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GLEANINGS ON THE BIONOMICS OF THE EAST-ASIATIC NON-SOCIAL WASPS (HYMENOPTERA)

VI. Some Species of Trypoxyloninae

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By K. TSUNEKI
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I. GENUS *PISON* JURINE.

PISON STRANDI YASUMATSU (= *PISON IWATAI* YASUMATSU)

This species is the largest of the *Pison* group occurring in Japan, measuring 12–14 mm in both sexes, with the dark clouded wings (the origin of the Japanese local name, the black-winged Pison). It is rather common in the montanic regions of the central and northern parts of Japan proper (Honshu). It has been well known among the Hymenopterists of our country that in this species the male cooperates with the female in constructing and managing the nest. The habits were first studied by Masuda (1939) in detail. This is a very curious and rare phenomenon among the solitary wasps. But the part played by the male is apparently restricted to the protection of the nest against the intruders while the female is away for collecting the prey or the nesting material. Therefore, it is a common occurrence that we see the face of a wasp looking out at the entrance of the nest of this species every time we meet with it. If we go close to the nest entrance the porter retreats and disappears. But as soon as we leave a step the face of the porter at once appears at the entrance. If we insert a grass halm into the tunnel after the backing porter and stimululate the wasp comes out to show that it is a male. When the female comes back he gives the way to her to pass, usually after backing a little in the tunnel.

The nest of this species is usually made in the abandoned beetle burrow that appears at the cut end of the firing logs piled up for drying, or in the hole found on the pillars and railings of the old house or on the trunk of the dead standing tree. Apparently the wasp prefers the broad cavity to the narrow well fitting hollow tube, probably for the benefit of the symbiotic life of the two sexes. They therefore frequently make their nests in the comparatively broad inviting tubes set by us horizontally among the fire wood. However, they never build the longitudinal partitions to section the too broad space of the cavity, as frequently done by some species of the *Osmia* bees, but always arrange many cells linearly in a row. But they know the way of utilizing most effectively the broad space of the cavity. In this respect they are far superior to the Eumenid mason wasps that waste the space when they nest in the broad cavity. The black-winged *Pison* makes the interval between the transverse partitions short. Accordingly, each cell becomes broad and short. As a result when the larva pupates the cocoon is made transversely against the axis of the tube hollow, in nature standing somewhat obliquely upright, with the head of the larva upward. As the other result, a comparatively large number of the larval cells are constructed in the comparatively short inviting tube. The partitioning walls are usually built somewhat oblique, an instinctive technique to make the cells somewhat longer than the width of the tube under the given condition.

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The following are the instances made in the bamboo inviting tubes set by me in the montanic region of Fukui Prefecture.

Nest 1. Set among the firing logs in the village, Koike, about 800 m above the sea level, on August 4, 1963, collected on September 1 and examined two days later. When collected the male was in the tube and imprisoned by a plug. When examined he was dead and laid outside the last cell. The inner diameter of the tube was 12 mm and the length 180 mm. Nine cells were linearly arranged. The partitions were made of mud, dark brown in colour, more or less concave at the bottom, about 1 mm at the centre and 2–4 mm at the margin where they were attached to the bamboo wall. They were thicker and more unhandy than those made by the members of the mason wasps of Eumenidae. They were built oblique, the lower part slightly advanced outward and the upper part slightly retreated inward and parallell to each other, the distance between both the parts being about 2∼3 mm. The length of each cell was from the bottom as follows: Cell 1 was at the upper side 17 mm and at the lower side 19 mm, thenceforth, 14, 13, 13, 13, 10, 12, 11 and 12 mm. The last cell was with the outer wall in the course of building, the low basis of the wall being observed at the lower part of the tube.

Cell 1. Including 17 young spiders of Thomisidae, *Misumena tricuspidata* (Fabricius), with the body length from 3 to 6 mm, to one of them near the outer end of the prey mass an egg of the wasp was attached, but it had already been dried up and shrunk.

Cell 2. The larva was spinning the cocoon which was already brownish in colour.

Cell 3. Ditto, but the cocoon spinning was soon after commencement. The larva was moved into a tube bottle.

Cell 4. With 18 spiders of the same species as above. They were well paralysed but were fresh and very vivid. The larva was dead soon after hatching.

Cell 5. The plump, nearly full-grown larva, about 12 mm in length; 2 spiders remained intact. They were moved into a tube bottle.

Cell 6. The larva was dead (5 mm in length), with 18 spiders of the same species as above remained, all being fresh and vivid.

Cell 7. The larva was about 5 mm in length, eating the spider placed near the middle; 22 spiders could be counted. All belonged to *Misumena tricuspidata*, all were young.

Cell 8. Ditto, except that the larva was smaller, about 3 mm in length and the prey was 17 in numbers. The larva was among the prey and it was undetermined where the egg was laid.

Cell 9. With 8 spiders of the same species, No egg of the wasp.

The cocoon found in cell 2 was European-pear-shaped, 14 mm in length and 6 mm in width at the widest part. The spiders collected belonged all to a single species above described, considerably varied in size, hence with various patterns of marking on the abdomen.

Nest 2. The conditions regarding the place and the time of setting of the inviting tube of this nest were the same as in nest 1. The cavity of the tube was 145 mm in length and 9 mm in diameter. It included 9 cells. They were from inner to outer 19(17), 20, 19, 17, 15, 14, 12, 9 and 8 mm in length respectively. The partitions were made of the common grey mud, but on the outside a layer of the reddish brown clay was plastered. They were built oblique, with the upper margin somewhat retreated inwards, about 1.0–1.2 mm in thickness at the centre and 2–4 mm at the margin, all being parallel to each other.

Cell 1. The larva was dead and the spiders were already rotten and stuck to one another into a mass. Separated by means of alcohol it was made out that they were 12 in number, varied in size and all but one belonged to *Mismena tricuspidata*, the exceptional one being *Oxytate striatus* L. Koch.

Cells 2–6. Each with a completed cocoon. It filled almost whole the space of the cell.

Cell 7. A full-grown larva, soon after beginning to spin the cocoon, with 2 small maggots of the parasitic fly, still living at the corner of the cell. It seemed curious that the maggots did not attack the larva of the wasp.

Cell 8. The larva was dead. The spiders were dried up, 7 in number, larger in size, belonging to the same species as above. There were 5 small (about 2 mm) chrysalides and 2 small living maggots of a species of the parasitic fly.

Cell 9. Ditto, except that the spiders were 5 in number. The outer wall was in the course of building. It was raised to about one third of the height of the cell, indicating that the partition was built up from the bottom floor upwards, different in technique from the method of the mason wasps nesting in the tube cavity who make the partition spirally from the peripheral part towards the centre. In this cell 5 smaller chrysalides of the fly were discovered.

Nest 3. This nest was set and collected together with the above mentioned nests, but was examined one day later together with nests 4 and 5, on September 4, 3 days after collecting.

The space of the bamboo tube was 160×10 mm, the cell-length from the inside: 18(16), 13, 14, 10, 12, 12, 12, 10(13), 14 and 12. The final wall was in the course of building, the other walls being made oblique as in the preceding nests, except that the outer wall of cell 8 was not parallel with the inner wall and the next cell wall was parallel to this aberrant wall.

Cell 1. The prey spider were 18 in number, all that could be identified belonged to the same species as observed in other nests, of which only 5 were fresh, others being dried and hardened. The larva, 6 mm in length, was dead, blackened, dried up and was found near the outer wall of the cell.

Call 2. The full-grown larva, about 12 mm in length, was spinning the cocoon which was still semitransparent. Five dried up prey remained, all belonging to *Misumena tricuspidata*. This larva died without completing the cocoon.

Cell 3. The prey stored were 18 in number, including 5 fresh ones. The larva, 5 mm long, was dead and laid near the outer partition of the cell.

Cell 4. The full-grown larva was spinning the cocoon, only the hammock had been completed.

Cell 5. The full-grown larva was about to start the cocoon spinning.

Cell 6. The larva was 9.5 mm in length, eating the dried up spideres, still remained 5 in number. I gave it the living 5 spiders from cell 1.

Cell 7. The larva was 8.0 mm in length, much slenderer than the above, also eating the already hardened spider. The prey were 10 in number. I gave it fresh 10 taken from cell 10.

Cell 8. The larva was 6.0 mm, much slenderer than that in cell 7. It was near the outer wall. The prey were 29 in number, all belonging to *Misumena tricuspidata*, all young.

Cell 9. The larva was 4.0 mm, probably at the second instar. The prey were the small spiders of the same species as above, 33 in number.

Cell 10. 24 spiders of *Misumena tricuspidata*, including adult and young, male and female. The base of the outer partition was observed at the floor. A small larval wasp was dead and near the outer part of the cell. Some of the spiders moved their legs fairly vigorously when stimulated. The prey included some spiders belonging to *Misumena yunohamensis* Boes. et Str.

This nest was left as it had been. The bamboo tube opened was replaced to make the larvae complete each cocoon.

Nest 4. The space of the the bamboo tube utilized was 120×12 mm. The partitions between cells were inclined as usual. The cell length were from inside: 15(14), 13, 14, 16, 14, 13, 11 and 8. All but cell 6 included the completed cocoon. The cocoons were deep brown in colour, without the mud particles inlaid, all were made parallel with the cell walls, hence all stood obliquely, filling almost full space of the cells. The remains of the prey in cell 6 were decomposed, stuck to one another, about 10 in number.

Nest 5. The same bamboo tube as nest 4, only separated by the node left between the two cavities, that is to say, this nest was made in the opposite side of nest 4. The space was 123 mm long and 12 mm wide and included 7 cells. They were in length from inside: 13(11), 12, 13, 15, 14, 14 and 13.

In cells 1–3 the cocoon had been completed and in cells 4 and 5 the larva was spinning the cocoon. In cell 6 the prey were 27 in number, of which 3 were darkened and hardened, including 1 spider of *Laufeia aenea* Simon, Salticidae. The larva was about 7–8 mm in length, found near the outer partition and was eating the prey. Cell 7 included 27 *Misumena tricuspidata* and the larval wasp which was nearly equal in length to that of cell 6.

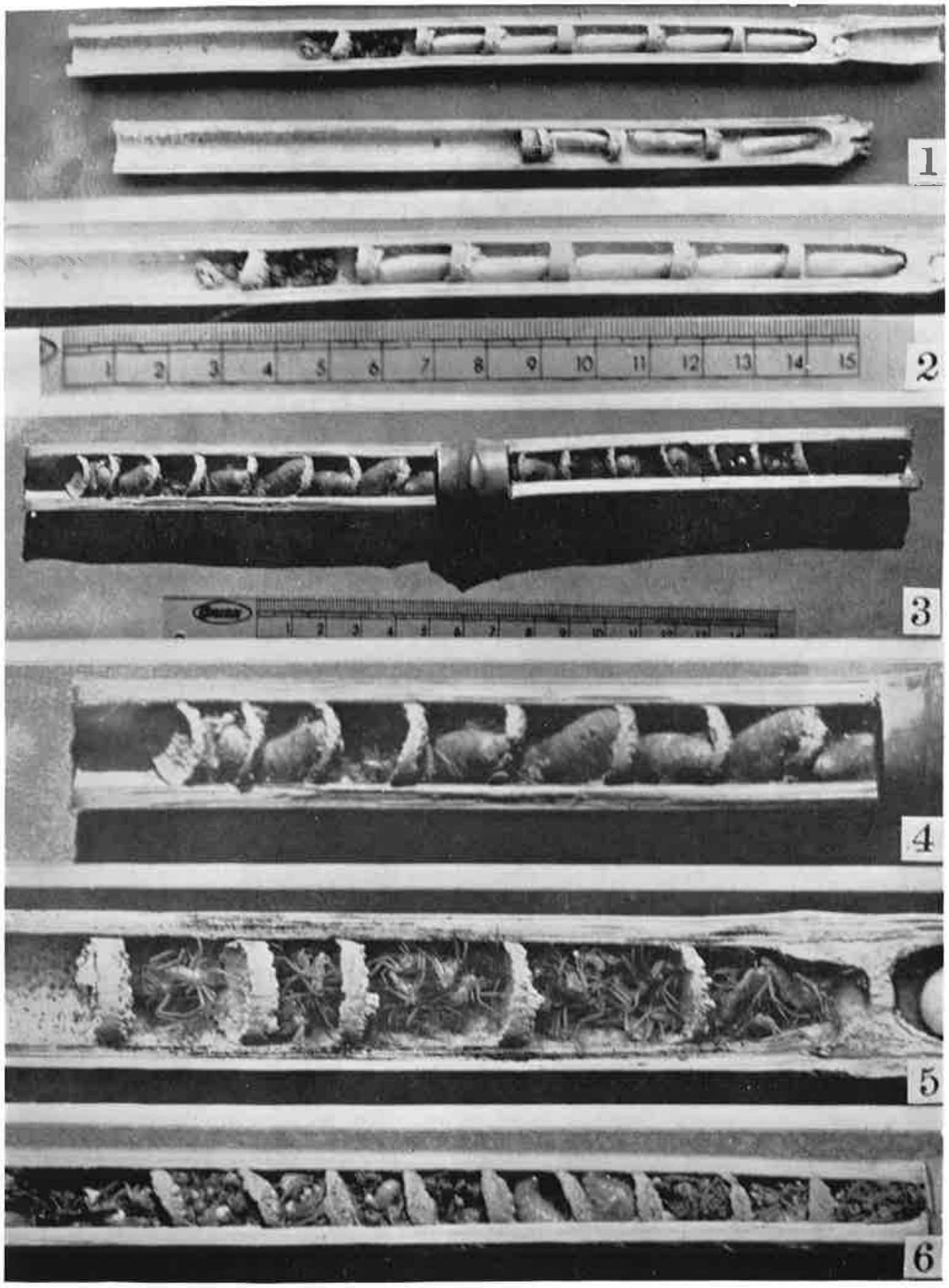
Location of the wasp's egg in the cell. I could not observe the egg of the wasp, because my examination of the nests collected was delayed due to my trip after the collection. But I could observe some small larvae still attaching to the prey spider. They were always found on the abdomen of the prey stored near the outer portion of the cell. In the cells, because of their form that was wider than long, the spiders collected were not laid in rows, but were placed in a mass. Therefore, the order of their collection could not always be determined. But in all the cells that included a young larva it was always found on one of the prey laid near the outer end. In some cases the larva was found on one of the spiders stuck to the outer cell wall. The latter fact was frequently observed probably because the wasp constructed the partition close to the mass of the prey in order to utilize the space most efficiently.

These observations indicate that the egg is laid toward the end of the provisioning to the cell, either on the final prey or on the one several before the final victim.

Effect of the part played by the male. According to the observations of the nests of this species it is very impressive that they receive almost no damage from the parasitic fly. Only in nest 2 were included some small chrysalides, about 2 mm in length, in the outer 3 cells. One of the cells included the full-grown larva of the wasp which was beginning the cocoon spinning and 2 maggots of the fly. Apparently the maggots did not attack the waspling. In one of the others the waspling was certainly dead, but the death was considered not due to the intrusion of the maggots, because the dead body of the larva remained intact. Possibly they were not the parasitic fly of the usual sense and intruded after my collection during the time when I placed the tubes on my rücksack in the tent, through the loose tampon of soft paper. With a doubtful exception all the nests observed were completely free from the attack of the parasites. In the nests of the sympatric other species, such as *Anterhynchium flavomarginatum*

EXPLANATION OF THE PLATE

Fig. 1. Two nests of *Trypoxylon obsonator* Smith. Upper... Nest 10 in table 3, lower... Nest 11 in the same table.
Fig. 2. Nest 10 somewhat more enlarged.
Fig. 3. Nests 4 and 5 of *Pison strandi* Yasumatsu.
Fig. 4. Nest 4 somewhat more enlarged.
Fig. 5. A nest of *Trypoxylon responsum hatogayuum* Tsuneki (table 3, nest 1).
Fig. 6. Nest 3 of *Pison strandi* Yasumatsu (upside down).



K. Tsuneki: Bionomics of Trypoxyloninae *micado* (Kirsch) and several other species of the mason wasps, a considerable part of the nests or cells were destroyed by the much larger parasitic flies. The nests of these mason wasps are always left open while the wasps are away from there to hunt the prey. Judging from such contrastic instances the impurity of the nests of the *Pison* dealt with here seems to be due to the presence of the porter at the entrance.

Cocoon and cocoon spinning. The larvae found in nest 1 were reared and observed. The larva in cell 2 which was in the course of the cocoon spinning was left in its own cell, closed with the other half of the bamboo tube, those in cells 3 and 5 were put in a tube bottle, 10 mm in diameter, separated with a cotton partition and those of cells 7 and 8 were placed in the second bottle with their prey without the partition. It was on September 3, at 15:00.

I examined them the next day at 15:00. The cocoon of cell 2 was covered with mud particles on the outside and apparently made of mud. This was quite curious and I could not realize how this was effected after the cocoon took a complete form, because when I saw it the previous day it had not any opening on the surface. Larvae 3 and 5 were spinning the cocoon, in the former the cocoon form had been completed, though still very thin and semitransparent, and in the latter only the silk hammock had been formed. The space given to the larvae was about twice as large as their natural cell. It must be mentioned that the cocoons found in other nests were not made of mud, only purplish brown in colour. I took out the cocoon of cell 2 and moved it into a bottle.

On September 5, at 8:00. The larva in the cocoon of cell 2 protruded its anterior body from the rent of the cocoon resulted from tearing it off the tube wall and moving its head along the bottle wall as if to plaster the silky secretion. The cocoon of larva 3 turned brownish, but the part attached to the bottle wall was semitransparent yellow through which the movement of the wasp could be observed. Larva 5 could not make the form of the cocoon. The hammock was thickened and the silk threads were irregularly attached and stretched to and between the cell wall and the floor.

The next day at 8:00. Larva 2 laid in the bottle quietly. Larva 3 also got out of the cocoon through a small hole made by itself and was attaching the silk secretion to the bottle floor. Larva 5 was still adding the silk threads to the bottom hammock. Larvae 7 and 8 were eating the spiders separately at each end of the prey mass.

On the 7th at 10:00. Larvae 2, 3 and 5 laid quietly. Larvae 7 and 8 were found at the inner portion of the bottle, lying side by side with each other and the mass of the prey was in front of them which they were eating.

On the 8th. Larvae 7 and 8 grew to about 10 mm respectively and lay still without trying to spin the cocoon. It seemed very curious that the two carnivorous larvae, usually separately placed by the mother wasp, lived peacefully side by side in one cell, without showing the cruel cannibalism which was in the similar experimental situation usually observed between the larvae of various species of the digger wasps. On the 9th the two larvae were dead.

Judging from the behaviour of larvae 3 and 5 it seems that the narrow cells made by the mother wasp of this species are not only for the effective utilization of the space, but also, or rather, for preparing the indispensable conditions of the larva to spin the cocoon safely.

Method of emergence of the adult wasps in a series of cells in the bamboo tube. As given previously the cells made in the bamboo tube of a considerable thickness are much wider than long, with the partitions on both ends which are obliquely inclined with the upper margin retreated inwards. The cocoon spun in such a cell fills whole the space, with a result that it obliquely stands with its cephalic end upwards. It seems interesting, therefore, how do the adult wasps behave when they must leave their cells. Using nest 5 above described I attempted to observe behaviour of the wasps under such a condition.

Nest 5 included 7 cocoons. The tube was split in two halves without destroying the partitions, owing to the careful preparation made before their setting. The contents of the nest were completely left in the bottom half of the tube which was deeper than the upper half. The bottom part including the cocoons and partitions was tightly covered with a sheet of the cellophane paper and placed on a table without receiving the direct sunshine.

On May 29, at 8:00, when I saw 2 wasps were emerged from the 2 outermost cells. One of them was already in the porch room between the outermost partition and the cotton plug at the entrance of the tube, biting at the cotton plug, while the other was in cell 7 and calmly sitting. The two outermost walls were broken at the upper half and the cocoons in the cells were torn and crashed at the bottom. Possibly the wasps proceeded by one cell outwards respectively.

At 9:00, the wasp that had been in cell 7 was in cell 5, having passed through cell 6 by breaking the outer wall of cell 5. But the cell was almost completely filled with the cocoon of larva 5 and the wasp could not enter there, only thrusting its anterior body into the cell. At that moment the cocoon of cell 2 began to be broken from the inside. It was not cut open roundly at the anterior end, but was irregularly and roughly torn and broken with the mandibles. As the cocoon filled whole the space of the cell the wasp could not get out until more than half of its body escaped from the cocoon.

At first the wasp tore the cocoon, venter up, but as soon as the opening became enough large it bent its head and thorax over the venter and pressed down the cocoon crust with the legs. Thus the cocoon crust was pushed down and crashed on the floor of the cell. At this moment the wasp still folded its body in two and in this posture began to break the outer wall of the cell. The wall was fragile and easily crumbled. The wasp thrust its head into cell 3 through the opening and tried to bite the cocoon. The cocoon was too tough to be cut open by such an attempt. The wasp soon ceased to gnaw it, turned round and broke the inner partition. It thrust its head into cell 1, but at once turned round again and entered cell 3. It pushed its head into the narrow aperture between the tube wall and the cocoon and passed there by force and began to destroy the outer partition of the cell. Finally it succeeded to go in cell 4, but it was too narrow to move freely. The wasp backed and backed and came back to its own cell, there it turned round and again began to bite at the rest of the outer wall of cell 1 and the cocoon. Soon it ceased the work, turned round again and passed through cells 3 and 4 by force, destroyed the outer wall of cell 4 and thrust its head into cell 5. During the time the wasps of the outermost cells turned back to each own cell and rested still, with their heads inwards. When the wasp from cell 2 (wasp 2) began to break the inner wall of cell 5, wasp 6 turned round to go to the porch. It passed by the side of wasp 7 and reached the cotton plug at the entrance. However, without trying to cut open the plug, turned round and came to cell 6, its own cell, and thrust its head into cell 5 where it met, for the first time, with wasp 2. Both wasps touched with each other with the antennae, apparently without any emotional movement. Wasp 6 which was distinctly smaller than the two others caught the cocoon of cell 5 and pulled it violently. Wasp 2 at once thrust its head and thorax into the apperture arisen by the pulling of wasp 6 and passed there by force and entered cell 6. It did not pay any attention to wasp 6, went to the porch cell, passing by the side of wasp 7 which was resting in cell 7 and at once bit at the cotton plug.

At this moment the three wasps were removed by me from the nest. All were females.

At 9:45, wasp 5 emerged from the cocoon in cell 5, The partitioning walls of the cell had been broken by other wasps and they did not become any obstruction to the emergence of the wasp. It could easily escape from the cocoon and entered cell 4. But at once turned round and came to the porch and bit at the cotton plug.

Table 1. Distribution of sexes in the nest.

Nest \ Cell	1	2	3	4	5	6	7	8	9	10
1	?	?	?	?	♀	?	?	?	?	?
2	?	♀	♀	♀	♀	♀	♂	?	?	
3	?	?	?	♀	♀	♂	♂	♀	?	
4	♀	♀	♀	♀	♀	?	♀	♀		
5	♀	♀	♀	♀	♀	♀	♀			

At 10:30, wasp 4 appeared from the cocoon. It went to cell 3, passed there by violence and entered cell 2. There it thrust its head into the broken opening to cell 1 and gnawed the cocoon of the cell for a long while. But it could not cut open it and finally at 11:05 turned round, passed through cell 3 by force and through the four outer cells and reachd the porch. There it met with wasp 5, but without showing any familiar or hostile movement it also began to bite at the cotton plug. At this moment the two wasps were removed. They also were the females.

At 18:00 wasps 1 and 3 did not emerge. But the next morning at 7:00 I found the two wasps at the porch room. They were also females.

According to the observation the following facts were made clear:

(1) The emergence of the adult wasps, though in this case all were the female, is not always made in order of their birth. Wasps 6 and 7 were the first, wasp 2 the third, wasp 5 the fourth, wasp 4 the fifth and wasps 1 and 3 the seventh.

(2) But the emergence is made within a comparatively limited time, in this case within a day, in other instances, however, not always so short (Table 2).

(3) The wasp that appears earlier in the inner cell does not wait for the emergence and escape of the sisters in the outer cells, but passes these cells by force, destroying the partitions one after another and goes out of the nest.

(4) The cocoon is tough enough to resist the rough treatment of the early born sisters and does not receive any damage.

(5) Apparently there is no digital communication between the mother wasp and her offspring, as usually observed on many species of the tube-nesting wasps and bees. Possibly this is due to that the space of the cell is not broad enough to allow the free movement of the emerging wasp. The new born wasp tries to break either of the partitions at both ends of the cell. The escape is succeeded as a result of trial and error.

Distribution of the sexes in the nest. The rule that the female is inwards and the male outwards is generally obeyed, but with one exception (nest 3). See Table 1.

Order of the emergence. This was shown in Table 2.

Table 2. Order of emergence

Cell \ Nset	1	2	3	4	5
1	–	–	–	♀. 30. V.	♀. 30. V.
2	–	♀. 31. V.	–	♀. 30. V.	♀. 29. V.
3	–	♀. 31. V.	–	♀. 30. V.	♀. 30. V.
4	–	♀. 31. V.	♀. 29. V.	♀. 31. V.	♀. 29. V.
5	♀. 28. V.	♀. 28. V.	♀. 28. V.	♀. 31. V.	♀. 29. V.
6	–	♀. 31. V.	♂. 31. V.	–	♀. 29. V.
7	–	♂. 31. V.	♂. 31. V.	♀. 29. V.	♀. 29. V.
8	–		♀. 29. V.	♀. 25. V.	
9	–				
10	–				

PISON PUNCTIFRONS SHUCKARD

In a village at the foot of Mt. Haku, Ishikawa Prefecture, I found various species of solitary wasps make their nests in the pith cavity of the miscanthus of a thatched roof of an abandoned horse-pen. A female of this species was among them. She carried in her nest the prey spiders one by one. The entrance was of course facing down, but the wasp when flew back with a prey very promptly entered there, holding it between the mandibles. It was on July 29, 1955.

I pulled out the stem and examined it. It included 2 completed larval cells and 1 provisioning cell. The entrance gallery leading to the provisioning cell had the inner epidermis of the stem torn off, split lengthwise into pieces, with their apical portion free from the stem. Thus it formed a sort of the abatis, probably of use for preventing the intrusion of the parasite. However, it was unknown whether it was the result of the intentional work of the wasp or not. It was also uncertain whether such a technique could always be found in the nest of this species living in that district or not.

The pith cavity of the stem was 4 mm in diameter. Cells 1 and 2, both about 12 mm in length, included respectively 22 and 24 young spiders compactly stuffed. In cell 1 at the outside there was a fairly grown larva, about 5 mm in its curved posture, and in cell 2 a younger larva of the wasp on one of the spiders located slightly interior of the mass of the prey. In cell 1 some of the spiders had already be eaten, in cell 2 probably the first prey was eaten and in cell 3 only 5 spiders had been collected. They were bound together with fine threads and hung from the cell wall so as not to fall down from the cell. Possibly the threads derived from the prey spiders themselves. The partitions between the cells were made of mud, pale brownish white and very fragile. It was presumed that the material was collected on the white wall of the human house. Under the magnifying glass it included white plaster and the basal clay of the white wall. The partition was, as usuall, smooth at the outside and rough at the inside, holding several mud particies on the inner surface as they were attached.

II. GENUS *TRYPOXYLON* LATREILLE

As to the biology of the species of *Trypoxylen* occurring in Japan some authors such as K. Yasumatsu (1929), H. Masuda (1931, 43), H. Katayama (1931, 32, 36), D. Yamamoto (1944 a and b) have observed and recorded the nesting habits of some of the species. In those days, however, the taxonomic study of the Japanese species of the genus was not conducted and it seems possible that the wasps called *T. obsonator* F. Smith by some authors included various species of large-sized, red-banded *Trypoxylon* and those indicated under the name of *T. pygimaeum* Gussakovskij contained every species of the small-sized, wholly black ones and, therefore, it is safe to read the records with a caution and querry.

Recently T. Nambu (1966, 67) published his observations on the 8 species of this genus, on the basis of the correct identification of the species. This is probably one of the most detailed and most comprehensive ones ever made on this genus of the world.

My own observations are far less complete as compared with his, but will be of some interest because of the difference in the locality of the observation and of including one new addition in species.

TRYPOXYLON RESPONSUM HATOGAYUUM TSUNEKI

Nest 1 (Table 3, No. 1). The inviting tube of bamboo that was utilized by this wasp was set in a log pile found in the village of Arashi, about 600 m high, situated in the eastern montanic region of Fukui Prefecture. It was set on August 15, collected on 26 and examined the next day. It included 5 completed cells. The inner diameter of the nest tube and the length of each cell were given in the table. The partitions between cells were made of clayey soil, concave and smooth on the outside and convex and rough on the inside. They were comparatively thick, only slightly thinner toward the centre where they were 1.5–2.0 mm in thickness. Except for the innermost wall which was somewhat thinner than the others all of them were nearly equal in thickness (Fig. 1).

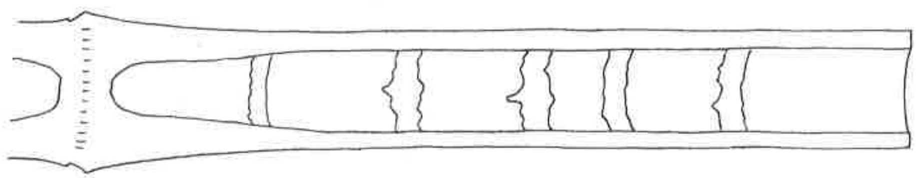


Fig. 1. A nest of *Trypoxylon responsum hatogayuum* made in a bamboo tube.

The prey belonged all to a single species of spider, *Oxytate striatipes* L. Kock, including adult and young, 4–8 mm in body length. The number of the prey from cell 1 to cell 5 was 13, 19, 19, 8 and 8. The spiders in cells 4 and 5 could move their legs and palpi fairiy actively when stimulated. They could even cling to one another. But left alone they remained quite motionless. The spiders placed on the floor of the cells were venter up, while those on other spiders were dorsum up, all were intertwined into a mass.

The larva in cell 1 was very slender, about 9 mm in length, and was on the largest prey located toward the middle of the cell. Those in cells 2 and 3 were 6 and 4 mm respectively, both on the prey placed toward the middle of the cell. In cells 4 and 5 the egg was glued to one of the prey stuffed at the innermost part of the cell. In both the egg was attached to the ventral side of the abdomen on the median line, apparently with the cephalic end at the center and the caudal end at the base, that is to say, inverse in orientation to the pedestal prey.

I reared two of them in a glass tube and observed the method of cocoon spinning. The result will be described later together with that of other species. The form of the cocoon was as given in Figure 2. The adult wasps emerged between the 10th and 15th of May, the next year. They were from inner: ♀, ♀, ♀, ♂ and ♂.

Nest 2 (Table 3, No. 2). The inviting tube utilized by the wasp was set in the same village as in nest 1. It was collected on September 11 and examined two days later. The data on the nest structure were given in table 3. Three cells were included, but the outer two were the empty cells and the innermost one alone was provisioned with spiders. But the cell was invaded by three maggots of a species of the parasitic fly and I could count the remains of 7 spiders, all belonging to *Oxytate striatipes* L. Koch.

Fig. 2. The form of the cocoon of *Trypoxylon responsum hatogayuum*.

The mud partitions were comparatively thick as in nest 1. Judging from the character of the partitions and the species of the prey spider there was no doubt that the nest was made by the wasp of this species.

Nest 3 (Table 3. No. 3). The nest was collected and examined with nest 2. Three cells were made, but in this nest also the outer two were the empty cell. And the provisioned first cell was also invaded by two maggots of the parasitic fly. One of the maggots was alredy in cell 3, perforated the two partitions and the other in cell 1 passed through the holes made by the fore runner and went to cell 3 while I was observing. Apparently the cell wall was melted by the secretion of the maggot and easily perforated.

It is a rule among the maggots of the parasitic fly that laid in the cells at the inner portion of the nest to pass through all the partitions and cells to gather together in the outermost cell before they pupate. During the course they destroy successively the contents of the cells that lie on the way. On this account the damage aroused by them becomes increasing great.

TRYPOXYLON MALAISEI GUSSAKOVSKIJ

Nest 1 (Table 3, nest 4). The inviting tube utilized by the wasp was set on August 4 in the village, Koike, cellected on August 28 and examined the next day.

It included 1 empty cell at the inner end and succeedingly 3 completed cells and the 5th was in the course of preparing. The partitions were more skillfully made than by *T. r. hatogayuum*, less than 1 mm at the central area and about 2 mm on the average at the margin. The outermost wall was thicker, about 2 mm at the centre and 4 mm at the margin, though its outer space was being prepared for the next cell. The prey were the young spiders of *Araneus ventricosus*, 3–6 mm in body length, in cell 2 three, in cell 3 five and in cell 4 two. The wasp was still working. All the three cells included the egg of the wasp, showing that they were successively and promptly constructed and provisioned. The egg was found on the 2nd, 3rd and 2nd prey from the inside, all were attached to the ventral side of the abdomen. But the exact point of attachment was more or less varied. It was common to all of them, however, that they were glued to the anterior portion of the abdomen with the cephalic end. The eggs were reared separately in each glass tube. The egg in cell 2 hatched out on August 29, finished its diet at 8:00 of September 4 (eating peaiod 6 days) and made up the outer form of the cocoon at 8:00 of the 5th and had completed it when observed at 8:00 on the 6th. It had the form as given by T. Nambu. The adult wasp emerged between the 10th and 13th of May, the next year.

Nest 2 (Table 3, No. 5). Outside the cells of this wasp the tube was utilized by a wasp of *Anterhynchium flavomarginatum micado* (Kirsch) and 2 cells had been constructed (nest supersedure). All the cells were destroyed by some maggots of the parasitic fly. Besides in cells 1 and 2 a number of mites were crowded.

Nest 3 (Table 3, No. 6). The same condition as above. The cocoon in cell 2 was in form somewhat different, 17 mm in length and 4.0 mm in maximum width, from which a female adult wasp emerged on May 29, the next year. The prey remained in cell 1 belonged all to the young spider of *Araneus ventricosus*. Cell 4 contained a strange incomplete cocoon from which an Ichneumon fly emerged on May 15, the next year. The partitions were markedly thin like a sheet of paper at the centre and about 1.5 mm at the periphery. They became thicker at the outer two.

Nest 4 (Table 3, No. 7). In this nest also the outer remained part of the tube was occupied by a mason wasp of the same species as mentioned above in connection with nest 2, and the 4 cells of *Trypoxylon* were shut in with the 5 cells of *Anterhynchium*. The prey remained in cell 2 of *Trypoxylon* were young spiders of *Araneus ventricosus* and the waspling was dead at the second instar. In cells 3 and 4 was contained a cocoon respectively, measuring both 17 mm in length. They were spun with the cephalic end 2–4 mm distant from each outer partition. From the cells separately kept in a glass bottle, however, a numberless small wasps belonging to Cynipidae emerged.

Nest 5 (Table 3, No. 8). An old record taken when I was young. The bamboo tube used by the wasp was collected and examined in January, 1930. The cocoons were from inside 18, 19, 14 and 13 mm respectively. That in cell 4 was ceased on the way of construction and the larva escaped from the incompleted cocoon. It spun the second cocoon which was curved along the tube wall in front of the outer partition. The outer two walls were markedly thicker than the others.

Table 3. Data regarding the nests of three species of *Trypoxylon*

No.	Sp.	Width	Length of cell (mm) 1	2	3	4	5	6	7	8	Rest
1	R	12	20(♀)	19(♀)	19(♀)	9(♂)	15(♂)				28
2	R	10.5	25(f)	33(e)	10(e)						118
3	R	10	26(f)	57(e)	60(e)						63
4	M	10	30(e)	38(♀)	38(d)	-(p)					86
5	M	11	27(f)	28(f)	20(f)						33 1)
6	M	12	36(d)	25(♀)	14(e)	22(i)					97
7	M	9	11(e)	25(d)	22(c)	20(c)					97 2)
8	M	10	30(♀)	32(♀)	20(♂)	20(♂)	18(e)				35
9	M 7)	6	7(e)	27(♀)	42(♀)	16(♂)	54(♂)				15
10	O	8	20(♀)	21(♀)	22(♀)	18(♂)	18(♂)	20 3)			68
11	O	8	30(♀)	25(♀)	18(♂) 4)						110
12	O	10	8(e)	22(o)	22(d)	22(o)	93(e)				52
13	O	10	20(o)	17(o)							125
14	O	8	35(o)	7(e)	15(o)	2(e)					60
15	O	9	28(♀)	95(e)							90
16	O	10	60(e)	7(e)	35(o)	10(e)	22(d)	18(d)	15(o)	7(e)	10
17	O	10	22(o)	15(o)	21(o)	23(o)	213(e)	18(o) 5)			13
18	O 6)	9	23(d)	55(e)	21(d)	2(e)	24(e)				215
19	?	7	13(d)								40

Remarks. R ... *Tr. responsum hatogayuum* Tsuneki
M ... *Tr. malaisei* Gussakovskij
O ... *Tr. obsonator* F. Smith

Abbreviation:

e ... empty cell. p ... provisioning. d ... death of offspring. f ... fly maggot. i ... ichneumon parasite. c ... cynipid parasite. o ... old cell, imago emerged.

1) Outer space was occupied by 2 cells of *Anterhynchium* wasp.
2) Outer space was occupied by 9 cells of *Anterhynchium* wasp.
3) No egg, with 5 prey.
4) Outer wall duplicated.
5) Possibly made by other wasp.
6) Possibly including cells made successively by two wasps.
7) A miscanthus stem used for thatching, with the entrance directing obliquely downward.

The cocoons were taken out and placed in a tube of glass in the original order. They were separated by the walls of pith and the glass tube was plugged with a cork at both ends and kept in a card-board box. On the 9th May, the next year, at 8:00 when I observed a female wasp emerged from cocoon 2. It first tried to break the inner wall and then the outer. The glass tube used was 10 mm in diameter and the wasp could easily turn round in it. At 9:00 wasp 3 came out of cocoon 3 of cell 3. It was smaller than wasp 2 and was distinctly a male. It soon began to bite at the outer cell wall. At this moment, probably attracted by the sound or the vibration came from cell 3, wasp 2 vigorously began to destroy the outer partition that formed the inner wall of cell 3. I stopped the observation. But when I came back at 17:00 I found the two wasps in cell 1, having broken through the two partitions. The wasp in cell 1 had already turned into the adult form, but still remained in the cocoon. The same was true also with wasp 4. The fact is presumed by the blackened body of the wasp that could dimly be seen through the cocoon wall. The next day at 8:00 the two wasp were found in cell 5, the outermost empty cell, and the wasps in the cocoons remained without move. I broke the cocoons and found that they were dead in the state of the pupa, the wasp in cell 1 being the female and that in cell 4 the male.

Nest 6 (Table 3, No 9). This nest was made in the reed cane used for thatching of the roof of a barn in the village of Mitsudani, at the foot of Mt. Haku. Therefore, the cells were made from upper to lower. The innermost small cell was an empty cell. The cocoons found in the successive four cells were 18, 19, 16 and 15 mm respectively and all directed the cephalic flattened end towards the entrance. Except for that in cell 2 all the cocoons were made 2 mm apart from the outer partition. In cell 2 which was very broad (Table 3) the cocoon was spun toward the centre of the cell. Despite the fact the cocoon took the corrrect orientation (see Cooper, K. W., 1957, digital communication). As to the partitions all but the outermost one were delicately thin.

TRYPOXYLON OBSONATOR F. SMITH

This species is a lowland inhabitant and comparatively common in Japan. It is one of the southern derivatives in the Japanese insects and its relatives live from Formosa till India.

Nest 1 (Table 3, No. 10). The inviting tube of bamboo used by the constructor of this nest was settled horizontally on the wood-board wall of a house in the city of Fukui, 2 m above the ground, late in August and was examined in winter of the year. The partition walls were comparatively thick, mostly 3.5–4 mm at the margin, but thinner toward the centre as usual. Each of cells 1–5 contained respectively one cocoon which was, similar in form to that of *T. malaisei* and truncate at the outer end. They were 17. 17. 18, 15 and 14 mm respectively from inside, the outer 2 being of the male as given in the table. Cell 6 contained 5 dried spiders of *Menemerus confusus* Bösenberg et Strand, but none of them carried the dried shell of the egg of the wasp. At the outside of the outermost partition there were several pellets of mud pastes piled up and pressed against the wall, the trade mark of this species already pointed out by T. Nambu (1966). The emergence of the adult wasps early in summer of the year confirmed that the inner three cells contained the female and the outer two the male.

Nest 2 (Table 3. No. 11). The tube of this nest was set and examined together with nest 1. The cocoons were from inside 20, 17 and 14 mm in length, all directing the cephalic end outwards as usual. The inside of the outer mud wall and the tube wall between this wall and the cocoon were considerably thickly covered with silk threads. This lining was thinly connected with the cocoon. This was considered to be a foothold to spin the cocoon. In one of the cocoons (in cell 2) a further thin layer of silk was made in front of the outer end of the cocoon. The outermost mud wall was a double wall, consisting of 2 thick layers constructed close together. The outermost layer might be a metamorphosed mud pile usually made by this species.

Nest 3 (Table 3, No. 12). Set in May under the roof of my house in Fukui and examined on August 12. Despite that the bamboo tube utilized was not narrowed at the inner node the wasp first made an empty cell. From cells 1 and 3 the offspring adult wasps had emerged and escaped. In cell 2 remained 6 spiders belonging to 3 species of Attidae, namely, 4 *Rhene atrata* (Kirsh), 1 *Plexippus paykulli* (Audouin) and 1 *Menemerus brachygnathus* (Thorell). The outermost wall was made 10 mm inside the opening, without the pile of mud pellets. But judging from the kind of the prey and the cell size there was no doubt that it was a nest of *T. obsonator*.

(*T. pulawskii* is, according to T. Nambu, similar in habits to *T. obsonator*. but that species does not occur in the vicinity of my house.)

Nest 4 (Table 3, Fig. 13). The same condition as nest 3. From both cells the wasps emerged had already escaped. In cell 1 one, and in cell 2 two black fly-catching spiders, *Rhene atrata*, remained uneaten. No empty cell nor pile of mud pellets outside the second cell.

Nest 5 (Table 3, No. 14). The same condition as above. In cell 1 remained one *Harmochirus brachiatus* (Thorell) and two *Plexippus paykulli* (Audouin) and in cell 2 two

Harmochirus brachiatus. From both cells the adult wasps had already escaped. The outer wall of the second cell was duplicated, leaving only 2 mm interval. The outermost one might be a transformed pellet-pile in the usual nest of this species.

Nest 6 (Table 3, Fig. 15). The same condition. It included only one cell that involved a blackened pupa. The second partition was constructed far apart from the cell, leaving a long space as the empty cell. Outside this wall the pile of the mud pellets were observed.

Nest 7 (Table 3. Fig. 16). It was curious that 2 empty cells were made at the bottom of the tube. There was a further empty cell next to the first larval cell and at the outside of the outermost cell. There was a pile of the mud-pellets at the outside of the outermost wall.

In cells 5 and 6 the egg did not hatch and the collected prey remained as they were, in cell 5 five and in cell 6 four spiders. They belonged to four species, namely *Harmochirus brachiatus*, *Hasarius adansoni* (Audouin), *Plexippus paykulli* and a species unknown to me.

Nest 8 (Table 3, No. 17). The cells included in this inviting tube might be made by two different wasps, because the empty cell located before the last is too long, although the outer wall of which had not the trade mark of this species showing that the nest had already completed. Cell 1 contained remains of 2 *Harmochirus brachiatus* and an empty cocoon which was reverse in direction. Cell 2 also contained the remains of 1 *Harmochirus brachiatus* and a cocoon of the wasp. Cell 3 contained the empty cocoon and in cell 4 the empty cocoon was made reverse in direction and the remains were fragmental. The outermost cell contained also an empty cocoon and its outer wall possessed the additional mud pile on its outer surface.

Nest 9. The same condition as above. The outer wall of cell 3 was double in structure, having two walls at an interval of 2 mm in length, in other word, having an empty cell of 2 mm in length. It was curious that one other empty cell was made outside such a doubled partition. In this nest a further empty cell was made next to the first cell. Probably this abnormal arrangement of the additional partitions shows that the nest was made late in the season by an old female. In cell 1 remained dried spiders of 4 *Plexippus paykulli* (2 large and 2 small) and 1 *Harmochirus brachiatus*. In cell 3 remained 1 small *Plexippus* and 2 *Harmochirus* (1 large and 1 small). Of the partitions the outer one of the doubled partition and the outermost wall were thicker than others, 4–5 mm at the margin and about 2 mm at the centre, while all the others were about 3 mm at the margin and 1 mm at the centre.

COCOON SPINNING

In one of his recent papers T. Nambu recorded in detail the method of cocoon spinning of *T. malaisei* and *T. obsonator*. My own observation made earlier on *T. responsum hatogayuum* and *T. malaisei* well coincident with his. As his paper was in Japanese I will describe one of my own observations in the following:

The larva (*T. responsum*) was reared in a glass tube which was 10 mm in diameter and was partitioned on both ends with the pith plugs, leaving for its cell the space of 25 mm in length. The full-grown larva moves about in the cell and soon begins to spin the cocoon. It first covers the inner surface of one of the partitions with silk thread which will hereafter be called the outer wall, because in nature the wall selected as such is as a rule the outer wall. Then it extends the lining inwards for some distance along the cell wall. But soon the lining is detatched from the glass wall, narrowed and extended as a thin, almost transparent, funnel-shaped pouch towards the interior. To support the funnel in place the larva stretches the silk threads between the glass wall and the edge of the opening at that moment. In some long cells in nature we often observed the presence of a second silk membrane stretched across the nest tube at some distance from the outer partition and that on the basis of this membrane the cocoon was newly formed.

The opening of the pouch is further narrowed almost to its body size and this narrowed portion of the pouch mouth is further extended inwards into a subcylinder, which is slightly attenuate towards the end. Thus, the pouch turns, as a whole, into the fig-shape. Thanks to the supporting silk threads the stalk portion of the fig is hung along the central axis of the nest tube. The hanging threads are, however, not irregularly nor everywhere uniformly stretched, but are, in the main, radiately, somewhat inclining inwards, spun at a certain intervals. The cause of the inward inclination of the supporting threads lies in the fact that when the thread is spun the larva stretches its anterior body out of the opening and glues the secretion of the silk gland to the obliquely anterior portion of the cell wall. When some threads are spun in one direction, the next moment the larva stretches another threads in the opposite direction, just as done by the web-making spider when it spins the radiating strings, to keep balance of the construction. The intervalic distribution of the hanging threads is not well visible in the natural nest, because the back ground is not dark. When the cocoon is made in a glass tube the fact is most clearly observed. When the stalk portion of the fig reaches a certain length the larva closes the opening and turns round in the cocoon, by folding its anterior body over its own belly. The silk cylinder is elastic and allows the larva to do so. The next work of the larva is to spin the anterior part of the cocoon. It extends the cylindric portion into the funnel, stretching the supporting threads between the mouth of the cylinder and the inside of the funnel. Thus the anterior part of the cocoon is protruded into the basic funnel. It was not so long extended as its posterior portion and soon closed subtruncately at the end. At this stage the cocoon is thin and fairly clear, clearer than semitransparent. The time needed to reach the stage is considerably different with the individual, from about 12 hours to about 20. Then the waspling turns round again and begins to add the silk to the inner surface of the cocoon. Thereafter it repeatedly turns round and thickens the cocoon wall. By and by the worker in the cylinder becomes obscure, but the cocoon does not turn into complete opaque to the last. It takes about 20–24 hours before the larva ceases the spinning work. The completed cocoon is wet at first as is uaual among the solitary wasps and semitransparent. After several hours it dries up and becomes opaque. At this time, however, the extreme inner end alone of the cocoon remains semitransparent. After about a day of the calm rest the larva retreats backward and excretes the feces into this semitranslusent end. Thus the portion becomes completely dark.

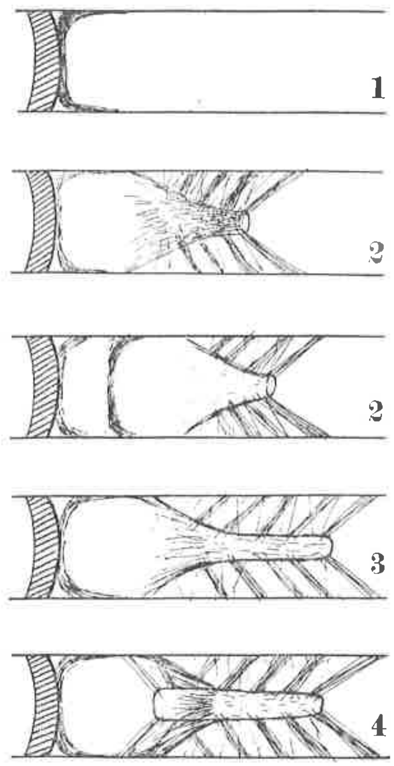


Fig. 3. The process of the cocoon spinning of *Trypoxylon responsum hatogayuum*.

The cocoon spinning process of the larva of this species is divisible into 5 stages: (1) Lining the outer partition, (2) making the funnel, (3) weaving the middle and posterier portion of the cocoon, (4) spinning the anterior portion, and (5) thickly lining the cocoon.

COMPARISON BETWEEN SPECIES

(*1*) *Common nature.* As is common to the general tube-nesting solitary wasps the species investigated here of *Trypoxylon* make the female cells inside and the male cells outside and make the one or two outermost mud partitions thicker than the inner. As the three species dealt with here are almost equal in body length the larval cells made by them are also almost equal in size accordingly, of course, those for the female being larger than those for the male. The empty cells are frequently met with. Apparently such a cell is rarely made by the wasp in the early time of her life and frequently made toward the decline of her life time. But the true reason of the presence of the empty cell remains unsolved. The structure of the partition follows the general rule smong the tube-utilizing solitary wasps, that is to say, rough and convex at the inside and smooth and concave at the outside. Most of the cocoon examined directed the anterior end toward the tube entrance, but some exceptional ones were spun in the reverse direction. The nest tube choiced by the wasp is considerably broad as compared with the slender form of the adult wasp. The use of the digital communication (K. W. Cooper, 1957), therefore, might be unnecessary in this case. However, in nature they may nest in the narrow tubes and the technique of the digital communication may become of much use under such a condition. As is well known all the species hunt the spiders as food for the larva. The form of the cocoon is also similar in general among them, in all the cephalic end is subtruncate. Adding the knowledge from Nambu regarding the cocoon spinning in *T. obsonator* it becomes that the technique used by them, possibly by all the species of this genus, is the same with each other.

(*2*) *Specific character.* (a) Prey. *T. responsum hatogayuum* hunts the spiders belonging to Attidae, as far as observed they were confined to a single species of *Oxytate striatipes* L. Koch. While *T. malaisei* captures various species of Argiopidae and *T. obsonator* collects in our district only Attidae. According to Nambu the last mentioned species collects also Lycosidae. One wasp of an undetermined species (Table 3, No. 19) collected Attidae and Argiopidae almost equal in number. Judging from the circumstantial condition there is a possibility that the species is *T. obsonator.* If truly so Argiopidae must be added to the menu of the larval food of this species. But a question must be left as to the determination of this species, because the cell was too small to be the one of *T. obsonator.* (b) Character of the partitioning wall. Generally speaking the walls made by *T. responsum hatogayuum* seem to be thicker than in other species. The nest of *T. obsonator* has a distinct trade mark of the pile of mud-pellets outside the outermost wall. It turns, however, into a rough wall attached to or somewhat detached from that wall, resulting a duplicate wall. (c) Shape of the cocoon. In the three species the cocoon is nearly truncate at the cephalic end. In *T. malaisei* and *T. obsonator* it somewhat attenuates towards the caudal end and is more or less constricted in front of the extreme end where the excrement of the larva is stuffed. In *T. responsum hatogayuum* the cocoon is parallel-sided and narrowed near the caudal end on the underside only.

A NEST OF AN UNKNOWN SPECIES

The nest was collected and examined on May 21, 1964 in the city of Fukui. Only one cell was made. It was a nest of the previous year and the wasp ceased the work probably accidentally just after sealing the first cell, because the partition of the cell was as thin as in the case of the inner one of a series of cells. The prey spiders were dried up, containing 10 *Mememerus confusus* Bös. et Str., having the body length of about 4–5 mm, 5 *Araneus* sp. of about 4 mm in length, 5 young spiders of about 3–5 mm of probably *Tetragnatha praedonis* L. Koch and 6 young spiders of about 2–4 mm in body length of some undetermined species. I thought it at first to be a nest of *T. obsonator*, because in the habitat this species was the commonest one and a number of *Menemerus* spiders were included in the nest. However, the admixture of spiders of Attidae and Argiopidae is an exception to the list of the species of the prey in this species. So far known *T. obsonator* confines the range of the prey-spiders to the members of Attidae and Lycosidae. According to T. Nambu *T. frigidum cornutum* Guss. captures mainly Argiopidae and Theridiidae and rarely mixes Attidae and *T. pulawskii* collects mainly Attidae and exceptionally mixes Lycosidae and Clubionidae. The latter wasp does not occur in my distict and to presume the former as the nest-builder the constitution of the prey species seems to be too different. I put on record the contents of the prey of this nest only for a material of the future study.

A SIMPLE EXPERIMENT ON THE RECOGNITION OF THE NEST SITE AND THE NEST ITSELF BY *TRYPOXYLON MALAISEI* GUSSAK.

This observation was made while I lived in Seoul, Korea. It was on July 13, 1942. At 16:40 I saw a wasp of this species come in my room and go to the pen-stand on my desk. She alighted on the cap of one (*A*) of the *fudê* (hair pen), made of fine bamboo-grass, about 4 mm in inner diameter, and penetrated into the hollow. In the pen-stand there was the other *fudê* (*B*) that was similarly covered with the cap of bamboo-grass, but that was slightly thicker than the first. The two *fudês* outstood over the top level of other writing tools and were considered to be very conspicuous to the wasp (Fig. 4). The cap was about 7 mm in length and the space left above the hair-pen was supposed to be scarcely enough to make a single cell for the wasp. *B* was certainly somewhat thicker than *A*, but the width of the inside hole was similar. *A* was at the farthest end from the window through which the wasp came in and went out and *B* was at the nearest. The distance between them was about 10 cm and the distance between *A* and the window-sill was 50 cm.

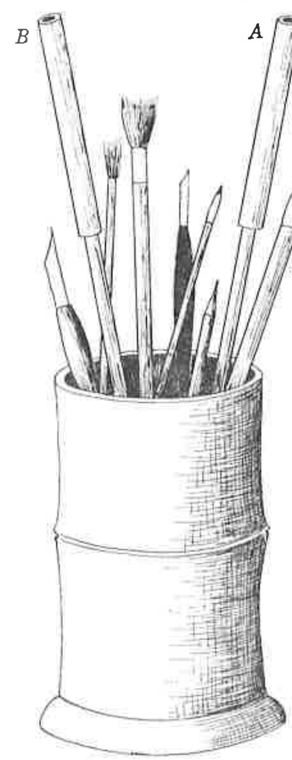


Fig. 4. The condition of the nest site.

While the wasp was away from the room the position of *A* and *B* was interchanged, without giving any other change to the surrounding conditions.

(1) The wasp returned empty-handed. She went straight to *B* (at the previous site of *A*), alighted and tried to enter. But she hesitated, flew up, turned back towards the window for about 30 cm and thence returned to *B* and alighted on the top. She thrust her head in the opening, but at once stopped, flew up, came back to the window and thence turned back to *B* again. Again she thrust her head into the opening, but hesitated as before, backed out, flew up, flew about around the pen-stand and finally came back again to the window. Without going out the wasp turned there her way and went again to *B*. This time, however, she did not alight on the cap, approached and quitted on the wing and the same manoevre was 7 times repeated. At last she alighted on the top of the sheath and went in the hole about half of her body length, but at cone she

retreated. However, without leaving there she went in the hollow again till the end of her abdomen and completely disappeared. Again she backed out and the same series of behaviour thrice further repeated. At the sixth times she stayed in the hollow for some time and when she backed out she carried some dust in her mouth to discard it at the entrance. Then she flew about around the pen-stand, alighted, went in the hollow without hesitation and carried out again the dust. The series of behaviour was thrice further observed and finally the wasp flew away out of the window.

(2) Soon the wasp returned with a pellet of moistened mud in her mouth. She went straight to *B*, but showed a marked hesitation to enter. She thrust her head in the hollow, but at once backed out and the same movement was twice and thrice repeated. Finally she lost her foot-hold and slipped down on to the desk, when she let off the mud pellet. However, when she flew up she happened to go to *A* and entered it without showing the least hesitation. She stayed inside for some time, then appeared at the entrance backing and flew away. It seemed strange that despite sush a profound confusion she did not try any orientation flight before she flew off.

(3) The wasp soon turned back with a mud pellet. She passed by the side of *A*, went straight to *B*, alighted and tried to enter. But she stopped on the way, backed out, but without flying off she tried to enter. Again she hesitated and the same series of behaviour was again and again repeated. Finally the wasp flew off the place, flew about around the pens and *fudés* and at last flew to the window and thence returned to *B*, flying slowly as if to follow the route fixed in her memory. She tried again to enter, but after three trials flew off, went westward to the furniture, flew along it slowly and when she flew off she happened to come near *A*, alighted on it and entered it with the mud that had been kept in her mouth during the course, without showing the least hesitation. Soon from the tube a keen buzzing of the wasp was heard. After a while she appeared at the entrance backing and flew away, this time, too, without trying any locality study.

(4) Soon she came back with a mud pellet and went straight to *B* as before. After several hesitating trials to enter she flew westward to the furniture, flew slowly along it, flew off and happened to find the entrance to *A* and entered it smoothly. No orientation flight when she flew off.

(5) Again she went straight to *B*, passing by the side of *A*. Again she showed marked confusions and finally flew about around the pen-stand. She did not go, however, westward, showing that the route was not learned to follow when she could not find the true nest. Sometimes she came by the side of *A*, but did not take notice of it. She thus spent just 100 seconds before she happened to find A to enter. No orientation flight when she flew off.

(6) She went to *B* straight with mud, flew up and flew about as before. After 20 sec. she happened to find *A* (16:50).

(7) Came back empty-handed, went directly to *B* again. After 5 times of flying up and alighting from and to the opening of the tube in confusion she took the course shown in the 3rd and 4th returns, found *A* and entered it.

(8) Came back with a mud-pellet, went straight above *B*, but without alighting, circled minutely above it, but finally landed on it. After a single trial to enter the wasp at once flew up and during her flight apparently casually found *A* and entered it.

(9) Came back with a pellet of mud, went straight to *B* and landed on it. But without trying to enter at onec flew up. However, she did not go elsewhere, soon alighted at the entrance, but without trying to enter, again flew up at once. The same series of behaviour was

4 times repeated. At the 5th flying up she happened to come above A and when landed on it entered it without showing any hesitation.

(10) The same series of behaviour and after spending 10 sec. she happened to find A and entered it.

(11) Similar procedure, but the time needed to find A was 23 sec.

(12) The same process, the time spent being 16 sec.

(13) Ditto, with 18 sec.

After this she did not return that day.

According to the result it is very clear that the wasp could not learn the altered site of her nest to the last, in spite of the fact that she must have decidedly learn that tube *B* to which she always returned straight is not the true nest. The repeated natural punishments (confusion) given to her are apparently of no effect upon her new learning. Until the last did she repeat the confusion and did she rely upon the casual discovery of the true nest. Apparently she was a very foolish individual.

However, to my mind it seemed that the wasp could not notice the difference of the exact site of *A* from that of *B* (in this respect certainly she was foolish!).

She found *A* always in the course of confusion and she could not get the chance of relearning the changed site of *A*. In other word, the changed sites of *A* and *B* might have been one and the same to the wasp and it might have been the first site of *A*, that is to say, the second site of *B*. According to my supposition the tube at the site of her memory was sometimes incorrect and sometimes correct as if it was alternately given by some experimenter. It seems a proof toward my supposition that the wasp did not try any orientation flight before she finally flew off the correct but site-changed tube. At that moment she might have been confident of that the new site of *A* (unnoticed by her in reality) was identical with the old site of *A*. As a result she did not feel (!) the necessity of relearning the altered site of the true tube and as a result she went straight to *B* in her next return journey.

The resemblance of the appearance of *A* and *B* and the smallness of the distance between them are considered to be the main causes of impedence to the wasp for relearning the new site of her true nest.

* * *

The next day the door was not opened until 16:20 when I came back. At 16:25, however, the wasp came in the room, went straight to *B*, alighted and showed the same confusion as on the preceding day. Finally she found *A* after confused flight of 15 sec. and entered it. After staying in the tube for 2 min. she appeared backing at the entrance, turned round and entered it again backing, abdomen first. At 16:37, however, she reappeared and flew away.

After this time till the 23rd of the same month I did not see the wasp, although the window was regularly opened in the morning and in the evening. On the 16th I examined the tube and observed that a mud wall was constructed just above the tip of the hair-bundle of the *fudé* but the cell was still empty. On the 23rd I started to excursion and returned on the 8th of the next month. The next day I recollect the work of the wasp and examined the tube. It included 2 spiders of about 5 mm in length and in spite of the fact that it was provisioned at least 17 days before they were quite fresh and soft. I examined it again on the 26th of the same month, when it still retained its softness of the body, although the abdomen was shrunk. According to the result the spiders lived more than one month after being hunted by the wasp.

LITERATURE

Cooper, K. W. 1957. Digital communication in wasps. Jour. Exp. Zool., 134: 469–514.

Katayama, H. 1934. Observations on the habits of *Pison fabricator* Smith. Kontyu. 8 (4-5-6): 225–227. (In Japanese).

Krombein, K. V. 1967. Trap-nesting wasps and bees — Life histories, nests and associates. Smithsonian Press, Washingtn, D.C.

——— 1970. Behavioral and life history notes on three Floridian solitary wasps (Hymenoptera: Sphecidae). Smithsonian Contr. Zool., 46: 1–26.

Maruyama. K. 1940. Observations on *Trypoxylon obsonator*. Hachi, 2: 13–21. (In Japanese).

Masuda, H. 1939. Biological notes on *Pison iwatai* Yasumatsu. Mushi, 12 (2): 114–144. (In Japanese with English summary).

Nambu, T. 1966–67.* Studies on the biology of eight species of *Trypoxylon* (Hym., Sphecidae) occurring in Japan, with some notes on their parasites. Life Study, 10: 25–34; 11: 6–16. (In Japanese, with summary, tables, figures and plates in English)

Sonan, J. 1925. Observations on some species of the Formosan Sphecidae. Zool. Mag. (Tokyo): 226–240. (In Japanese).

Yamamoto, D. Habits of two species of *Trypoxylon* in Japan. Hachi, 2 (6): 22–28. (In Japanese).

* Literature appeared in Japan on the biology of the species of *Trypoxylon* is all listed in this paper.