On the Subfamily Astatinae, with a Systematic Study of the Genus *Astata* of America North of Mexico (Hymenoptera: Sphecidae)[1]

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ABSTRACT

Three genera of Astatinae are recognized, namely, *Diploplectron* Fox, *Astata* Latreille, and *Dryudella* Spinola, the last-named having formerly been considered a subgenus of *Astata*. These are discussed and keyed. *Astata* is characterized, the biology of its species is summarized. Twelve Nearctic species, one with two subspecies, are keyed, described, and discussed, and their probable relationships are evaluated. New to science are: *Astata* **bakeri,** *A. nubecula* **bechteli,** *A.* **boharti,** *A.* **clypeata,** and *A.* **williamsi,** all western in their distribution though *A. bakeri* is reported also from Ontario.

During the 19th century many authors were engaged in describing species of North American Astatinae. However, except for *Diploplectron* Fox, the subfamily has received little attention during the 20th century. Cresson (1865, 1872, 1881) contributed fundamentally to the systematics of the Astatinae by describing 10 species, 8 of which are valid today. Fox (1892, 1894) presented synopses of the genus *Astata* Latreille which included keys to the described species. Other important workers of the 19th century were Say (1823, 1824), Ashmead (1897, 1899), and Cockerell and Fox (1897).

The knowledge of the Nearctic genera *Dryudella* Spinola and *Diploplectron* has been augmented recently by Williams (1946, 1950, 1959), who described several new species and made biological observations on them.

Since the taxonomic work of the previous century, new information and ideas have developed which call for a redefinition of the genus *Astata*. In this study seven previously described species are recognized, four new species and one new subspecies are described, and five names are regarded as synonyms. A key to the genera of Astatinae and one to the species of *Astata* are also presented. Holotypes have been deposited in the California Academy of Sciences.

I would like to express my appreciation to the persons who have assisted in making this study possible. To Dr. R. M. Bohart I am indebted for his examination of types and for his many helpful suggestions during the course of the study. I wish also to thank Dr. F. M. Summers and Mr. H. L. McKenzie, who reviewed the manuscript. Mr. Paul M. Marsh and Mr. Lionel A. Stange also furnished helpful information after examination of types.

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SUBFAMILY ASTATINAE

At the present time the subfamily Astatinae consists of two genera, *Astata* and *Diplopectron*. Previous authors have divided *Astata* into two subgenera, *Astata* and *Dryudella*. These two entities seem to be sufficiently distinct to warrant full generic status.

Most present-day authors consider the Astatinae to be the most primitive subfamily of the Sphecidae. Evans (1958b) points out that, although the adults share some characters in common with the Sphecinae and Larrinae, the larvae of *Astata* do not resemble those of either of them. Evans (1958b) also states that the Astatinae appear to have split from the primitive stock of Sphecidae a long time ago. From my studies I am inclined to agree on this point, since the Astatinae possess a number of unique characters which the other sphecids do not have. One should be careful in assuming the Astatinae to be very primitive, as they exhibit many specialized characteristics, both structurally and biologically. The forked setae of the labrum, the holoptic eyes of the males, and the enlarged anal lobe of the hind wing are a few of the more important characters.

KEY TO THE AMERICAN GENERA OF ASTATINAE NORTH OF MEXICO

1. Antenna with 13 segments, abdomen with 7 tergites (males) 2
   Antenna with 12 segments, abdomen with 6 tergites (females) 4
2. Dioptic ..... ***Diploplectron*** Fox
   Holoptic 3
3. Distal breadth of median clypeal lobe less than length of last antennal segment; median lobe reflexed ..... ***Dryudella*** Spinola

Distal breadth of median clypeal lobe much greater than length of last antennal segment; median lobe not reflexed ..... ***Astata*** Latreille

4. Pygidium with marginal, stout, recurved spines (fig. 38) ..... ***Astata*** Latreille
   Pygidium with few setalike hairs (fig. 39) 5
5. Flagellomere II as long as I (fig. 5); pleura shiny, spiculate ..... ***Diploplectron*** Fox
   Flagellomere II much shorter than I (fig. 3); pleura dull, granular ..... ***Dryudella*** Spinola

Diploplectron Fox, 1893

Currently 10 species of *Diploplectron* are recognized (Krombein 1951, 1958). However, relatively little is known about the genus, either taxonomically or biologically. The known distribution of *Diploplectron* is restricted to North Africa and North America.

Williams (1946) observed the nesting habits of two unidentified species. One of these provisioned its nest with nymphs of *Sphragisticus nebulosus* (Fallén), a small black lygaeid, and the prey of the other was *Rhyparochromus californicus* Van Duzee and also probably nymphs of *Emblethis vicarius* Horváth. The nest is constructed in sandy soil with several bugs to a cell.

This genus is closely related to *Dryudella*, but is easily distinguished in the male by its dioptic eyes as compared with the holoptic eyes of *Dryudella*. The females present more of a problem, but can be separated by the antennal characters as stated in the key.

Although the wing venation is reduced in *Diploplectron*, this is probably the most primitive genus in the subfamily. The species of this genus do not have the modified antennae, the enlarged anal lobe of the hind wing (fig. 43), the forked setae of the labrum (fig. 17), or the holoptic eyes.

Dryudella Spinola, 1843

Superficially *Dryudella* appears very similar to *Astata*, but when these two genera are critically examined they are found to be quite distinct. Their respective morphological differences are discussed under *Astata*. All the North American *Dryudella* appear to be closely related except for *D. caerulea* (Cresson), which differs not only in color, but structurally. The genus contains 10 described species (Townes 1951), some of which are probably synonyms.

The species of *Dryudella* are more specialized than *Diploplectron*. The finely granular punctation of the integument, especially of the propodeal enclosure, is quite distinctive, although some species of *Astata* approach this condition. Only the males of *Dryudella* have the area below the ocelli flattened and usually pigmented. The development of white pigmentation in most of the species of *Dryudella* indicates its relative advancement over the other genera.

The biology of the Nearctic forms of this genus is poorly known. The habits of only two species are recorded. Williams (1946) succeeded in rearing successive generations of *D. immigrans* (Williams) within glass jars. The nest is a short burrow with more than one cell. The prey consists of immature bugs of the lygaeid genus *Nysius*. Verhoeff (1951) recorded Pentatomidae and Scutelleridae as prey of the European *D. stigma* (Panzer).

The known distribution of *Dryudella* is restricted to North America, Africa, and Eurasia.

Genus ***Astata*** Latreille

Astata Latereille, 1796. Précis Caract. Génér. Ins. p. xiii (spelled *Astatus* on p. 114). Type: (*Tiphia abdominalis* Panzer)=[*Sphex*] *boops* (Schrank), included by Latreille, 1802.

Dimorphia Jurine, 1801. *In:* Panzer, Intelligenzblatt Literatur-Zeitung Erlangen 1: 164. Type: (*Tiphia abdominalis* Panzer)=[*Sphex*] *boops* (Schrank), monobasic.

Astatus Latreille, of Fox, 1892 and 1894. Canadian Entomol. 24: 232; and Proc. Acad. Nat. Sci. Philadelphia 1893: 539.

Astata Latreille, of Maidl and Klima, 1939. Hymenopt. Cat. pars 8 (Sphecidae 1): 8.

Astata, subgenus *Astata* Latreille, of Townes, 1951. U. S. Dept. Agric., Agric. Monogr. 2: 939.

General Appearance: Small, 6 to 17 mm., stout-bodied wasps. Head and thorax black; abdomen either black or red, or a combination of red and black; wings usually stained in part; texture of body coarse, punctate, shiny.

Head: Compound eyes holoptic, reddish brown in males; dioptic, black in females. Flagellomere I longest, others decreasing in length toward apex in males; flagellomeres of females variable; clypeus of male with median truncate lobe, as broad apically as length of fifth segment of maxillary palpus, broader basally; clypeal lobe of female with lateral margins parallel; mandible bidentate, inner tooth subapical; marginal setae of labrum forked or branched; maxillary palpus six-segmented, labial palpus four-segmented; pubescence of head short, thick, erect, that of occipital area long, twisted; clypeal bristles stout, projecting forward.

Thorax: Pitting of scutum, scutellum variable, margins heavily pitted, shagreened; summits shiny, hardly punctate; dorsal propodeal enclosure reticulate, reticules of the males closer together than those of the females; coxae, trochanters, femora spiculate; tibiae, tarsi spinous, more so on mid- and hindlegs; females with tarsal comb. Pubescence short, erect in males, that of females setalike, projecting posteriorly; postscutellum, propodeum with long twisted hairs.

Wings: Marginal cell truncate, appendiculate, and exceeding third submarginal cell. Marginal cell, measured from apex of pterostigma to apex of marginal cell, longer than length of pterostigma, except in females of *nevadica* Cresson; second submarginal cell receiving first recurrent vein medially (fig. 40); anal lobe of hind wing very broad in male (fig. 40), narrower in female.

Abdomen: Apex of sternite VII in males somewhat truncate, spatulate (fig. 36); pygidium spatulate in males, trigonal in females. Pitting obscure. Sternal pubescence of males long, twisted; females with sparse, apical, setalike pubescence on sternites; first

tergite of males with long twisted hairs, others with short, marginal setae; tergites of females with short, sparse, marginal setae; pygidium with sparse setae in males; stout spines recurving posteriorly, bordering the pygidium of the female (fig. 38).

Astata can be distinguished from *Dryudella* by a number of characters, most of which are in the male sex. The males of the two genera are separated by the following combination of characters: the truncate clypeal lobe of *Astata* is three times as broad apically as that of *Dryudella*; the area before the declivity of the face is not flattened or pigmented like that of *Dryudella*; the anal lobe of the hind wing is broader in *Astata* (fig. 40) than in *Dryudella* (fig. 41); *Astata* (except *unicolor* Say) possesses medial brush-like hairs on some of the sternites which *Dryudella* does not have; the apical lobe of sternite VII is more pointed in *Dryudella* (fig. 37) than in *Astata* (fig. 36); tergite III is wider in *Dryudella* than in *Astata*. The females can be separated by the pygidial spines which are uniform, recurved and bordering the pygidium in *Astata* (fig. 38), whereas in *Dryudella* they are erect, sparse and do not border the pygidium (fig. 39). In both sexes of *Astata* the marginal spines of the labrum are forked (fig. 16) and the integument of the body is shiny, coarsely punctate. The marginal spines of the labrum are never forked nor branched in *Dryudella* (fig. 17) and the integument is dull, finely granular. The length of the marginal cell is much greater in *Astata* (except females of *nevadica*) (fig. 40) than in *Dryudella* (fig. 41). The first recurrent vein joins the second submarginal cell closer to the first transverse cubital side in *Dryudella* than in *Astata*. The coloration of the abdomen is never black in *Dryudella* as is the case in some species of *Astata*.

Astata is the largest genus in the subfamily and the only one which is cosmopolitan.

BIOLOGY

The males of *Astata* have unique behavioral characteristics. They are often seen perched on some object, such as a clod, rock, or twig. From this perch short, spontaneous flights are made. These flights are so quick that they are almost impossible to observe. After one of these short flights the wasp returns to the same perch, rotating its body with the antennae rigidly extended.

Both males and females are often seen crawling among weeds. I once observed the copulation of a pair of *Astata* among the foliage of *Tetradymia glabrata*. From this observation and from the fact that the males and females are often observed among the stems of plants, I believe that copulation occurs in that situation and not during the perching activity of the males.

It is characteristic of *Astata* that several species are found together. I have often observed this semi-social sort of behavior. During the perching activity of the males, it is not unusual to find several species perched close to one another. Frequently more than one species is found among the stems of a plant, whereas none are found on similar plants nearby.

Nest Construction: The location of the nest varies among the members of the genus. Some species of *Astata* nest beneath overhanging vegetation whereas others prefer open, bare soil. The type of soil in which the nest is constructed also depends upon the species. Some prefer loose, sandy soil whereas others nest in hard, compact clay. According to Evans (1958a) the primary burrow penetrates the ground at an angle of from 40° to 80° with the surface and varies from 7 to 15 cm. long. The earth from the burrow is piled up at the entrance and is never scattered. At the end of the burrow a broad, elliptical cell is constructed, the walls of which are smooth and polished. When the cell is provisioned, the end is sealed with a small plug of dirt. Additional cells are constructed above the first one in a short chain. Side-burrows are constructed from the initial burrow. These are usually short, with from one to three cells. The arrangement of the side branches along the initial burrow depends on the type of soil utilized. A nest may contain as many as 14 cells when completed.

Hunting and Provisioning: The usual prey of *Astata* consists of adults and nymphs of Pentatomidae or Lygaeidae, depending on the size of the wasp. Also Scutelleridae, Coreidae, or Cydnidae are captured either with or in place of the usual prey.

The female hunts its prey in weedy areas and is often seen crawling up and down plant stems. When the bug is located, the wasp grasps and stings it to immobility. Evans (1958a) states that the wasp then may either clean herself or grasp the bug by the base of the antennae, venter up, and fly off with all her legs straddling the bug. Upon landing the prey is held by the antennae. The wasp never moves directly to the burrow, but takes a circuitous route to the nest entrance. The bug is then either brought into the nest directly or left outside and pulled in. Ultimately the bug is placed at the bottom of the burrow and loosely covered with soil. Upon emerging from the nest entrance the wasp again orients herself by circling the nesting area, either by walking, hopping, or flying.

Evans (1958a) observed that a cell is constructed only after several bugs are accumulated. It is possible that cell construction takes place after the completion of a day's hunting. The bugs are stored venter down, horizontally, and are tightly packed in the cell in a very specific manner. The egg is attached to the prosternum of the first bug so that it projects backward along the midline of the body, the posterior end always free. The number of prey stored in a single cell varies from two to nine, depending on the size of the bugs.

Evans (1958a) has observed that the egg usually hatches within 3 days, and the resulting larva remains feeding at the point of attachment for the first few days. In later instars the larva feeds on the remaining store of bugs and can move about the cell by means

of a middorsal lobe which acts as a pseudopod. Larval maturity is reached in about 8 days, at which time a cocoon is spun. The larva merely lines the smooth cell walls to form a very flimsy cocoon. It then either pupates or enters diapause, depending upon the species, time, and locality.

Parasites: The Peckhams (1898) described an instance wherein a chrysidid (*Chrysis*) entered a nest of *A. unicolor* Say, but they were unable to determine whether it was actually parasitizing *unicolor*. Powell and Burdick (1960) observed another cuckoo wasp (*Hedychrydium*) flying about the nesting site of *A. occidentalis* Cresson, but they were unable to link the two together as host and parasite. There is one definite *Astata*-chrysidid association. A pinned specimen of *Holopyga* sp. bears the label "ex nest of red-abdomen *Astata* stored with bugs, November, 1951." The specimen was reared by F. X. Williams from material taken at Danvile, Contra Costa County, California.

Powell and Burdick also encountered several females of *Myrmosa bradleyi* Roberts (Tiphiidae) crawling about the nesting site and entering the burrows of *occidentalis*. They, however, were not able definitely to associate the two species.

These are the only parasite records of the North American species of *Astata*. Undoubtedly additional parasites will be discovered when more biological studies are made on this genus.

KEY TO THE AMERICAN SPECIES OF *ASTATA* LATR. NORTH OF MEXICO

1. Holoptic (males) 2
   Dioptic (females) 16
2. Abdomen marked with red 3
   Abdomen completely black 10
3. Either abdominal sternite IV or V emarginate medially (figs. 30–35) 4
   Sternites entire medially 7
4. Abdominal segments V-VII black, others red; reticules of propodeal enclosure large, raised ..... ***bicolor*** Say
   Abdomen all red; reticules of propodeal enclosure small, radiating laterally 5
5. Hind coxa flanged on inner anterior margin (fig. 10) ..... ***nevadica*** Cresson
   Hind coxa rounded on inner anterior margin 6
6. Abdominal sternite V slightly emarginate medially (fig. 35) white pubescence of sternites interspersed with brownish-black hairs ..... ***williamsi*** Parker
   Abdominal sternite V with U-shaped medial emargination (fig. 34); pubescence of sternites white ..... ***mexicana*** Cresson
7. Last three abdominal segments black or dark brown, others red 8
   Abdomen completely red ..... ***boharti*** Parker
8. Body pubescence black 9
   Body pubescence white ..... ***bakeri*** Parker
9. Tangential line between compound eyes at most equal to length of flagellomere I; mid coxa ridged on inner ventral margin, flattened posteriorly ..... ***nubecula nubecula*** Cresson
   Tangential line between compound eyes equal to length of scape and flagellomere I taken together; mid coxa without ridge on inner ventral margin, slightly depressed posteriorly ..... ***nubecula bechteli*** Parker
10. Prominent raised median carina on propodeal enclosure (fig. 2); either flagellomeres broadly rounded beneath (fig. 12) or the mandible with a white band medially 11
    Propodeal enclosure without distinct, raised median carina (fig. 1); flagellomeres with tyloides (fig. 11), mandible without white band 12
11. Mandible with a white band medially; tyloides present on flagellomeres III-VIII ..... ***clypeata*** Parker
    Mandible black medially; flagellomeres broadly rounded beneath ..... ***unicolor*** Say
12. Body pubescence black 13
    Body pubescence white 14
13. Tangential line between compound eyes at most equal to length of flagellomere I; mid coxa flattened posteriorly, ridged on inner ventral margin ..... ***nubecula nubecula*** Cresson
    Tangential line between compound eyes equal to length of scape and flagellomere I taken together; mid coxa without ridge on inner ventral margin, slightly depressed posteriorly ..... ***nubecula bechteli*** Parker
14. Tangential line between compound eyes equal to length of flagellomeres II and III taken together; forewing with triangular-shaped medial brown stain ..... ***bigeloviae*** Cockerell and Fox
    Tangential line between compound eyes at most equal to length of flagellomere II; forewing stained in cellular area 15
15. Pubescence of sternites white, interspersed with long, dark brown setae; striae on propodeal enclosure close, radiating laterally ..... ***occidentalis*** Cresson
    Pubescence of sternites light; striae on propodeal enclosure widely spaced, radiating posteriorly ..... ***leuthstromi*** Ashmead
16. Abdomen marked with red 17
    Abdomen entirely black 25
17. Ventral surface of mid coxa bare, small spine or tubercle present (figs. 4 and 7) 18
    Ventral surface of mid coxa pubescent, without spine or tubercle 21
18. Flagellomere II shorter than I (fig. 6); stigma yellowish, transparent ..... ***bicolor*** Say
    Flagellomere II as long as I (fig. 9); stigma black 19
19. Marginal cell not exceeding third submarginal cell; pubescence of face, sternum, sternites black ..... ***nevadica*** Cresson
    Marginal cell exceeding third submarginal cell; pubescence of face, sternum, sternites white 20
20. Pits large, clumped between ocelli (fig. 13); pubescence of face and thorax long, as long as flagellomere I ..... ***mexicana*** Cresson
    Pits small, evenly spaced between ocelli (fig. 14); pubescence of face and thorax short, not longer than length of flagellomere IV ..... ***williamsi*** Parker
21. Vertex and posterior part of scutum heavily punctured; distinct median carina on propodeal enclosure 22
    Vertex sparsely pitted, posterior margin of scutum shiny, hardly punctate; propodeal enclosure at most with broken, discontinuous median carina 23
22. Pubescence of sternites black; wings violaceous ..... ***boharti*** Parker
    Pubescence of sternites white; wings at most lightly brown stained ..... ***unicolor*** Say
23. Pubsecence of body silvery-white ..... ***bakeri*** Parker
    Pubescence of body black 24
24. Mesopleura shiny, spiculate ..... ***nubecula nubecula*** Cresson
    Mesopleura reticulate ..... ***nubecula bechteli*** Parker
25. Abdominal sternite II bare medially; median clypeal lobe toothed ventrally 26

Abdominal sternite II pubescent medially; median clypeal lobe truncate, without ventral tooth 27

26. Clypeal margin incised on either side of medial lobe (fig. 15) ..... ***clypeata*** Parker
Clypeal margin entire on either side of medial lobe ..... ***occidentalis*** Cresson

27. Vertex and posterior part of scutum heavily pitted 28
Vertex sparsely punctured; scutum shiny, hardly punctate 29

28. Sternal bristles black; pleura reticulate; forewing violaceous ..... ***bigeloviae*** Cockerell and Fox
Sternal bristles white; pleura spiculate; forewing light brown posteriorly ..... ***unicolor*** Say

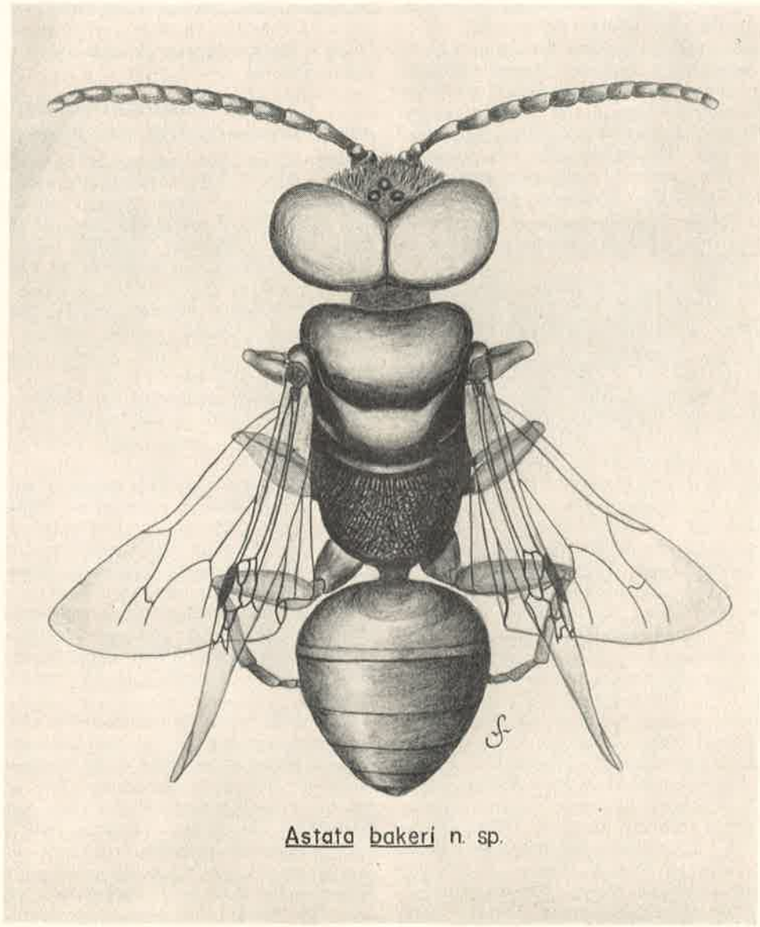
29. Pubescence of sternum yellowish-white ..... ***leuthstromi*** Ashmead
Pubescence of sternum black 30

30. Mesopleura spiculate ..... ***nubecula nubecula*** Cresson
Mesopleura reticulate ..... ***nubecula bechteli*** Parker

Astata bakeri Parker, n. sp.

Text figure 1

Male.—Black; red apically on abdominal segment II, posteriorly on segment IV, all of segment III; tarsi reddish brown; cellular area of forewing light brown, hyaline posteriorly; hindwing clear anteriorly, light brown posteriorly. Head, thorax, abdomen clothed with silvery pubescence; sternites IV–VI with short, medial, tan, brushlike hairs projecting posteriorly. Punctation moderate, close on head, thorax; punctures of scutum close, evenly spaced over entire area, except summit; scutellum shiny with scattered pits on summit; postscutellum shagreened; propodeal enclosure finely reticulate, reticules close, radiating laterally from postscutellum; side of pro-



TEXT FIG. 1.

podeum spiculate. Flagellomeres II-VIII with double, orange tyloides; tangential line between compound eyes equal to length of flagellomeres III–IV taken together; mid coxa ridged on inner ventral margin. Body length 9 mm., wing length 7.5 mm.

Female.—About as in male except as follows: abdomen completely red; wings clear anteriorly, brownish posteriorly. Punctation close on face; interocellar area with 25 to 35 pits; vertex shiny, sparsely pitted; scutum shiny, moderately pitted anteriorly; scutellum, postscutellum shiny with few punctures; mesopleura shiny, faintly striate posteriorly. Body length 6.5–7.5 mm., wing length 5–6 mm.

A. bakeri has been mistaken for *bicolor,* which is superficially very similar. The males of these two species can be separated by the shape of sternite IV which is emarginate in *bicolor* (fig. 32), but entire in *bakeri.* The densely pubescent mid coxa of the *bakeri* females distinguish them from *bicolor* females.

Two females from Menlo Park, California (F. X. Williams) were taken carrying *Nysius raphanus* Howard; one was carrying an adult and the other a nymph. On the same pin with the nymph is another nymph, probably of *Lygaeus bicrucis* Say, which was dug from the nest. This information was published by Williams (1946) under an undescribed species.

A. bakeri is one of the commonest members of the genus. It is widely distributed over western North America, occupying a habitat comparable to that of the eastern *bicolor.*

Types.—Holotype male and 16 paratypes: Davis, California, Sept. 27, 1959, on *Tamarix* (F. D. Parker). Other paratypes, CALIFORNIA: 7 males, 5 females, Davis, July 9-Oct. 13, 1953-59 (R. W. Bushing, H. M. Court, A. T. McClay, L. A. Stange, F. D. Parker); Woodland, Aug. 15-20, 1953 (A. T. McClay). Paratypes deposited in the collections at (UCD), (CIS), (USNM), (AMNH), and (UK).

This species is dedicated to Mr. Charles W. Baker, a close friend and student in entomology.

Distribution: In addition to the type series I have seen 248 males and 154 females from the following states and provinces in North America: ARIZONA: ShowLow, Portal, Tsegi, Oracle, Dewey, Phoenix, Fort Apache, Seneca, Bumble Bee, Stafford, Tucson, Organ Pipe Nat'l Mon., Eloy, Willcox, Huachuca Mts., Kingman, Cedar Creek. NEW MEXICO: Granite Pass, Rodeo. TEXAS: Lee Co., Davis Mts., Carrizo Springs. KANSAS: Norton Co. NEBRASKA: Mitchell. IOWA: Sioux City. SOUTH DAKOTA: Piedmont. WYOMING: Quincy, Lusk, Lyman, Grand Teton Nat'l Park, Freedom. COLORADO: Golden, Craig, Pueblo, Fort Collins, Salida, Boulder, Crowley Co. UTAH: Farr West, Collinston, Newton, Park Valley, Farmington, Corinne, Logan, Snowville, Elberta, Tooele, Erda, Paragonah, Murray, Garfield, Delta, Petersboro, Cedar City, West Utah Lake, Salt Lake, Uintah Co., Cornish, Portage, Showell, Amalga, Grantsville, Curley Valley, Smithfield, Myton. NEVADA: Bunkerville, Kalamazoo Creek, Yerington, Paradise Hill, Hazen, Lamoille Canyon, Mesquite, Canyon Creek, Paradise Valley, Gerlach, Mustang, Reno. CALIFORNIA: Yucaipa, Menlo Park, Imperial Co., Quincy, Blythe, Goleta, Coachella, Stockton, Danville, San Leandro, Artois, Wood Lake, Santa Cruz, Tolay Creek, McFarland, Hopkins Well, Hallelujah Junction, Lake Forest (Lake Tahoe), Berkeley, Ludlow, Tracy. OREGON: LaGrande, Corvallis, Wallowa Mountains, Blooming, Near Crane, Eagle Ridge, Klamath Lake. WASHINGTON: Lind, Prosser. IDAHO: Sublett, Emery Canyon, Lewiston, Owynza, American Falls, Springfield, Rupert, Preston, Parma, Coyote Grade, Regina, Grandview, Saint Anthony, Weiser, Fruitland, Castleford, Hollister, Weston, Twin Falls, Melba, Robin, Nampa, Payette, Mountain Home, Montpelier, Luck Pass, Notus, Coeur d'Alene. MONTANA: Huntley, Bozeman, Sweetgrass Co., Ravalli Co. BRITISH COLUMBIA: Kamloops, Vernon, Okanagan Falls, Richter Pass Road, Oliver. ALBERTA: Lethbridge, Onefour, Ludge, Burdett, Taber, Irving. SASKATCHEWAN: Rock Glen. ONTARIO: Prince Edward.

Astata leuthstromi Ashmead

Astata leuthstromi Ashmead, 1897. Psyche 8: 129.

Male.—Black; forewing dark brown in cellular area (light brown in eastern specimens), anal part clear; hindwing hyaline. Head, thorax, abdomen clothed with thick, silvery pubescence; sternites IV–VI with short, medial, yellowish, brushlike hairs projecting posteriorly. Punctation moderate on head, notum; mesopleura shiny with faint oblique striae; propodeal enclosure uniformly reticulate, reticules widely spaced, broken, slightly raised; median posterior portion of enclosure depressed, striae broken. Flagellomeres III-VIII with tyloides, those on IV-VII double, anterior one larger; tangential line between compound eyes equal to length of flagellomere IV; sternite II slightly humped. Body length 7.5–11 mm., wing length 6.5–8 mm.

Female.—About as in male except as follows. Forewing darkly stained posteriorly. Pubescence of sternum light, golden-tan, projecting posteriorly; that of sternite II, short, light; other sternites mostly bare except for marginal dark setae. Punctation close on face; interocellar area with 35 to 45 small pits; vertex, scutum, scutellum shiny with scattered pits; pleura obliquely striate towards propodeum; side of propodeum vertically striate, striae becoming reticules dorsally. Body length 7–12 mm., wing length 6.5–9 mm.

Fox (1892) recorded this species as a white-haired variety of *nubecula.* It has been confused by many authors either as *nubecula* or as *occidentalis.* The males are difficult to distinguish from *occidentalis,* but by a combination of characters they can be separated. The larger compound eyes, the more openly reticulate propodeal enclosure, the slightly humped second sternite, and the darker staining of the wings readily distinguish *leuthstromi* from *occidentalis.* The females have been confused with *nubecula,* but are readily separated by their golden-tan pubes-

cence on the head, sternum, and second abdominal sternite. The pubescence is entirely black in *nubecula*.

The nesting behavior of the females has been recorded twice, but both attempts at excavating the nests were unsuccessful. One nest was located beneath a dead weed. Evans (1957) recorded the prey to be nymphs of *Cosmopepla bimaculata* (Thomas).

There appear to be two forms of this species in respect to wing pigmentation. The eastern forms have the wings almost hyaline, whereas in the western forms the wings are very dark. Also the reticules of the propodeal enclosure are larger and more widely spaced in the eastern specimens than in the western material. I do not feel that these slight differences sanction a subspecific rank.

This species is widely distributed over Canada, parts of Alaska, and the northern part of the United States. The southernmost record I have examined is from Arizona.

Material Examined: 105 males, 68 females.

Astata nubecula nubecula Cresson

Astata nubecula Cresson, 1865. Proc. Entomol. Soc. Philadelphia 4: 466.
Astata nigropilosa Cresson, 1881. Trans. Amer. Entomol. Soc. 9: Proc. p. iv.

Male.—Black; anterior part of abdomen occasionally red; wings dark brown, anal portion sometimes clear. Pubescence of body black; sternites IV–VI with short, medial, brownish, brushlike hairs projecting posteriorly. Integument shiny, finely spiculate; summit of scutellum shiny, slightly punctured; propodeal enclosure reticulate, reticules broken, widely spaced, radiating from postscutellum; propodeal side spiculate. Flagellomeres IV–VIII with round tyloides, sometimes slightly pointed; tangential line between compound eyes at most as long as length of flagellomere I; mid coxa ridged on inner ventral margin, posteriorly flattened; sternite II slightly humped medially. Body length 8–13 mm., wing length 7–10 mm.

Female.—About as in male except as follows. Abdomen sometimes entirely red; forewing darker posteriorly. Punctation close, distinct on face; interocellar area with 45 to 60 pits; vertex shiny, sparsely punctured; scutum shiny, closely pitted anteriorly; scutellum shiny with few pits; pleura shiny, spiculate; reticules of propodeal enclosure fewer, more widely spaced; side of propodeal enclosure reticulous dorsally, posteriorly. Body length 9–13 mm., wing length 7–9.5 mm.

A. nubecula is distinguished from all other species by its thick black pubescence. This is the most variable member of the genus. In the males the shape of the compound eyes, the tyloides, and the mid coxa vary. The punctation of the body and the wing staining are variable in the females. From the material studied the species appears to be differentiating into a number of subspecies. There is, however, only one entity that merits subspecific rank.

The abdomen of *nubecula nubecula* is either black, black and red, or entirely red. The individuals with the abdomen marked with red are found only from May-July (first generation) and make up only a small percent of the total specimens (414:26).

One female with a red abdomen is worth special mention. The propodeal enclosure is shiny, not reticulate, with several large, wavy, raised striae radiating from the postscutellum. This is the only specimen that I have examined with such a propodeum. Since it agrees in general with *nubecula* I have placed it here until more material is available.

Nothing has been published on the biology of this subspecies. Pinned with some of the females are nymphs of pentatomids. Dr. R. M. Bohart dug three pentatomids from one nest which was constructed in sandy soil. The nymphs were identified as *Thyanta* sp., probably *casta* Stål or *pallidovirens* Stål by Dr. R. C. Froeschner.

The distribution of this subspecies includes the northern states of North America, extending, finger-like, as far south along the coast as San Diego. In the East, it extends as far south as Virginia. In the Great Basin it is primarily northern, but extends southwards along the north-south mountain chains.

Material Examined: 229 black, 21 red males; 164 black, 5 red females.

Astata nubecula bechteli Parker, n. ssp.

Male.—Black; forewing dark brown from basal vein to end of cellular area, clear posteriorly; hindwing hyaline. Integument dull, reticulate except sternum which is shiny, spiculate. Flagellomeres IV–VIII with double tyloides, anterior one larger; tangential line between compound eyes equal to length of scape and flagellomere I taken together; mid coxa rounded beneath, slightly angulate on inner ventral margin. Body length 9.5 mm., wing length 8.0 mm.

Female.—About as in male except as follows: forewing dark brown, violaceous. Interocellar area with 40 pits; side of propodeum with raised reticules, those posteriorly larger. Body length 6–13.5 mm., wing length 6.5–9.5 mm.

This subspecies is characterized in the female by the reticulate pleura and in the male by a combination of characters. The tangential line between the compound eyes is much larger in *n. bechteli*, causing the eyes to appear bulging. The mid coxa is rounded or slightly angulate in *n. bechteli* whereas the mid coxa is ridged on the inner ventral margin and flatter posteriorly in *n. nubecula*.

The distribution of this subspecies is more southern than that of *n. nubecula*, extending over the desert areas of California, Arizona, New Mexico, Texas and most of the Great Basin, the southern parts of Oregon, Idaho, and easternly in Wyoming and Colorado.

Types.—Holotype male and four paratypes: 6 miles south Beowawe, Eureka Co., Nevada, Sept. 15, 1957, on *Chrysothamnus albidus* (R. C. Bechtel). Other paratypes 9 males, 6 females, NEVADA: 20 mi. S. Beowawe, VIII-29-57 (R. C. Bechtel); Golconda,

V-31-57 (T. R. Haig); 26 mi. N.E. Golconda, IX-12-57 (R. C. Bechtel); Orovada, VII-14-60 (F. D. Parker); 42 mi. S.E. Warm Spring, Nye Co., VI-26-58 (R. W. Lauderdale); 44 mi. W. Hiko, VIII-25-58 (R. W. Lauderdale); 8 mi. E. Hiko, VII-20-58 (F. D. Parker); Valmy, IX-13-56 (T. R. Haig); Alamo, VII-22-58 (R. C. Bechtel); Coyote Summit, Lincoln Co., VIII-20-58, on *Chrysothamnus* (R. C. Bechtel); 18 mi. S. Caliente, VIII-20-58, on *Eriogonum* (R. W. Lauderdale). Paratypes deposited in the collections at (UCD), (CIS), (NSDA), (USNM), (AMNH), and (UK).

This subspecies is named for Mr. Robert C. Bechtel, who collected many specimens of this group.

Material Examined: In addition to the type series I have seen 64 black males, 37 black, 1 red females from the following states: CALIFORNIA: Lancaster, Lassen Park, Yermo, Cuyama Ranch, Blythe, Hallelujah Junction, Boca, Coachella, Imperial Co., Borrego Springs. NEVADA: Reno, Baker. UTAH: Delta, West Utah Lake, Salt Lake Co., Park Valley, Curley Valley, Beaver Canyon, Soldier Summit. ARIZONA: Houserock Ranch, Pearce, Toltec, Elfrida. NEW MEXICO: Albuquerque, Pinedale, Rodeo. COLORADO: Livermore. WYOMING: Worland, Toppenish, Shoshone National Forest. MONTANA: Huntley. IDAHO: Owynza, Fall Creek, Twin Falls, Burley, Hollister, Glenns Ferry, Bliss, Terreton, Shoshone, Melba. OREGON: Grants Pass, Tollgate. WASHINGTON: Lind.

Astata bigeloviae Cockerell and Fox

Astatus bigeloviae Cockerell and Fox, 1897. Proc. Acad. Nat. Sci. Philadelphia, p. 138.

Male.—Black; forewing hyaline with V-shaped, brown band medially in cellular area. Head, thorax, abdomen with silvery-white pubescence; sparse, tan, brushlike hairs medially on sternites V–VI. Punctation of pleura coarse, reticulate, hammered-like; summit of scutum shiny, sparsely punctured; surface of propodeal enclosure with reticules radiating laterally from postscutellum. Flagellomeres III–VIII with tyloides, double on segments IV–VIII. Tangential line between compound eyes equal to length of flagellomeres II and III taken together. Sternite II slightly humped medially. Body length 10–11.5 mm., wing length 8–9 mm.

Female.—About as in male except as follows. Forewing dark brown, violaceous; hind wing light brown apically. Pubescence medially on face, clypeal lobe stiff, black; that of occipital area, postscutellum long, silvery-white; stiff, black setae projecting posteriorly on anterior part of scutum, sternum, abdominal sternites. Pitting coarse on face; interocellar area with 25 to 30 oval, merging pits; small group of pits above each ocellus on vertex; scutum shiny, heavily pitted anteriorly, along parapsidal sutures, posteriorly; propodeal enclosure finely reticulate, appearing granular; side of propodeum striate towards dorsum, striae ending in large reticules. Body length 9–10 mm., wing length 7–8 mm.

Previously the male of this species was undescribed. Males are easily recognized by their large, bulging compound eyes, the V-shaped, brown staining of the forewing, and the hammered-like punctation of the body. The females are characterized also by the hammered-like body sculpturing. The heavy pitting of the vertex and the white pubescence of the sternum and postscutellum are distinctive characters in the females.

This species is closely related to *boharti.* The females are especially close, but *bigeloviae* is easily distinguished by the black abdomen, whereas the abdomen of *boharti* is red. The females of *nubecula* and *bigeloviae* have been confused, but they can be distinguished from one another by the color of the pubescence of the occipital area and the postscutellum which is white in *bigeloviae* and black in *nubecula.* The males are similar to both *occidentalis* and *leuthstromi,* but the large, bulging eyes readily distinguish it from the others.

There have been no observations recorded on nest construction or the prey of this species, but there is one floral record (*Baileya multiradiata* var. *pleniradiata* Cov.).

The distribution of this species, from known records, appears to be restricted to the southwestern desert areas of North America. I have examined specimens from California, Arizona, New Mexico, and western Texas.

Material Examined: 10 males, 7 females.

Astata boharti Parker, n. sp.

Male.—Black; abdomen red except base of segment I, sternite II; wings hyaline anteriorly, brown posteriorly. Head, thorax, apical margin of tergites clothed with silvery-white pubescence; sternite II with stiff, long brownish-black setae; sternites III–VII with marginal stiff, black setae, not longer than last hind tarsal segment; sternites V–VI with medial, tan, brushlike hairs projecting posteriorly. Punctation coarse on head; pleura reticulate, appearing hammered; scutum heavily pitted over most of surface, summit moderately pitted; scutellum shiny with few scattered punctures; postscutellum shagreened; dorsal propodeal surface granular, finely reticulate; reticules raised, radiating laterally from faint median carina; side of propodeum reticulate. Flagellomeres IV–VIII with double tyloides, the anterior one larger; tangential line between compound eyes equal to length of flagellomere IV; mid coxa slightly ridged on inner ventral surface; sternite II sharply humped medially. Body length 11 mm., wing length 9 mm.

Female.—About as in male except as follows. Abdomen completely red; forewing dark, violaceous; hindwing clear anteriorly, dark brown posteriorly. Clypeal bristles stiff, black; sternal bristles black, setalike. Punctation close on face; interocellar area heavily pitted; vertex heavily pitted above ocelli, summit sparsely punctured; scutum shiny, moderately punctured anteriorly, posteriorly; scutellum shiny, hardly pitted; postscutellum shagreened, summit shiny; side of propodeum reticulate, reticules larger

posteriorly. Body length 10–11 mm., wing length 8–9 mm.

A. boharti might be confused with the red form of *nubecula,* but the former can be distinguished by the occipital and postscutellar pubescence which is white.

This species is known only from four specimens from the mountainous regions of southern Arizona and New Mexico.

Types.—Holotype male and one paratype: 18 mi. N. Rodeo, New Mexico, VIII-25-58 (C. G. Moore, R. C. Rice). Other paratypes, 2 females, ARIZONA: Brown Canyon, Baboquivari Mountaïns, IX-7-58 (A. Menke, L. Stange); Sabino Canyon, VIII-17-54 (R. M. Bohart). Paratypes deposited in the collection of (UCD) and in the author's collection.

This species is dedicated to Dr. Richard M. Bohart, of the University of California, Davis.

Astata occidentalis Cresson

Astata occidentalis Cresson, 1881. Trans. Amer. Entomol. Soc. 9: Proc. p. iii.
Astatus sayi Fox, 1894. Proc. Acad. Nat. Sci. Philadelphia 1893: 542.

Male.—Black; forewing light brown in cellular area, anal portion clear; hind wing hyaline. Head, thorax, abdomen clothed with silvery pubescence, that of sternites white, interspersed with brown; sternites IV–VI with short, medial, tan, brushlike hairs projecting posteriorly. Punctation of head, scutum, scutellum, postscutellum granular, summits shiny; that of pleura suggesting broken striae; propodeal enclosure closely reticulate, numerous thin, close, striae radiating from postscutellum; median posterior margin of propodeum depressed with recurrent striae. Flagellomeres IV–VIII with double tyloides, anterior ones larger; tangential line between compound eyes equal to length of flagellar segment VI; mid coxa slightly ridged on inner, ventral surface. Body length 9.5–13 mm., wing length 7.5–11 mm.

Female.—About as in male except as follows. Forewing brown, darker posteriorly. Pubescence stiff, black, projecting posteriorly on anterior portion of scutum, sternum; sternites mostly bare medially and apically. Punctation moderate, close on face; interocellar area with 50 to 70 small, merging pits; vertex shiny, sparsely pitted; scutum mostly shiny, lightly pitted anteriorly; scutellum shiny, sparsely punctured; postscutellum striate, summit shiny; pleura finely, obliquely striate towards propodeum; dorsal propodeal enclosure reticulate, reticules large, widely spaced, median carina broken anteriorly; propodeal side striate, striae ending in large reticules posteriorly. Median clypeal lobe with prominent medial ventral lobe or tooth, appearing tridentate; flagellomere II nearly as long as I (fig. 8). Body length 10–15 mm., wing length 8–12 mm.

A. ocidentalis is one of the largest species in the genus and the females are often as large as the males. The staining of the wings varies in the males from a light brown to a dark brown.

A. sayi Fox is merely a form of *occidentalis* in which the scutum is entirely pitted. It appears to be an east coast variant. The males from this area, however, do not differ from typical *occidentalis.*

Recent biological studies have established that this species preys almost exclusively on adult Pentatomidae. Evans (1958a) reported the prey to be *Hymenarcys nervosa* (Say), *Thyanta calceata* (Say), *Thyanta pallidovirens accerra* McAtee, *Euschistus variolarius* (Beauv.), *Holcostethus limbolarius* (Stål), and *Banasa calva* (Say). Prey reported by Powell and Burdick (1960) were *H. limbolarius* (Stål), *Thyanta brevis* Van Duzee, *Thyanta p. pallidovirens* Stål, *Perillus bioculatus* (Fabr.), and *Thyanta punctiventris* Van Duzee; also two nymphs, one of *Trichopepla* sp. and one of *T. p. pallidovirens.* Other habits are typical of the genus.

This species is widely distributed over the entire United States. In Canada the range appears to be limited to the southern provinces. In Mexico it ranges as far south as Michoacán and is also found on the southern tip of Baja California. This species is more commonly collected in the Lower Sonoran areas.

Material Examined: 231 males, 140 females.

Astata clypeata Parker, n. sp.

Male.—Black; mandible creamy yellow medially; cellular area of forewing light brown, anal portion clear; hind wing hyaline. Head, thorax, abdomen clothed with silvery pubescence; sternites with long, mixed tan and silvery pubescence; sternites V–VIII with medial patch of short, tan setae projecting posteriorly. Punctation of body close, coarse, granular; summits of scutum, scutellum shiny, sparsely pitted; postscutellum shagreened; propodeal enclosure with large, raised reticules radiating from postscutellum; median carina prominent, raised; side of propodeum finely reticulate. Flagellomeres IV–VII with double, orange tyloides, VIII with single tyloides (some of the paratypes have either a single or double tyloides on flagellomere II or VIII); tangential line between compound eyes equal to length of flagellomere I; mid coxa ridged on inner ventral surface; sternite II slightly humped medially. Body length 12.3 mm., wing length 9.5 mm.

Female.—About as in male except as follows. Forewing evenly brown. Pubescence sparser on head; stiff, black, projecting posteriorly on anterior part of pronotum and on sternum; pubescence short and sparse on abdomen; sternite II mostly bare. Pits large, close on face; interocellar area with 20 irregular, oval pits; vertex with large, scattered pits; scutum heavily pitted anteriorly, fading posteriorly; scutellum, postscutellum heavily pitted marginally, summits shiny, evenly punctured; mesopleura obliquely striate towards propodeum; side of propodeum reticulate, reticules larger posteriorly. Median clypeal lobe with prominent ventral tooth; U-shaped emargination at either side of median clypeal lobe. Body length 10–11.5 mm., wing length 8–9 mm.

This is probably one of those that Fox (1892)

recorded as a variety of *nubecula*. He mentioned the white medial band on the mandible, which occurs only in this species.

A. clypeata is similar in appearance to *occidentalis*. The female has the toothed median clypeal lobe and the bare second abdominal sternite as does *occidentalis*. The female differs from *occidentalis* by its unique incised clypeus (fig. 15). The males of *clypeata* are characterized by the white band on the mandible.

The tyloides on flagellomere III and VIII vary from none to two, but the other structural characters appear rather constant.

From the specimens at hand the distribution of this species appears to be very disjunct: along the eastern slopes of the Rocky Mountains, extending into the Great Plains and on the western coastal mountains of Mexico. Undoubtedly additional collecting will show that this species is found both on the eastern and western slopes of the Rocky Mountains from Canada to Mexico.

Types.—Holotype male, Alliance, Nebraska, Aug. 8, 1949 (R. R. Dreisbach, R. K. Schwab). Other paratypes, 5 males, 3 females, NEBRASKA: McCook, VIII-18-49 (R. R. Dreisbach, R. K. Schwab); SOUTH DAKOTA: Platte, IX-8-17 (C. N. Ainslie); MONTANA: Cheyenne Co.; Kansas (F. X. Williams).

Material Examined: In addition to the types I have seen four other specimens from MEXICO as follows: 8 mi. S. Guadalajara, IX-54 (F. X. Williams); Mazatlan, III-1-18; San Bernardo, I-27-35 (Bohart collection).

Astata unicolor Say

Astata unicolor Say, 1824. *In* Keating, Narrative of Long's 2nd Exped. 2: 337.
Astata rufiventris Cresson, 1872. Trans. Amer. Entomol. Soc. 4: 218.
Astata unicolor, var. *rufiventris* Cresson, Townes, 1951. U. S. Dept. Agric. Agric. Monogr. No. 2: 940.

Male.—Black; wings hyaline, sometimes light brown in cellular area. Pubescence of head, thorax, abdomen silvery-white. Punctation of head, body close, coarse; summits of scutum, scutellum shiny, heavily pitted; propodeal enclosure with large, raised reticules radiating from postscutellum; prominent, raised median carina present. Flagellomeres IV-VIII enlarged, broadly rounded; tangential line between compound eyes equal to length of flagellomere II; second sternite slightly humped medially. Body length 10–14 mm., wing length 7–9 mm.

Female.—About as in male except as follows. Forewing light brown, darker posteriorly. Pubescence of sternite II short, projecting posteriorly. Punctation of face coarse; interocellar area with 70 to 90 small pits; vertex heavily pitted; scutum entirely pitted; summit of scutellum shiny, sparsely punctured; postscutellum shagreened; mesopleura obliquely striate towards propodeum, striae more distinct posteriorly. Body length 9–13 mm., wing length 7–10 mm.

A. unicolor is closely related to and often mistaken for *bicolor*. They are easily separated in the females by the small tubercle on the bare mid coxa of *bicolor*. The male of *bicolor* is distinguished by its red and black abdomen, whereas the abdomen of *unicolor* is entirely black. In addition, *bicolor* is a much smaller species than is *unicolor*. Sometimes *leuthstromi* and the black form female of *unicolor* are confused with one another. The heavy punctation of the face, vertex, and scutum distinguish *unicolor* from *leuthstromi*. The presence of tyloides on the antenna of male *leuthstromi* differentiates it from *unicolor*.

The females of *unicolor*, as in many other wasps, have either black or red abdomens. Townes (1951) considered the red female of *unicolor* to be simply a variety. The distribution of this form was recorded as the Atlantic to 100° W. I have found that the red variety occurs over the entire United States, whereas the black form occurs only east of 100° W.

I feel that neither of these forms deserves a varietal name, and I have synonymyzed *rufiventris*.

A. unicolor utilizes most types of loose soil for nest construction. This nesting behavior has been recorded by several authors: the Peckhams (1898), Evans (1957), Krombein (1936). The short sideburrows are usually farther apart than those of *occidentalis* and often contain only a single cell. The prey consists of several species of nymphal Pentatomidae—*Podisus modestus* (Dallas), *P. maculiventris* (Say), *Euschistus tristigmus* (Say), and *E. euschistoides* (Voll.).

This species is widely distributed over the entire United States, southern Canada and Mexico. It is the commonest one in the eastern part of North America. Westwardly it is superseded by *occidentalis* and *nubecula*.

Material Examined: 237 Males, 101 black, 106 red females.

Astata bicolor Say

Astata bicolor Say, 1823. Western Quarterly Reporter 2: 78.
Astata terminata Cresson, 1872. Trans. Amer. Entomol. Soc. 4: 218.
Astatus pygidialis Fox, 1892. Canadian Entomol. 24: 234.

Male.—Black; abdominal segment II, anteriorly on segment I, posteriorly on segment III, red; tarsi reddish brown; forewing light brown in cellular area, stigma straw-yellow, transparent; hind wing hyaline. Pubescence of body silvery-white; sternites IV–VI with short, medial, brushlike hairs projecting inwardly, posteriorly. Punctation of head close; scutum moderately pitted, summit shiny; scutellum shiny, sparsely punctured; pleura coarsely pitted, pits oblong; propodeal enclosure reticulate, reticules large, broken, radiating away from prominent, raised median carina; side of propodeum spiculate. Flagellomere IV–VIII rounded beneath; tangential line between compound eyes equal to length of flagellomere II; slight ridge on inner ventral margin of mid coxa; sternite II humped medially; sternite V with U-shaped

medial emargination, as broad as length of hind tarsal segment III; sternite VI slightly emarginate. Body length 7–10 mm., wing length 6.5–8 mm.

Female.—About as in male except as follows. Abdomen completely red; punctures of face small, numerous; interocellar area with 40 to 55 pits; vertex shiny with scattered pits; scutum pitted over most of surface, heavier anteriorly; scutellum shiny, sparsely punctured; pleura obliquely striate towards propodeum. Mid coxa with nipple-like tubercle on inner ventral surface. Body length 7–9 mm., wing length 6–7 mm.

The females of *bicolor* can be separated from those of all the other species by the small tubercle on the mid coxa (fig. 7).

The emarginate sternites and the red and black abdomen separate the males of *bicolor* from the rest of the species within the genus.

The Peckhams (1898) recorded this species as nesting beneath overhanging vegetation. The burrow was very shallow, 6 cm. long, with a group of cells at the end. They also observed malaxation and stinging of the prey in a jar. Although they state *bicolor* as preferring a certain bug, they did not record the species or family of the bug.

A. bicolor occurs only east of the Rocky Mountains in the United States and Canada, but it is found over a wider area in Mexico.

Material Examined: 80 males, 41 females.

Astata mexicana Cresson

Astata mexicana Cresson, 1881. Trans. Amer. Entomol. Soc. 9: Proc. p. v.

Male:—Black; abdomen red except base of segment I, small patch on sternite II; tarsi, median part of mandible reddish brown; cellular area of forewing light brown, clear posteriorly. Head, thorax clothed with silvery pubescence; sternites IV–VI with white, brushlike medial hairs projecting inwardly, posteriorly. Punctation moderate, close on head; scutum moderately pitted, summit shiny; scutellum, postscutellum shiny, feebly punctured; propodeal enclosure reticulate, reticules close, radiating from postscutellum, curving laterally away from posterior propodeal margin. Flagellomeres IV-VIII rounded beneath; tangential line between compound eyes equal to length of last three flagellomeres; mid coxa flanged on inner ventral margin; sternite II humped medially; sternite IV with shallow, wide, U-shaped medial emargination (fig. 30); sternite V with a deep, U-shaped medial notch (fig. 34), as deep as length of fourth hind tarsal segment. Body length 8.5–11 mm., wing length 7–8 mm.

Female.—About as in male except as follows. Abdomen completely red; anal portion of wings darkly stained, forewing more so than hind. Pubescence of head, thorax long, not longer than flagellar segment I, white, setalike; clypeal bristles black; mid coxa bare, with sharp tubercle medially on ventral surface; abdominal pubescence sparse, light, hairlike. Pits of face large, evenly spaced; 10 to 15 pits clumped between ocelli; vertex moderately pitted anteriorly, shiny posteriorly; scutellum shiny with few punctures; postscutellum shagreened, summit shiny; mesopleura obliquely striate towards propodeum, striae beginning as pits; flagellomere II as long as I. Body length 7.5–9 mm., wing length 6–7 mm.

A. mexicana is very closely related to *williamsi*. The females are very similar, but *mexicana* is larger, the pubescence longer, and interocellar pits are clumped between the ocelli (fig. 13). The males are easily separated by sternite V which is deeply incised in *mexicana* (fig. 34), but slightly incised in *williamsi* (fig. 35).

The morphological variance was negligible in most of the material, but Dr. Bohart, who examined the type, states that "the type is much hairier, but structurally the same as the homotype."

Previously this species was not recorded from the United States. Its distribution is west of the Rocky Mountains from Canada to Mexico, the biocenter being the southwestern section of North America.

Material Examined: 32 males, 6 females.

Astata williamsi Parker, n. sp.

Male.—Black; tarsi, median spot on mandible reddish brown; abdomen, except for small medial black patch on sternites I and II, red; forewing light brown, darker posteriorly and in marginal cell; hind wing hyaline. Head, thorax with silvery-white pubescence; sternites III–VI with interspersed light and dark hairs, that medially short, thick, white, brushlike and projecting posteriorly. Punctation moderate on head, thorax; summits of scutum, scutellum shiny with scattered punctures; postscutellum, mesopleura shagreened; propodeal enclosure radially reticulate, thin median carina present (in some paratypes the carina is indistinct), reticules obliquely radiating from median carina. Flagellomeres IV–VIII rounded beneath; tangential line between compound eyes equal to length of last three flagellomeres; mid coxa flanged on inner ventral margin; sternites IV and V slightly emarginate medially, the latter more so; sternite II sharply humped medially. Body length 8.7 mm., wing length 7.2 mm.

Female.—About as in male except as follows. Abdomen completely red; forewing darkly stained posteriorly; pubescence of face light, hairlike, clypeal bristles black; ventral surface of mid coxa bare with short tubercle medially. Punctures of face close, evenly spaced; interocellar area with 22 to 30 pits; vertex sparsely pitted; scutum shiny, punctures heavy anteriorly; scutellum shiny, feebly pitted; postscutellum shagreened; propodeal enclosure closely reticulate, median carina faint; mesopleura obliquely striate towards propodeum; flagellomere II as long as I. Body length 6.5–8 mm., wing length 4.5–6 mm.

A. williamsi is closely related to both *nevadica* and *mexicana*. The female is distinguished by its moderately pitted interocellar area (fig. 14) and the male by its barely incised sternite V (fig. 35).

I have no prey records for this species. One fe-

male was taken on *Tetradymia glabrata* and one on *Xanthium canadense*.

Types.—Holotype male, 20 mi. S. Goldfield, Nevada, July 20, 1952 (M. Cazier, W. Gertsch, R. Schrammel). Other paratypes, 2 males, 3 females, NEVADA: Smith, VI-7-60 on Tetradymia (F. D. Parker); 12 mi. N.W. Gerlach, VIII-18-60 on *Xanthium* (F. D. Parker). CALIFORNIA: 3 mi. W. Westgard Pass, VI-19-53 (J. W. MacSwain); Carnelian Bay (Lake Tahoe), VII-22-57 (R. M. Bohart); Deep Springs, VII-1-53 (W. D. McLellan). Paratypes deposited in the collections of (UCD), (CIS), (AMNH), (UK), and (USNM).

This species is named for Dr. Francis X. Williams, who has contributed to the knowledge of the group, both taxonomically and biologically.

Material Examined: In addition to the type series I have seen 6 males and 1 female from the following states: UTAH: Toquerville. IDAHO: Moscow. OREGON: Blooming, Shed, and Corvallis. CALIFORNIA: North end San Bruno Mts., Mill Valley.

Astata nevadica Cresson

Astata nevadica Cresson, 1881. Trans. Amer. Entomol. Soc. 9: Proc. p. v.

Male.—Black; abdomen red except base of segment I, small patch on sternite II; tarsi reddish brown; forewing light brown, staining pattern variable; hind wing hyaline, occasionally light brown. Pubescence of head, thorax, abdomen silvery-white; white pubescence of sternites III–V interspersed with tan; sternites IV–VI with short, medial, yellowish, brushlike hairs projecting inwardly, posteriorly. Punctation of head, dorsum sparse, summits of scutum and scutellum shiny with few scattered pits; pleura shiny, obliquely striate towards propodeum; propodeal enclosure finely reticulate, reticules small, close, radiating obliquely from middle; side of propodeum spiculate laterally, reticulate dorsally. Flagellomeres IV-VIII rounded beneath; tangential line between compound eyes equal in length to flagellomere I; inner margin of mid and hind coxa flanged; sternite II humped medially; III slightly emarginate medially; IV and V broadly emarginate medially, as broad as length of hind tarsal segment III. Body length 6–8 mm., wing length 5–7 mm.

Female.—About as in male except as follows. Abdomen completely red; anal portion of forewing darkly stained. Pubescence of head, thorax, abdomen stiff, black, setalike except for white pubescence of the occipital area, propodeum, and postscutellum. Mid coxa with sharp, black tubercle medially on ventral surface. Punctation of face close anteriorly; interocellar area with 5 to 8 pits in a double row; vertex shiny, sparsely punctured; scutum, scutellum, postscutellum shiny, feebly pitted; pleura shiny, obliquely striate posteriorly; reticules of propodeal enclosure larger; side of propodeum striate, shiny anteriorly, rugose posteriorly. Flagellomere II as long as I (fig. 9). Body length 6–7.5 mm., wing length 4.5–5.5 mm. The female of *nevadica* is easily distinguished by the black body pubescence and the short marginal cell. The male of *nevadica* is characterized by its flanged hind coxa (fig. 10).

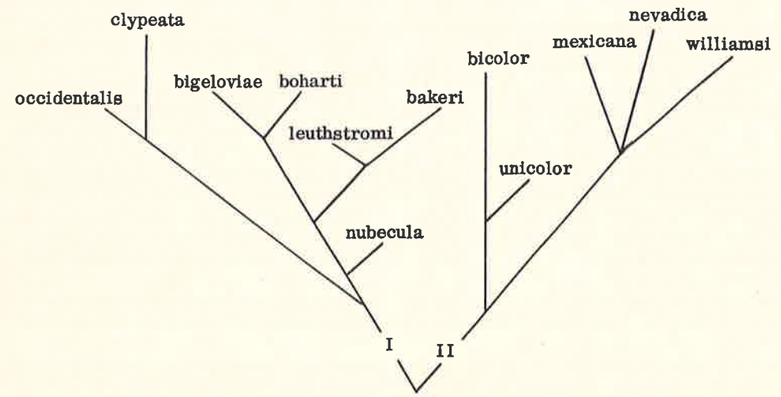
This is the smallest species in the genus and is often mistaken for either a *Dryudella* or a *Diploplectron*. It is widely distributed over western North America from Canada to Mexico.

The biology of this species is not known. I once encountered a large aggregation of males and females crawling among the stems of a low, matlike weed located on a grassy knoll near Goleta, Calif.

Material Examined: 186 males, 114 females.

RELATIONSHIPS BETWEEN THE SPECIES

The presence or absence of tyloides on the flagellomeres of the males and the bare or pubescent mid coxae of the females roughly divide the genus into two species groups. In group I the males have tyloides (fig. 11) and the females have pubescent mid



TEXT FIG. 2.—Diagram of the hypothetical relationships between the species of North American *Astata* north of Mexico.

coxae. This group includes *bakeri, leuthstromi, nubecula, bigeloviae, boharti, occidentalis,* and *clypeata.* The opposing antennal (fig. 12) and coxal characters (except for *unicolor* females) define the other species group, which includes *mexicana, nevadica, williamsi, bicolor* and *unicolor.* The relationships between the species are diagrammed in figure 2. These relationships are based mainly on morphological characters, as biological observations have not been adequately recorded. I have also utilized the shape of the distal part of the aedeagus to illustrate these relationships.

Group I.—There are two color forms in *nubecula,* and there are also localized populations that are becoming taxonomically distinct, both in structure and in color. These dissimilar populations serve to link *nubecula* with *boharti* and *bigeloviae* on one hand and to *bakeri* and *leuthstromi* on the other. In some populations the pleura are shiny and spiculate as in *bakeri* and *leuthstromi* whereas in other populations the pleura are dull and reticulate as in *bigeloviae* and *boharti.* The shape of the aedeagus in *nubecula* (fig. 20) indicates its intermediate relationship between these species. The variable shape of the compound eyes also indicates this relationship. The tendency of the mid coxa to become flattened and ridged posteriorly in some populations of *nubecula* probably stems also from this situation.

A. bakeri and *leuthstromi* are closely related, especially in the shape of the aedeagus (fig. 21, 22). *A. bigeloviae* and *boharti* are also closely related as illustrated by the shape of the aedeagus (fig. 24, 25).

The two remaining species in this group, *occidentalis* and *clypeata,* have much in common. However, the aedeagus is very different in these two forms (fig. 23, 26).

Group II.—Three of the species in this group are closely related, viz., *mexicana, williamsi,* and *nevadica.* The small spine on the mid coxa and the short flagellomere I (fig. 9) characterize the females of this subgroup, whereas the all-red abdomen with some sternites emarginate separates the males. The aedeagus is very similar in these species (fig. 27-29).

A. bicolor is related to the above subgroup, having many characters in common with it. However, the shape of the aedeagus (fig. 18, 19) and the longer flagellomere I of the females relate *bicolor* to *unicolor.*

OLD WORLD FORMS

The Old World species have recently been examined by Pulawski (1955, 1957, 1958, 1959). Of the material that I have examined, *A. minor* Kohl, *costai* Picc., and *boops* Schrk. demonstrate a very close structural relationship to *bakeri. A. miejii* Dug. is closely related to *clypeata,* both having an incised clypeal margin.

EXPLANATION OF FIGURES

PLATE 1

1. Dorsal propodeal enclosure, male *A. occidentalis*
2. Dorsal propodeal enclosure, male *A. unicolor,* showing median carina
3. Basal antennal segments, female *Dryudella* sp.
4. Mid leg, female *A. nevadica,* showing spine on coxa
5. Basal antennal segments, female *Diploplectron* sp.
6. Basal antennal segments, female *A. unicolor*
7. Mid coxa, female *bicolor* showing tubercle
8. Basal antennal segments, female *A. occidentalis*
9. Basal antennal segments, female *A. nevadica*
10. Lateral view, hind coxa, male *A. nevadica*
11. Antenna, male *A. bakeri,* illustrating the tyloides on segments II-VIII
12. Antenna, male *A. nevadica*
13. Interocellar area, female *A. mexicana*
14. Interocellar area, female *A. williamsi*
15. Head, female *A. clypeata*
16. Labrum, *A. nevadica*
17. Labrum, *Diploplectron* sp.

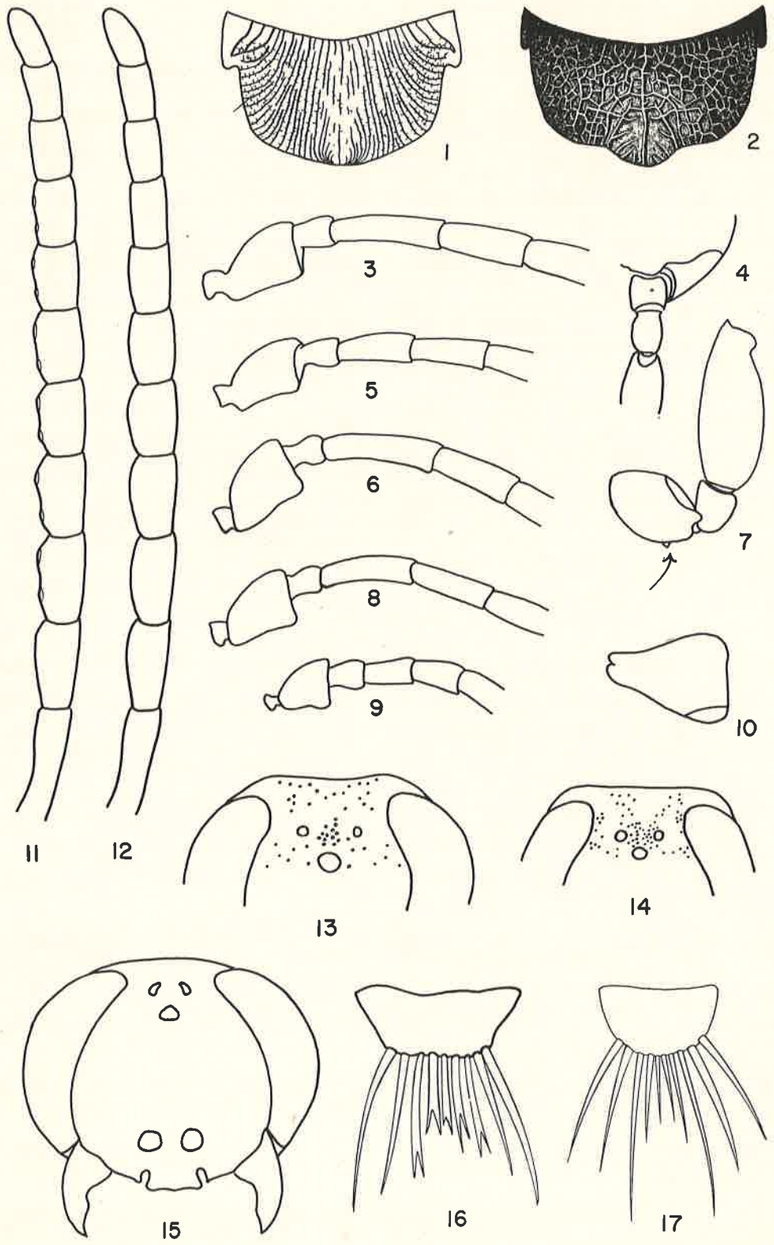
PLATE 2.

18–29. Distal part of *Astata* male aedeagus, 18-*bicolor;* 19-*unicolor;* 20-*nubecula;* 21-*bakeri;* 22-*leuthstromi;* 23-*occidentalis;* 24-*bigeloviae;* 25-*boharti;* 26-*clypeata;* 27-*nevadica;* 28-*mexicana;* 29-*williamsi.*

30. Fourth abdominal sternite, male *A. mexicana*
31. Fourth abdominal sternite, male *A. nevadica*
32. Fifth abdominal sternite, male *A. bicolor*
33. Fifth abdominal sternite, male *A. nevadica*
34. Fifth abdominal sternite, male *A. mexicana*
35. Fifth abdominal sternite, male *A. williamsi*
36. Seventh abdominal sternite, male *A. williamsi*
37. Seventh abdominal sternite, male *D. caerulea*
38. Pygidium, female *Astata*
39. Pygidium, female *Dryudella*

PLATE 3.

40. Fore and hind wing, male *Astata*
41. Fore and hind wing, male *Dryudella*
42. Fore and hind wing, male *Diploplectron*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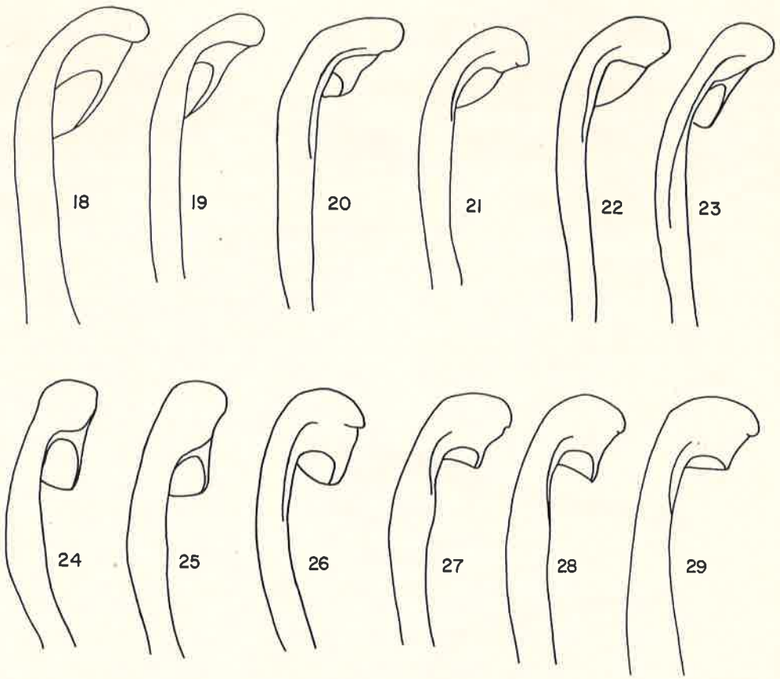
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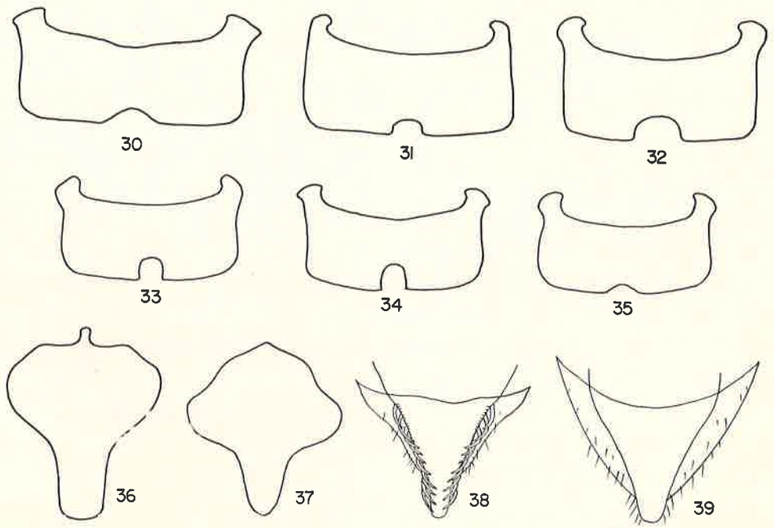
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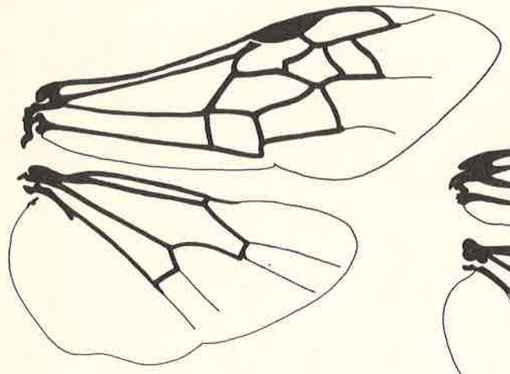

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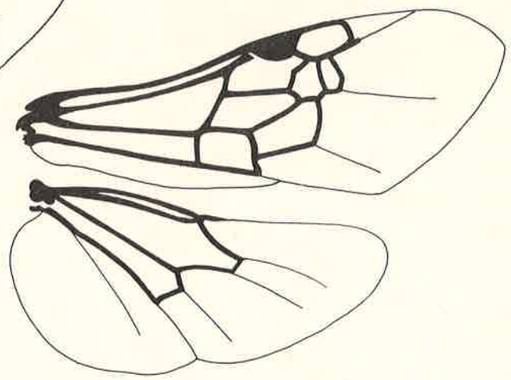

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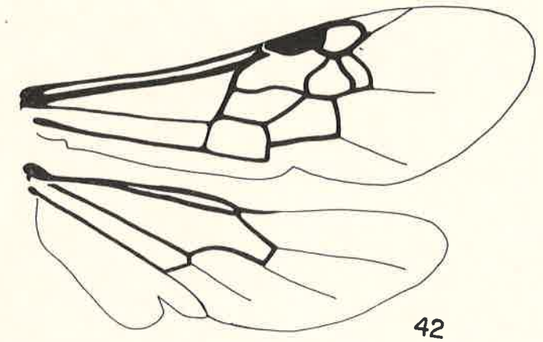

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