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By K. TSUNEKI
(Biological Laboratory, Fukui University)

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ASTATA BOOPS (SCHRANK)

Recently Evans (1957, 62) published his studies on several North American species of the genus *Astata*, reviewed the biology of the world hitherto investigated and discussed the general characteristics of the group. As to the biology of the present species which is widely distributed from Europe to Korea in the Palaearctic region several authors such as Shuckard (1836, 37), Westwood (1840), Fabre (1856), Curtis (1862), Adlerz (1900, 03) and Ferton (1901, 18, 10) touched more or less on the subject regarding the European representative. As to the East Asiatic member O. Piel (1936) and I (1947) dealt with the biology. My paper was given in Japanese and in the following I will redescribe the matter from my note book.

An observation at the first habitat

On June 10, 1943, at the entrance to the valley of Shoyozan, Central Korea, on the well-trodden road I found several species of the hunting wasps nesting, including *Lestica alata*, *Cerceris bicincta*, *C. hortivaga*, *C. arenaria* and among them I could distinguish an individual of *Astata boops*. Because of the fact that this species was biologically quite new to me my attention was at once attraced by the behaviour of the wasp. It was at about 10:00 and the weather was fine.

The wasp had just returned from her hunting excursion and was opening the entrance to her nest. The prey that was placed in front of the opeing was a species of the bug, just I knew through the literature. But before my examination the wasp appeared from the entrance, caught it by the antennae and dragged it backing in the tunnel. After that she did not make her appearance for a considerable while. So I covered the entrance with my insect net and observed the movements of other wasps. After a while I found the huntress of the bug dropped into my trap. I at once dug the nest (nest 1).

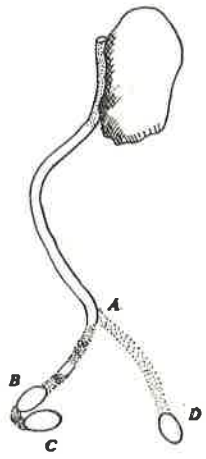

Fig. 1. The first nest observed (dorsal view).

The ground near the surface consisted of the hard soil mixed with pieces of rocks, but from 3 cm below it turned to the clayey soil. The entrance was made at a side of a stone and half closed. The tunnel ran shallowly in the earth and the first 3 cm was loosely packed with fine dust. Then it was left open and went for 12 cm, drawing a curve (Fig. 1) and ended at A at a depth of 4.5 cm from the ground surface. Thenceforth I persued the tunnel by following the loose soil and soon found 3 bugs buried in the packing just as done in the nest of the species of *Cerceris*. Then the tunnel was open for 5 mm, but soon filled again with the soil and went beneath a stone. Here 2 further bugs were stored in the filling. The packing became harder and harder and finally the tunnel could not be discerned from the surrounding soil. But there I found a cell (B), 2 cm

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apart sideways from A at the same depth.

In cell B which was 11 mm long and 6.5 mm wide and high 9 prey were stuffed, all dorsum up, keeping their heads inward and upward, with their body axis lying oblique, and were piled one above the other. The prey placed at the bottom of the cell carried a larval wasp which was probably soon after hatching out. Its mouth was attached to the underside of the neck of the prey, a little deviating to the right and its caudal end reached between the bases of the hind coxae.

I found the other cell (C) which was connected with cell B by the hardly packed tunnel of about 7 mm and was almost directly below the cell, reverse in direction and obliquely laid at a depth of 6 cm (to the cell roof). In this cell 15 prey of somewhat smaller stinkbugs were stored and to the bottommost one of which a larval wasp that was slightly more developed than that of cell B was attached. I further extended the excavation and found another cell (D), 3 cm apart from A. In the cell were stored 8 prey and there was a very young larva, possibly just after hatching out, attached to the bottom prey in the same manner as observed in cell B.

Another nests. In the city of Keijo (now Seoul), at the base of a stone wall of a house a wasp of this species came flying with a prey and tried to enter the burrow made between the stones. I captured them. The prey was a green coloured stinkbug of an unknown species.

In a village near Shoyozan, a nest was found between stones of a stone wall, at a height of about 70 cm above the ground. The wasp came back with a large stinkbug and tried to crimb up the wall. But the dirt attached to the stone easily crumbled and the wasp could not get a steady foot hold. She frequently tried to go to the nest by flying, but the prey was so heavy that she could not reach the place at a flight. So I helped her with my insect net. She went to the entrance from the net, entered the comparatively broad tunnel for about 3 cm, left the prey there, entered herself empty-handed, soon came back and dragged it backing deep into the tunnel. The same day, in the same village, at the base of an earth wall of a house I found a nest of this species. I followed the tunnel and found a bug buried in the stuffed soil. Soon the owner of the nest came back with a prey and searched about for the entrance. During the time I could well observed the manner of the prey carriage in this species. The prey was caught by the antennae with the mandibles of the wasp, and was held, venter to venter, with the middle pair of legs.

Observations at the second habitat

At the upper portion of the valley of Shoyozan, along a pretty brook, there was a famous temple comprising several small temples and the lodging houses for the believers. Each branch temple was varied in structure and size, but generally small in pattern and always provided with broad eaves under which the ground of the clayey soil was dried, well trodden by the worshippers and hard. On July 27, in such a place of the first temple I found 6 wasp of *Astata boops* Schrank working, 4 of which were digging their tunnels and the remaining 2 were searching for their nesting site. The two wasps last mentioned were walking about very actively, twitching their wings and trying very frequently to dig a hole at a side of the uneven ground or of the stones mixed. On the perpendicular wall of the fire-hole of the Ondol of a lodge which was at the outside of the house I found 5 wasps frequently provisioning their nests. It was 14:00 of a very fine and hot day. In front of the main temple called Dzizaian and under its broad eaves about 10 wasps of this species were either digging tunnels, searching for their nesting site or provisioning from time to time to their burrows.

I at first only observed the behaviour of the wasps outside their nests and could ascertain the following habits:

(1) The prey was carried by the wasp in the same manner as observed in the first habitat of the species.

(2) In taking in the prey to the nest, when the entrance is completely closed the wasp first tries to open there without leaving the prey, but soon lets it off and clears the opening

with the mandibles and front pair of legs. Then it enters the tunnel, head foremost, soon appeared at the entrance, head first, captures the prey by the antennae, sometimes by the rostril, with her mandibles and drags it backing into the tunnel. When the entrance is open for some distance she enters there as far as she can go, drops the prey at the end and makes the same series of behaviour as in the first case. In the second case it appears that the wasp enters the nest as she keeps the prey under her abdomen.

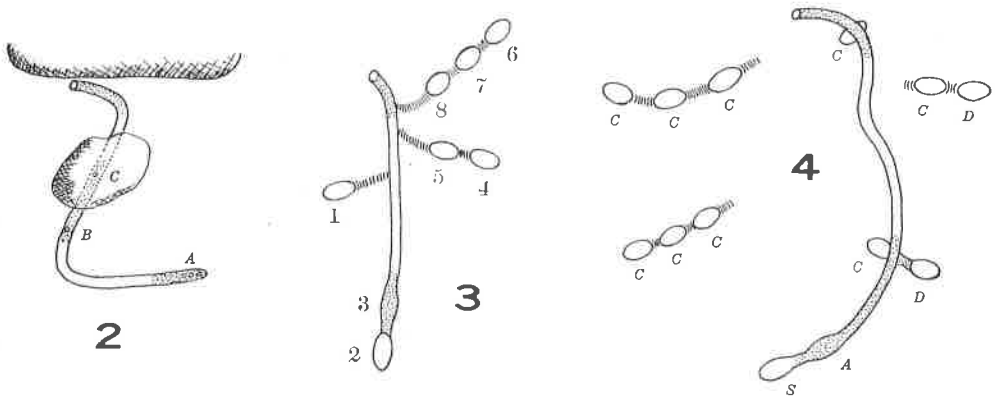
(3) During the course of digging the wasp makes a particular flight from time to time which is considered to have bearing upon the learning of her nest site, that is to say, it is a sort of the so-called orientation flight. The wasp flies up, or flies directly out of the tunnel and flies about very slowly over the nest, flying up and down, shortly to the right and left, lifting her head, keeping her body oblique, hanging her legs loosely down, as if to try an air dance. The direction of her head is variously changed. After a while she goes back to the nest to resume the burrowing work.

(4) When she leaves the nest she sweeps the dust into its entrance, without coming completely out of it, little by little crawls out, filling the space left behind with the dust gathered together. As soon as she appears out of the entrance she flies off immediately without examining or levelling the surface of the entrance of the nest.

(5) The prey insects carried in the same nest are sometimes the stinkbugs of the same species, but more often 2 or 3 species are mixed, mostly nymphs.

The aim of my visit on that day was to collect the ruby-tailed wasps and the digging tools were not prepared. But the work of the wasps appeared so interesting that I tried to examine some of their nests with my pincette only and succeeded in three of them.

Nest 2 (Fig. 2, from above). In this nest there was no larval cell prepared and the wasp was



Figs. 2-4. Other nests (dorsal view, explanation in text).

in the course of collecting the prey in the tunnel. In the figure the distance from the nest entrance to A was 8 cm and it was 2.5 cm below the earth surface. The tunnel for 2 cm from the entrance was loosely closed with soil. At C and B a prey was stored respectively in the loose packing soil and at A 3 prey were stuffed in a mass, without the packing soil, the innermost one being side up, the next dorsum up and obliquely piled on the first and the third similarly piled up. On none of them was found the egg of the wasp.

Nest 3 (Fig. 3, from above). The dotted portions was loosely filled with soil. The distance from the entrance to the end of cell 2 was 7 cm.

Cell 1. Situated 2.5 cm below the surface of the ground (measured at the roof, in the

following the same). It was 11 mm in length, 6 mm in width and included 6 nymphal prey of 2 species, *Halyomorpha picus* F. and *Nezara antennata* Scott. They were placed dorsun up and the bottom one carried the just hatched larva of the wasp.

Cell 2. 3.0 cm below the surface, included an old cocoon.

Cell 3. In the course of preparation, somewhat more enlarged than the tunnel, loosely filled with soil and in it a prey was stored.

Cells 4 and 5. Both cells, about 10×6 mm, were separated from each other by a tunnel of about 5 mm which was compactly stuffed with soil. Cell 4 was 3.5 cm below the surface, including a full-grown larva that had already lined the cell wall with the secretion of the silk gland. Cell 5 at the same depth, filled loosely with soil and included an old cocoon from which the imago had escaped.

Cells 6–8. An obliquely inclined series of cells, the uppermost being 2 cm below the surface and the lowermost 3.5 cm, all containing a full-grown larva that already lined the inner wall of the cell with the silk secretion. The cells were similar in size, about 10 mm long and 6 mm wide and high.

Nest 4. A very complicated nest as illustrated in figure 4 (dorsal view), comprising 12 larval cells. The bound including the cell is about 10 cm in diameter. The cells shown by *c* in the figure included a full-grown larva respectively, some ones being in the course of lining the cell with the silk secretion. In those shown by *s* the cocoon was distinctly formed and dimly showed the larva within and in those shown by *d* the larva was dead after finishing the growth and already decayed The depth from the surface to the cell ceiling was about 3–5 cm and the group of the linked cells was inclined obliquely, the inner the deeper, and the group as a whole was usually somewhat curved.

Development of the larva

The larva in cell C of nest 1 (observed on June 10) which was about one day after hatching was brought home and reared in a tube bottle, 7 mm in diameter and sectioned with cotton plugs. On June 12 it ate up the last one of the 15 prey. On the 13th it rested still. The next day it began to make the cocoon. As observed in nature the cocoon in this species was only the lining of the inner wall of the cell with the secretion of the silk gland. The larva lasted to work all day long, but the space given to it as a chamber was too large to be lined completely. Finally it ceased to line on the way and entered into the dormant stage. On the 23rd I found that it had already shed the larval skin and turned into the pupal stage. But the whitish colour of its skin showed that it was soon after the transformation. When I took up the bottle the pupal wasp moved fairly actively its abdomen. Toward the 27th the eyes began to blacken and thenceforth the body became to colour day after day. After the colouring commenced the pupae was able to move its bodily parts in responce to the stimulation. On July 3 it finished the final ecdysis and the male imago emerged. It rested quietly for about one day and on the 5th of July began to break the cocoon.

One of the full-grown larva in nest 4 that was obtained on July 27 was similarly reared in a tube bottle. It smeared the inner wall of the glass tube with the silk gland secretion. On the 31st it turned into a pupal stage. On August 3–9 the colouring progressed day by day and on the 11th an adult male wasp emerged from the pupa. On the 12th the wasp was striving to escape from the cell.

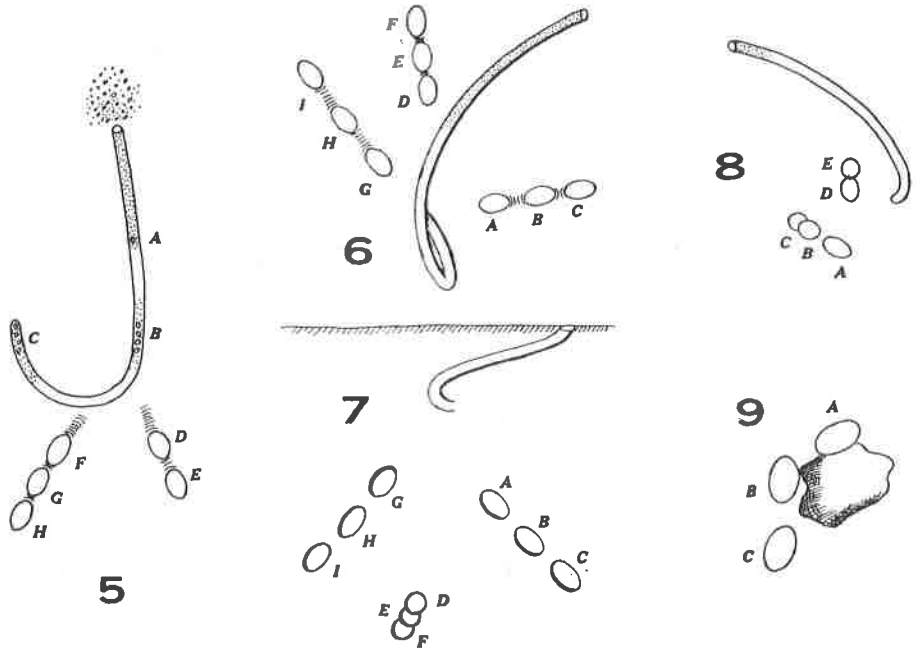
According to the observation in the larva of the first generation, the eating period is about 3 days. It rests one day and then spends one further day to spin the cocoon, in reality to smear

the silk substance over the inner wall of the cell. Prepupal stage is about 4–5 days and the pupal period 11–12 days.

Some supplementary observations

On July 31, in the second habitat above mentioned the nesting females were very much increased in number. Under the pent-roof of a branch temple, Reizanden, of the temple of Shoyozan, on the area, 6 m long and 1.5 m wide, a great number of the nests of this species were in the course of digging or provisioning. Because of the fact that the wasps did not level the debris dug out of the burrows, but left it as piled up at the entrance, the presence of the nests was easily known. I counted them and was surprised to know that they were as many as 104 in number. In front of the Mangetsu-Hoden I could count also more than 30 nests, mixed with those of *Cerceris hortivaga*. Here the nest distribution was much sparse and I could examine the interior of some of them without confusion.

Nest 5 (Fig. 5). The dotted portions shown in the figure were loosely filled with soil.



Figs. 5–9. Other nests (5, 6, 8 ··· Dorsal view, 7, 9 ··· Lateral view of 5 and 8).

At A, 3 cm from the entrance a prey was stored in the filling soil and at B, 2.5–3.5 cm inward from A, again 4 prey were found one after another buried in the soil. Thereafter the tunnel was left open, curved to the right and went 3 cm to reach again the filling soil. It was about 1 cm in thickness and in the narrow space behind the closure 4 bugs were obliquely piled up one above the other, all dorsum up, but none of them carried the egg of the wasp. The space was not the true cell, but merely an extention of the tunnel.

I enlarged the excavation and found two series of larval cells as given at D–E and F–G–H in the figure.

Cell D. Depth to cell-ceiling 2.5 cm, and 12×7 mm in maximum length and width; the prey 4 in number, all head in and dorsum up, and obliquely piled up as usual in this species.

The innermost one of the prey carried a young larva of the wasp. The larva attached its head to the underside of the neck of the prey, slightly deviating to the right, crossed obliquely over the rostril and reached the outer side of the left middle coxa. The larva was still very young.

Cell E. The separating wall between cells D and E was about 6–7 mm in thickness, distinctly narrower than the cell and stuffed compactly with soil. The prey were only 2 in number, but they were the larger ones of the final stage, about 12 mm in length and the inner one of which was half eaten by the larva that was distinctly larger than the larva found in cell D. The depth to the cell-ceiling was 3.0 cm.

Cell F. Depth 3.7 cm, prey 4, dorsum up, to the innermost one the egg of the wasp was laid which was 2.7 mm in length and 0.8 mm in width, wax white in colour and slightly bent.

Cell G. Prey 3, all dorsum up, to the innermost prey the wasp's egg was laid.

Cell H. Depth 4.5 cm, the cell itself obliquely inclined, prey 4, all were about 7 mm in length and laid dorsum up, the bottom one carried the egg of the wasp. The place and manner of oviposition were similar.

Nest 6. The structure and the depth were given in figures 6 (dorsal view) and 7 (lateral view).

Cell A. Prey 3, dorsum up, oblique, the egg of the wasp on the bottom one.

Cell B. Rotten (5 prey).

Cell C. Rotten (4 prey).

Cell D. Prey 6, all dorsum up, a young larva of the wasp on the bottom prey.

Cell E. Rotten (5 prey).

Cell F. Rotten (4 prey).

Cell G. Prey 4, obliquely dorsum up, a waspling on the innermost prey.

Cell H. Rotten.

Cell I. Rotten.

In 6 cells out of 9 the prey were rotten and the larval wasps were dead. The cause was unknown.

Nest 7. (Fig. 8, dorsal view). Cells A, B and C were made along a stone and B and C were laid almost perpendicular (Fig. 9, lateral view).

Cell A. Prey 6, including 1 particularly large and 1 particularly small one, all dorsum up, a waspling on the bottom prey.

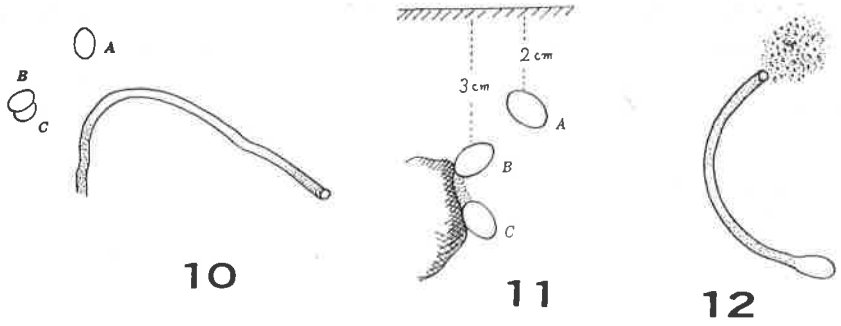
Cell B. Prey 2, 1 being large and 1 small, a larval wasp on the bottom prey. The prey were dorsum up, obliquely laid as usual.

Cell C. prey 3, 1 large and 2 small, dorsum up, oblique, a larval wasp on the innermost bug.

Cells D and E. Both contained a full-grown larva in each cocoon.

Nest 8. The nest was under the open verandah and the wasp was digging the tunnel at the end (Fig. 10). It included 3 completed cells in which 3 species of prey were provisioned, in cell A 4 prey with a young larva, in cell B 4 prey with an egg and in cell C 5 prey with an egg. The larva or the egg was found all on the bottom prey. The placement of the prey and the method of oviposition were as usual. In this nest there was no prey provisionally stored in the tunnel. Probably it was just after such prey had been arranged in cell C.

Nest 9. This nest (Fig. 12) was soon after the first cell had been completed and the wasp was working to collect the prey for the next cell in the tunnel. In the cell 8 prey were stuffed, including the wasp's egg. The compact packing in front of the cell was 1 cm in length and at the empty space next to it was somewhat enlarged and included 2 prey at the bottom and 1 prey



Figs. 10–12. Other nests (10, 12 ··· Dorsal view. 11 ··· Lateral view of 10).

at the entrance, without the wasp's egg. The wall of the space was not smoothed as yet and therefore it was not as yet completed as a cell. But it seemed interesting that the wasp somewhat enlarged the place of the future cell and stored provisionally the collected prey there.

Prey

The prey were the stinkbugs belonging to Pentatomidae and identified partly by Mr. M. Tanaka, then Keijo, and partly by Dr. T. Ishihara, Ehime University, as follows:

1. *Halyomorpha picus* Fabricius, larvae in 2, 3, 4 and 5 stadiis.
2. *Homalogonia obtusa* Walker, larvae.
3. *Elasmucha putoni* Scott, larvae.
4. *Rubiconia intermedia* Walker, larvae.
5. *Eurydema dominulus* Scopoli, larvae.
6. *Eusarcoris* sp., larvae in 4 and 5 stadiis.
7. *Carpocoris* sp. (?), larvae in 5 stadio.
8. *Nezara antennata* Scott, larvae in 3 and 5 stadiis.
9. *Plautia* sp. (?), larvae in 5 stadio.
10. *Aelia fieberi* Scott, larvae in 5 stadio.
11. *Palomena* sp. (?), larvae in 3 stadio.

General biology

(This section is a translation from my 1947 paper)

Appearance. In the districts near Keijô this species makes its appearance early in June and apparently disappears toward the middle of September. A full grown larva obtained on June 10 pupated on the 23rd and emerged on July 3. A similar larva dug out of a nest turned into the pupa on the 31st and emerged on August 11. Judging from facts, in Keijo and the districts this species repeats 3 generations a year and the larva born in August and September hibernates in a prepupal stage and emerges in April the next year.

Nesting site. The nesting place preferred by the wasps of this species is a well trodden, dried, clayey ground, usually mixing a more of less gravel, such as under the roof of the human houses, temples and shrines where the ground is not beaten by the rain. The crowded colony formed by this species in such a place was mentioned earlier in connection with the second habitat of the wasps. Sometimes, however, some wasps make their nests in the ground of the open road or path, showing that the dryness was not the indispensable condition of the nesting site. On the other hand, this species burrows not only in the flat ground, but also in the perpen-

dicular walls of the human houses, especially of the firing place of the Ondol and between the stones of the stone walls. P. O. Piel, in his account of the observation on this species on the Island of Chushan emphasized that the nest of this species was made in the perpendicular wall far above the ground. But Korean inhabitants of the species showed a marked adaptability in this regard.

Nesting activity. As in many of the hunting wasps this species also has a habit of returning to the birth place to nest. In such a case some wasp makes use of the mother's nest from which she came out as her own, as also observed on some species of *Cerceris* and *Sphex* (this fact requires a particular attention in studying the nest structure). As for the brood cell itself it is usually constructed by the wasp herself. Sometimes, however, the wasp utilizes also the old cell with a more or less emendation given by her.

Before the commencement of burrowing a simple selection of the nesting site is performed. But it is far simpler than in the wasps of some other genera, such as *Ammophila*, *Sphex* and so on. For digging the mandibles and the fore legs are used. The debris are supported with the mandibles and fore tarsi and the wasp comes backing out of the tunnel, discards them backward through the underside of her abdomen. During the time the wasp makes from time to time a particular movement which is considered a sort of the so-called orientation flight, as given earlier in this paper. The flight is continued usually for 1 or 2 minutes. When the tunnel becomes considerably deep the wasp closes the entrance temporarily, without preparing the brood cell and flew away to hunt the prey. The closure is made by gathering the debris in the tunnel while she comes little by little from the entrance. As soon as she comes completely out of the burrow she flew off without attempting to level the entrance and debris. This is also the case every time in her departure during the provisioning work. The closure at the entrance is, therefore, very simple, sometimes even it is omitted and the entrance is left open. Examination of the tunnel, however, shows that in every case it is not completely cleared. It is in some places filled with loose soil for some distance and makes the entrance stoppage unnecessary in order to defend the nest against the intruder such as the parasitic fly.

Provisioning. After digging the tunnel, but without preparing the brood cell, the wasp at once begins to hunt the prey. Therefore, if we wait at the site of a nest from which the wasp made the first departure we can see, not long after, the wasp fly back with a prey. In carrying the prey the wasp captures it by the antennae with her mandibles and holds it venter to venter with the middle pair of legs. In opening the temporary closure at the entrance the wasp at first trys to do so without letting off the prey, but almost every time she drops it during the course and finishes the work free-handed. When the closure is done at some distance from the entrance the wasp goes in the tunnel until the closure and clears it away in the same manner as mentioned. In this case it appears that the wasp goes in the burrow without letting the prey off. When the closure is removed the wasp enters the burrow head foremost, turnd in it, soon protrudes her head from the entrance, catches the prey by the antennae, sometimes by the rostril and drags it backing into the tunnel. During the provisioning period hunting is very frequently carried out. In one instance I could see a wasp carry in her nest 4 prey successively at an interval of 3–7 minutes. If the observer robs her of her prey the compensation hunting is as much quickly carried out. The prey thus hunted are provisionally stored in the tunnel, mostly in the loose filling of soil, usually hither and thither 1–3 prey in a mass. Sometimes some prey are apparently regularly placed in a mass at the end of the tunnel, as if the place were the brood cell. But the tunnel at the place is not fully enlarged and the wall is not smoothly pressed and, moreover, in such a case the egg of the wasp is not laid on any of the prey (the wasp lays her egg on the

Table 1. Contents of the nests of *Astata boops* (Schrank)

Nest No.	Cell No. In the tunnel	1	2	3	4	5	6	7	8	9	10	11	12	13	Remarks
1	5	15L	9L	8L	–	–	–	–	–						
2	5	–	–	–	–	–									NO cell
3	1	?FL	?FL	?FL	OC	?FL	6L	0C	–	–	–	–	–		Eaten up?
4	3	FL	FL	FL	FL	FL	FL	FL	FL	FL	D	FL	D	–	Eaten up?
5	9	2L	4L	3E	4E	–	–	–	–	–					
6	0	?D	?D	3L	?D	?D	6L	?D	?D	4L	–	–	–	–	Putrefied?
7	0	?C	?C	3L	2L	6L	–	–	–	–	–				Eaten up?
8	0	4L	4E	5E	–	–	–	–	–						
9	3	8E	–	–	–	–	–								

Figures: The number of prey stored. ?: Unknown number of the prey owing either to being completely devoured by the larva or the putrefaction. E: With an egg of the wasp. L: With a larva of the wasp. FL: With a full-grown larva. C: With a cocoon. OC: With an old cocoon. D: With a dead larva.

first prey taken in the brood-cell). When the prey provisionally stored as such reaches a considerable number the wasp makes the brood-cell and arranges the prey in it. Such strange habits have been known only on the members of the genera *Cerceris*, *Philathus* and *Paralus* in the East-Asiatic regions, all being the hunters of either the Hymenopterous or the Coleopterous insects, and it seems interesting to find the same habits in the bug-hunting and remotely distant genus, *Astata*.

In the course of the provisioning succeedingly performed this species shows the same manner of prey collection. The wasp collects a considerable number of the prey in the tunnel and then rapidly completes the brood-cell. The amount of the prey provisionally stored is considered sometimes ample enough to fill the need of 2 or 3 cells at a time. "The presence of many larvae of a similar development in one nest" doubted by Piel can easily be solved by the facts of the prompt provisioning and of the above mentioned peculiar habits of the wasp.

Cell construction, oviposition and cell closure. The tunnel is further extended and the end is enlarged into a brood-cell, then the prey provisionally stored in the tunnel are moved into it and to the first one of them the egg of the wasp is laid and finally the cell is closed. The egg is about 2.7 mm long, 0.8 mm wide, slightly yellowish in colour, attached with its anterior end to the underside of the neck, somewhat deviating to the right or the left, passing somewhat obliquely over or under the rostril of the prey and reaches the outside of the middle coxa of the other side. Sometimes the egg body is laid along the median line of the prey and reaches between the hind coxae. The number of the prey per cell varies according to the size of the bug, ranging from 2 to 15, so far observed. The prey in the cell are laid head in and dorsum up, keeping their bodies oblique, head high and caudal end low, and piled up, usually in a row, one above the other. The egg-carrying prey is not the exception in this respect. How can the wasp lay her egg to the prey in such a strange posture I can not say.

The closure of the cell is made once for all, which is 5–10 mm in thickness and very compact and hard. Then the wasp resumes her food collecting activity and stores the prey in the tunnel to repeat the above mentioned procedure. If the prey first collected are too many and remain in the tunnel after completing the first cell the wasp at once enlarges the tunnel in front of the first closure to make it a second cell. She then carries a stored prey into it, lays her egg, adds the necessary amount of the prey from the tunnel and closes it finally. She further makes a third cell outside the closure of the second cell by following either of the above mentioned procedure. After thus completing 3 cells (sometimes 2 cells) she closes the tunnel very compactly at some length, digs a new branch tunnel in other direction and from its interior makes a new series of cells, including the 4th, 5th and 6th, in turn, and so forth.

The structure of the nest. The nest thus made belongs to the branched compound type. The main tunnel is near the entrance somewhat broader than high, but in the interior portion turns into circular in cross section and about 4 mm in diameter. It inclines very gently and irregularly curves to the right and left, having a 10–15 cm total length. In the incomplete nest the end portion of the tunnel is sometimes abruptly markedly inclined. In such a case the inclined portion is considered to show the place in which a series of the larval cells is to be made in future. A series of cells consists usually of 3 cells, sometimes of 2. In general the interior cell is deep and the exterior one is shallow. This is due to that the branch tunnel in which the series is to be made is inclined more or less. The inclination of the brood cell itself is in accordance with that of the tunnel, ranging from perpendicular to almost horizontal. Usually the series is more or less arcuately curved, but sometimes it abruptly turns. The latter case is usually due to the presence of the obstacle such as a stone and the turn is made mostly vertically. The larval cell is usually 10–12 mm in length, 6–6.5 mm in width, situated 2.5–5.0 cm below the surface of the ground (measured at the cell roof).

Prey. Almost all the prey bugs robbed of from the wasp are completely immovable. The same is true with the bugs taken out of the tunnel. This is not due to the deep paralysis of the prey induced by the sting of the wasp, but in this case due to the complete death of the prey. Th fact is given evidence from the following observations:

(1) If the immovability is dependent upon the deep paralysis the prey must recover to a certain extent during the succeeding procedure. This is by no means the case with respect to the prey of *Astata*.

(2) When the prey is kept in a small bottle it begins to rotten within a few days. Of course a few bugs among many can respond to a given stimulus by a sluggish movement of the antennae or the legs. But such is quite exceptional, probably due to the failure of the operation of the huntress. Generally speaking, the prey of this species is killed by the sting of the wasp. To me it seems that the peculiar method of provisionig of this species, especially the collection of a number of the prey promptly within a limited time must have a close connection with this imperfect ability of stinging in this species[1].

The list of the species of the prey bugs captured by this species was given earlier. The prey collected by one wasp are sometimes confined to a single species (mostly *Halyomorpha picus*), but mostly ranges over 2–4 species. Almost all of them were the nymphs. Among the hundreds of the specimins examined by me only 2 were the adult insects, 1 *Eurydema dominulus* Scopoli and 1 *Rubiconia intermedia* Wolff. The instars of the nymphs are varied, ranging from the 2nd to the 5th. The prey of this species hitherto published are:

Eurydema sp., *Eurydema festivum* L., *Sehirus morio* L., *Dolycoris baccarum* L. (after Ferton).

Picromerus bidens L., *Palomena viridissima* Poda, *Palomena dissimilis* F. (added to the above by Ashmead).

Pentatoma albomarginella F., *Pentatoma bidens* L. (added by Berland to the list by Ferton)

Eurygaster sp., *Eusarcoris guttiger* Thunb. (after Piel).

Of the prey observed by me in the Shoyozan-valley the greatest number was occupied by *Halyomorpha picus* Scop., while *Eurydema* confined to a single specimen only, others were

1) In my present opinion this consideration seems doubtful, because in some other hunting wasps that have a similar method of provisioning, for instance the species of the bee-hunting *Cerceris*, the prey are never killed, but are in a rather light paralysis.

about equal in number. The contents of the cells given in connection with each nest were summarised in Table 1.

Comparison. Comparison was made between the observation by Piel in eastern Central China and mine in Korea. P. O. Piel published his observation on the Island of Chushan at great length. In spite of the fact that he saw a great number of this species nesting in the mud wall of the Chinese houses the nest he actually observed was nothing more than a single incomplete one which was, moreover, imperfectly dug out. From the observation on such a single nest he attempted to conclude the general biolgy of the species. As a natural result he fell in an error to generalize a particular fact as if it represents the common feature in this species.

As for the nesting site the utilization of the perpendicular wall is in Korea only one of the many adaptabilities of this species, whereas he emphasized it as if it is a particular habit in this species.

Apart from the minute points, he says with respect to the state of the tunnel "il s'enfonce dans le mur par une pente irrégulière, que est ensuite……puis coudée et enfine terminée presque verticalement," and it is further separated in sevearl linearly arranged cells. Accrdingg to him this is all the structure of the nest of *A. boops* and markedly different from the nest of *A. unicolor* in which the cells are radiately distributed around the main burrow. Speaking from my observations the nest he observed was only an incomplete one and when completed it includes several series of cells around the main tunnel and is not different from that of *A. unicolor* in this regard. The inclination of the end portion of the tunnel is not always perpendicular as he said, but shows a great variety according to the condition of the nesting site.

As for the time of oviposition Ferton said "l'oeuf est porté par punaise qui occupe le fond de la chambre, mais il m'a paru n'être pondue qu'après l'approvisionnement de la cellule, ou au moins quand les provisions sont presque au complet". Piel opposed the Ferton's opinion from various reasons and insisted that the egg must be laid soon after the first prey was carried in the cell. As for my opinion, I can not but answer that I am completely consistent with that of Piel. Probably Ferton actually observed that none of the prey stored at the bottom of the tunnel (of course he did not know the fact of provisional storing of the prey in the tunnel) did carry the egg of the wasp and yet in the completed cell the egg of the wasp was laid on the bottommost prey. From such contradicted facts observed he must have drawn the above cited conclusion. (His conclusion is certainly true with respect to most of the Crabonid wasps !). In reality, however, the prey observed by Ferton must have been provisionally preserved in the tunnel, or in the larval cell, and they must have been rearranged afterward in the brood-cell. Considering as such it is very clear that the process insisted by Piel is correct, as far as his statement is concerned. In reality, however, Piel is far more superficial and metaphisical as compared with Ferton. He did not know the case as observed by Ferton. He did not know the fact of provisional provisioning in this species (in reality it is presumed that he observed the same case, but he interpreted it by another way). He happened to be correct, depending solely upon the inadeqnacy of his knowledge on this species.

I have observed many instances in which some prey were collected at the bottom of the tunnel without the egg of the wasp, but 1 never observed the case in which a single prey placed in the cell carried the egg of the wasp. Despite the fact the reason that I am equal in opininon with Piel regarding the time of oviposition is that I know the fact of provisional storing of the prey in this species.

Finally, speaking to the state of the prey hunted by the wasp, there have been 2 opinions in this regard, the opinions that the prey is dead and that the prey is alive, only in a deep pa-

ralysis. The former is not regarding A. *boops*, but *A. picea* (after Ferton), *A. unicolor*, *A bicolor* etc. (After Peckham). Piel reported that all the bugs he obseved were killed, but he presumed that there would be a possibility of the latter case in *A. boops* also. The result of my observation is consistent with that of Piel and further proved that his presumation is correct in some rare case.

Of the facts dealt with in this paper (my paper of 1947) that which is considered new to the biology of *A. boops* is that the wasp has peculiar provisioning habits. Judging from this knowledge the fact that the 5th cell (!) observed by Piel did not include the egg of the wasp was not due to that the egg was missed during the course of his examination, but was due to that the place was not the cell, but a part of the tunnel where the prey was only provisionally stored.

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