The family include monogamous species and species which are polygamous ; in the first, the female prepares a bore, then goes out and returns with a mate and subsequently makes tunnels at right angles to her original bore ; each tunnel contains an egg and the male remains in the original tunnel. Such tunnels may be in one plane, since there is only one branching, and they may be contained in the bark only. In polygamous species, the male makes the first burrow, the females gathering in it and each making a tunnel from it ; from these they make other tunnels, in each of which eggs are laid. Of these tunnels, some must be horizontal and some vertical and they extend into the wood since the narrow bark will not accommodate them. Thus in the first case, the borings are simple, only a coupling burrow (made by the female) and larval burrows at right angles (the larvæ on becoming beetles burrowing straight out to the bark) ; in the second, they are complex and consist of the coupling tunnel, the mother tunnels at right angles each made by one female, and at right angles in another plane the egg-tunnels ; the system become so complex that air holes may be made to the bark by the mothers. In the different species the tunnels vary and the individual kinds are too complex to be noticed here.

The life-histories of many species are known and something is known of Indian species. Works on forest insects must be consulted for details. The chapter on Scolytidæ in Gillander's "Forest Entomology" (1908) should be consulted as giving an excellent resumé of the family. Over 50 'Indian' species have been described by Motschulsky, Blandford, Eichhoff and others.

The family is divided into two according to the tarsi :—

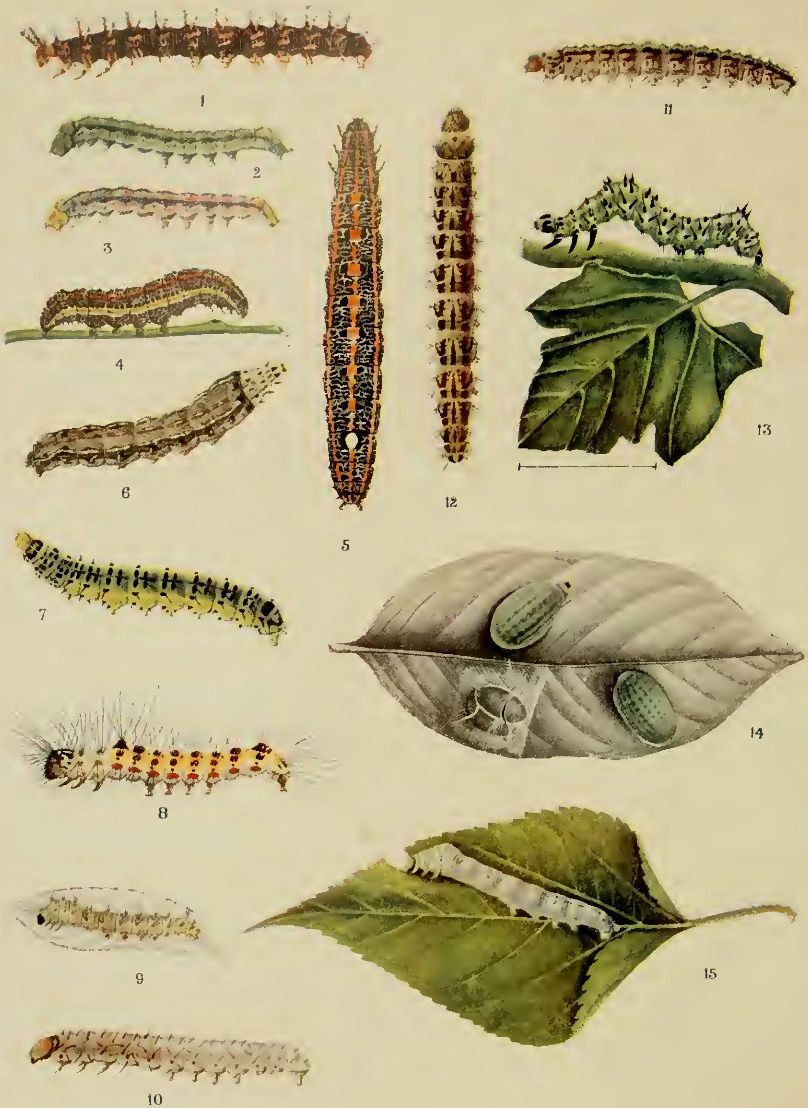
First tarsal joint shorter than the remainder together .. *Scolytinæ.*
First tarsal joint = the remainder .. .. *Platypinæ.*

The *Scolytinæ* are divided into three sub-families, *Scolytini*, *Hylesini*, *Tomicini* ; all are represented in Indian forests. We may mention *Xyleborus perforans*, Woll., reported some years ago as attacking beer casks in India and which is known to live in sugar-cane in the West Indies, where it however attacks only diseased cane. The mother beetle makes a tunnel in which she lays eggs, the larvæ feeding on fungus hyphæ in the cane and not boring themselves. (See Blandford, Kew Bulletin, September, 1890, April, 1892.) *X. fornicatus*, Eichh., attacks tea in Ceylon (Indian Museum Notes, III, 57), and Assam ; its presence is associated with a fungus and there is reason to believe it is also an "ambrosia" beetle, cultivating the fungus for its own food and for that of its larvæ. Of the *Platypinæ*, *Platydactyclus* (Eccotopterus) *sexspinosus*, Motsch., was reported as burrowing in the stalk of rice in Burmah. This observation has not been confirmed. The species is described by Blandford in Indian Museum Notes (III, p. 64). *Platypus pilifrons*, Chap., and *P. sordidus*, Wlk., occur in the plains. The *Platypinæ* are in some cases known to be ambrosia beetles.

STYLOPIDÆ.

These aberrant *Coleoptera* are of uncertain position. We are not aware that any are definitely recorded, but Horne, in his notes on the habits of Indian Aculeate Hymenoptera, states that many females of *Polistes hebræus* contain *Stylops* in the second abdominal segment. It is recorded that the genus *Polistes* is the host of *Xenos*, a genus in which the female is wingless and larviform, the male winged and active ; that *Xenos* occurs in *Polistes hebræus* in India has been ascertained recently, the male wasp showing the pupal cocoon projecting from its abdomen, as a brown body which on dissection proved to contain a dead male of *Xenos*. The hibernating females are also infested and in March, the female *Xenos*, in the body, yields abundant small active larvæ which apparently pass from the queens to their young in the new nests. The first brood of wasps is thus infected and from them males have been reared. The female is a mere egg-producing sac which lives always in the wasp and is fertilised there by the male, which is winged. Infection occurring thus in the nest, there is apparently a constant succession of broods; some wasps contain as many as three *Xenos*, which in their mature or pupal condition are readily visible as brown bodies attached at the junction of two abdominal segments, This *Xenos* appears to be a marked check on *Polistes hebræus*, a large percentage being infested in some cases.

Fig. 272.—Male of xenos from polistes hebræus. × 12.



CATERPILLARS.

PLATE XXVIII.—CATERPILLARS.

Fig. 1. Junonia orithyia. (Nymphalidæ).
,, 2. } Chloridea obsoleta (Noctuidæ).
,, 3. }
,, 4. } Catephia inquieta (Noctuidæ).
,, 5. }
,, 6. Sphingid.
,, 7. Glyphodes psittacalis (Pyralidæ).
,, 8. Porthesia xanthorhoea (Lymantriidæ).
,, 9. Bombyx mori, 2nd instar (Bombycidæ).
,, 10. Setomorpha tineoides (Tineidæ).
,, 11. } Cryptophlebia carpophaga (Tortricidæ).
,, 12. }
,, 13. Plusia agramma. (Noctuidæ).
,, 14. Belippa laleana. (Limacodidæ).
,, 15. Bombyx mori, full grown (Bombycidæ)