SOME BIOLOGICAL OBSERVATIONS ON A HORNET

Vespa tropica var. pulchra (Du Buysson), with special reference to its dependence on Polistes wasps (Hymenoptera)[1]

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Vespa tropica L. is a hornet distributed throughout the Oriental Regions and adjacent lands. On the biology of this species, BEQUAERT (1936) reviewed miscellaneous observations made by earlier authors. Although not cited by him, SONAN (1927, '29, '51) reported his observations on the Formosan variety, *V. t. soror* (DU BUYSSON) (First reported by SONAN as V. ducalis SMITH). The life history of this species is, however, not well known in detail and seems to be very interesting because of probable local difference in life cycle due to the wide distribution range, especially in seasonal trends of colony development. The present paper deals with the results of observations made by FUKUSHIMA in Shimoina District, Nagano Prefecture, Japan, of the Japanese variety, *V. t. pulchra* (DU BUYSSON).

ROTHNEY (after BEQUAERT 1936) mentioned the possibility of perennial colonies of this species in tropical regions. In Japan, however, the colonies are always annual like those of other hornets of temperate regions. Fertilized queens seem to prefer more or less protected narrow cavities for their winter quarter. The authors know only one example of a queen found in her hibernaculum, which was a small subterranean cavity about 30 cm under the ground (excavated on March 16, 1956).

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Fertilized queens of this species appear, among various hornets inhabiting Shimoina District, very late in spring, namely in the end of May. Thereafter, development of colonies proceeds generally in the following seasonal shift. 1. Appearance of queen (late May), 2. Nest foundation (early June), 3. Maximal development of colony and appearance of males (middle to late September), 4. Cessation of brood-rearing (October). Near the extinction of a colony, the workers pull out the still surviving broods from comb cells and throw them off on the ground. Workers seem to survive until the later part of October and males until the early part of November.

Favoured nesting sites are well protected cavities such as decayed or healthy hollow trees, mole-holes in rice-field paths, rocky crevices etc. There are still no records of nesting in the free aerial situations such as underneath the leaves or tree branches. The nests are generally so well protected in deeper cavities that they are, in comparison with those of other hornets, relatively immune against the attack of the honey buzzard, *Pernis apivorus japonicus* KURODA, a serious enemy of wasps and bees living gregariously. The manner of construction of the outer nest envelope is quite plastic. When a relatively wide space is chosen as the nesting site, the envelope covers the whole nest (see Pl. I, fig. 1, though under unnatural circumstances). But in relatively narrow spaces, it is constructed only partly over the uppermost comb. The nest is one of the smallest ones among those of various hornets in Shimoina District. Maximal diameter of combs is usually about 10 cm, reaching very rarely 20 cm. The combs seldom exceed three in number, and the cells in a single comb very rarely exceed 100. The adult population of a single nest reaches hardly 100, even at the period of maximal colony development. Nest materials are collected from the bark of old pines, hence they are very brittle and mostly reddish brown. Stripes in the envelope made by alternate dark and light bands are distinct, but not so conspicuous as in the nest of *V. crabro* L. (Pl. I, fig. 1). The characteristic feature of the nest of this hornet is the snowy white cocoons, which show a remarkable contrast to the dark nest coloration. As may be seen in Pl. I, fig. 2-4, exposed cocoons occupy almost 1/3 of the total cell length, which reaches 2.9 (worker cells) to 3.0 cm (queen cells) in mean and 3.2 cm in maximum. Diameters of cells are 0.8 to 1.0 cm in worker cells and 1.2 cm in queen ones, respectively. Dimensions of nest shown here are taken from two examples collected in Shimojômura, Shimoina.

Nest A (with two combs)[1])

comb. no. (from above)	size	number of cells		mean length of cell	length occupied by exposed cocoon	mean diameter of cell
		complete	half-built			
1	8.0 × 8.0 cm	70	—	2.9 cm	0.9—1.0 cm	0.9—1.0 cm
2	8.0 × 9.0 „	51	33	3.0 „ —2.9 „	0.9—1.0 „	0.9—1.0 „

Nest B (with three combs, Pl. I, fig. 2 & 3)[2])

1	7.0 × 9.0 cm	58	13	3.1 cm	1.2	1.0—1.2 cm
2	9.0 × 10.0 „	83	8	2.8—2.9 „	0.8	0.8—0.9 „
3	4.5 × 5.0 „	12	21	2.9—3.0 „	1.0	1.0—1.1 „

1) The second comb was attached to the first one by main pillar (4 mm in diameter) and two sub-pillars (2 mm in diameter).
2) The second and third combs were connected simply by main pillars of 2.5 mm and 1.2 × 2.5 mm in diameter, respectively.

As all the complete cells of both nests were lined with cocoons, it is clear that the total number of adults which had emerged from these nests exceeds at least 121 and 151, respectively. Whether these cells are used repeatedly or not, could not be determined.

The workers take, as in other hornets, both vegetable and animal nutriments. Various sorts of fruit juice are, if offered artificially, willingly accepted, though no serious damage to orchards has been reported up to the present for this species. Workers are rarely found on the flowers, but autumnal queens and males are often found on the flowers of *Aralia cordata,* and hibernated spring queens on *Rosa multiflora* or *Rhus verniciflua.*

As in other hornets, tree sap is one of the preferably visited nutritional sources. But, *V. t. pulchra* is, as reported previously (SAKAGAMI & FUKUSHIMA 1957), the most docile hornet in the district. Hence it is often driven away by other species, especially by *V. mandarinia.* Aside from this ferocious species, *V. t. pulchra* gives place, with little resistance, to any other hornets and even to large beetles.

The most peculiar habit of this hornet lies first of all in its remarkable partiality in taking the animal nutriment. Upon the basis of 20 years' experience, it can be concluded that the animal nutriment of this species consists almost exclusively of the immature stages of *Polistes* and

Parapolybia wasps. Up to the present, it has not been observed that this hornet preyed upon animals other than the above mentioned social wasps. In Nagano Prefecture, the broods of social wasps are held in high esteem as nutritious human food. Especially those of *Vespula lewisii* CAMERON are collected abundantly for tinning. The usual technique for finding a nest is to offer a piece of frog flesh, skinned and tied to a cotton ball, to a worker wasp and to trace the direction of its flight. This procedure is effective for all the hornets and yellow-jackets, but not for *V. t. pulchra*. This species rejects either the flesh of frogs, birds or mammals, or that of crickets, grasshoppers, dragonflies, caterpillars and various other insects accepted by other hornets. If these sorts of animal flesh are offered together with honey, she licks up only the spread honey and leaves the flesh. Even a piece of flesh put on the entrance of nest is not taken in but is thrown away.

Judging from the activities of the observed nests, any foraging flights of the workers belong to one of the following three activities, namely, visiting the flowers or tree sap, collecting the nest materials and attacking the nests of *Polistes* wasps. In this district, there are several *Polistes* species, such as *P. fadwigae* DALLA TORRE, *P. snelleni* SAUSSURE, *P. yokohamae* RADOSZKOWSKI, *P. mandarinus* FABRICIUS, *P. chinensis antennalis* PÉREZ and *Parapolybia varia* FABRICIUS. All these species are victimized by *V. t. pulchra*, but *P. fadwigae* and *P. mandarinus* most frequently, *Parapolybia*, on the contrary, relatively infrequently. Once a cruising worker has discovered a *Polistes* colony, it begins immediately to attack the nest, even in the case of a large colony. This situation can be artificially reproduced when a worker hornet attracted to the finger tip by honey is gently brought near to a nest of *Polistes* spp.

In attacking, first she flies about the nest. Correspondingly *Polistes* workers orientate on the comb surface towards the attacker in sticking the body forward. But the majority of *Polistes* workers retreat as soon as the hornet alights on the nest. They escape to the twigs near the nest and only a small portion of the inhabitants remains on the back of the nest. There is no direct combat between hornet and nest inhabitants, because the latter show no sign of resistance. The hornet worker begins her task on the nest quietly (Pl. I, figs. 5 & 6). At first the prepupae are chosen. The cell-lid is broken together with cocoon. Then she extracts and chews the prepupa. The outer integument is thrown down, the contents are swallowed on the nest. This whole act occupies from 3 to 7 minutes. In numerous observations on field and reared nests, the prey were always transported after having been swallowed, never by holding in the mouth.

after 20-30 minutes, she returns again to the *Polistes* nest and extracts the next prepupa. After all the prepupae were preyed up, the larvae and at last the pupae are victimized. The attacked pupae are restricted only to the soft ones of younger stages. The coloured pupae and pre-imagines remain intact in most cases. As the described order in extracting the immature stages was observed to be fairly constant among numerous cases, it is assumed that the hornet workers can discriminate prepupae and pupae over the cell cover by some sensory cues. A single prepupa (or larva, pupa) suffices to be carried away into the hornet nest in the case of large *Polistes* such as *P. fadwigae*, but often two prepupae are successively swallowed on the nest surface in smaller species. The attacked colonies are noticeable for the peculiarly broken fluffy cell cover, through which the immature stages were extracted. In the next or later visit, the hornet worker often comes back accompanied by one or two nestmates. Hence, it is probable that at least a non-directive alarm-type communication exists among the members of the same nest. If one worker discovered a *Polistes* nest, often even a large nest can be emptied during a few hours. The attack is so complete that the nest once attacked cannot recover; it will be abandoned in most cases, though the inhabitants stay occasionally on the empty nest until the autumnal fall.

In 1955, some observations were made with three colonies, Nos. 1, 2 & 3, which were transferred into the observer's house after discovery. The nests were located in transport bee-hives; the outer envelopes were destroyed at the time of setting the nest into the hive (Pl. I, fig. 2), but later reconstructed as seen in Pl. I, fig. 1.

nest no.	population size at discovery[1])	date of discovery	nesting site	date of opening entrance after transportation
1	17	Aug. 10	decayed hollow-tree	Aug. 11
2	ca. 20	Aug. 12	„	Aug. 14
3	48	Aug. 31	mole-hole	Sept. 1

1) As the nests were all taken at night, exact ratio of three castes could not be determined.

In each of these nests, several workers returned to the original nesting site after the nest entrance was opened at the new site. The distance between the last and new sites was in every case more than 1 km. Moreover, two workers of nest No. 2 marked with coloured paint were discovered at a tree sap about 1 km distant from the nest after the

colony was settled at the new site. Therefore, it is conceivable that the flight range of this species extends at least 1 km in radius.

On sunny days, one or two workers were engaged near the nest entrance in ventilation by fanning, often for 10 minutes without interruption. The ventilator's head is directed, as in the Asiatic honeybee, *Apis indica,* towards the outside, not toward the nest entrance as in the European honeybee, *A. mellifera.* These ventilators seem not to engage in the foraging at least until the later stages, because most foragers are characterized by their tattered wings and worn off hairs, which suggest their relatively older ages. Three regular foragers in Nest No. 1 were marked individually with coloured paint. As seen in fig. 1, the ordinary foraging courses of these workers (*a, b, c*) were remarkably constant during about three weeks. Worker *a* always flew away westerly over a kaki-tree and a plum tree and then toward the mulberry field where several nests of *P. fadwigae* existed. Worker *b* always flew away eastward under the low vine trellis. Finally, Worker *c* used to fly straight southward about 100 m until reaching the cemetery hedge and then flew around the hedge further southwardly. Unfortunately no observation could be obtained with respect to the behaviour inside the nests.

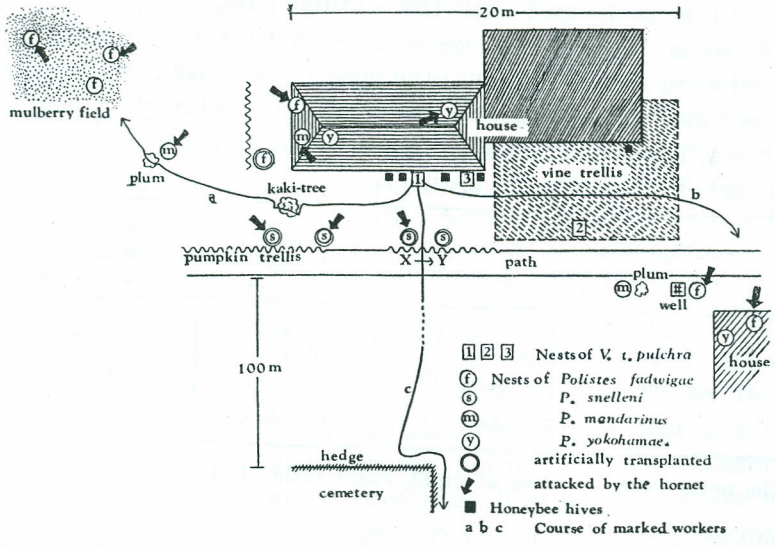

Fig. 1. Distribution of *Polistes* nests in the vicinity of hornet nests artificially transplanted.

The distribution of *Polistes* nests near the transplanted hornet nests is illustrated in fig. 1. The nest marked as X-Y is one of *P. snelleni,* at

which the actual scene of extracting (Pl. I, fig. 5) and chewing (Pl. I, fig. 6) pupa was photographed. In both instances, nearly all the inhabitants scaped into the neighbouring twigs before the photographs were taken; nly one male remained at the nest as shown by arrows. The inhabitants f this *Polistes* nest translocated to Y after the attack and constructed here a tiny second nest of 6 cm length and 2 cm width, which remained n safety until the autumn, hidden by pumpkin leaves. Of 16 nests of arious *Polistes* species (including four nests artificially transplanted) ıear the hornet nests, a total of 10 nests were attacked and destroyed by he hornets as indicated in fig. 1 by black arrows. These attacks, under- aken mostly during 3 weeks after the transplantation of hornet nests, ndicate clearly how this hornet plays an important rôle in controlling the development of *Polistes* colonies. Destruction was so complete that neither reconstruction nor commencement of new brood rearing was observed, except in the case of the one *P. snelleni* nest mentioned above.

In contrast to the frequent attack upon the *Polistes* nests, this hornet seems not to attack the bee hives. In Shimoina District bee hives are attacked by three hornet species, namely, *V. mandarinia* SMITH, *V. xanthoptera* CAMERON and *V. crabro* LINNÉ. *V. mandarinia* is the worst enemy of the honeybee in Japan. Thousands of hives are destroyed annually by this extremely ferocious hornet. Attacks of *V. xanthoptera* are less frequent but much more serious than those by *V. crabro,* which attack only occasionally bee hives. Up to the present, however, there are no records of attacks upon a hive by *V. tropica pulchra* at least in Shimoina District. Moreover, three observed nests were, as shown in Fig. 1, situated side by side with bee hives, mostly mediumsized colonies consisted of about 10,000 individuals (*Apis mellifera ligustica*). There were instances in which some hornet workers approached near to the hive entrance, perhaps attracted by honey odour. But the actual attack of hives was in no instance observed. Also, the worker hornets were often attracted to the sugar-syrup feeder offered to the honey bees, but in all cases retreated when more than five bees were present at the feeder. On the other hand, *V. xanthoptera, V. crabro* and probably *V. mandarinia* occasionally attack *Polistes* nests, but never frequently and habitually as in the case of *V. t. pulchra.*

Finally it would be worth while to consider the above results in comparison with the observations made in tropical districts. Unfortunately, as mentioned by BEQUAERT, the earlier authors mostly confused *V. tropica* (in many cases described as *V. cincta*) with *V. affinis*. The nests reported under the name "*V. cincta*" were, however, always discovered from the

hollow trees or other more or less enclosed cavities as in *V. t. pulchra* described in the present paper (ROTHNEY 1903, Bengal; KONINGSBERGER 1908, Java; BRISTOWE 1932, Siam; after BEQUAERT). On the other hand, the nests in aerial situations seem to belong to those of *V. affinis*. A nest of *V. t. soror* described from Formosa by SONAN (1927, '29) was also situated within a narrow space under the ceiling; its size was 18 × 25 cm² and three combs. Dimensions are therefore quite comparable to those of the nest of *V. t. pulchra* nests. Snowy white cocoons photographed by SONAN resemble closely those of *V. t. pulchra*.

The attack against *Polistes* wasps seems to be a common habit of *V. tropica*. MAXWELL-LEFROY & HOWLETT (1909) stated that this hornet attacks the nests of *P. hebraeus* and carries off the larvae from the cells, the *Polistes* making no opposition. SONAN (1927, 1951) reported that *V. t. soror* (first described as *V. ducalis*) is a serious enemy of *Polistes* species in Formosa. In numerous large *Polistes* nests, he often found neither larvae nor pupae but only eggs, probably a result of attack by this hornet. According to his observation, behaviours of attacking *V. t. soror* and attacked *Polistes* astonishingly resemble those described in the present paper, for example, the absence of any resistance by the attacked *Polistes*, the extracting and chewing of larvae by the hornets etc. This carrying off was made one or two times per day and the victimized colony became empty after 4-5 days. Unique difference in the behaviour between these two varieties of *V. tropica* is the method of transporting the prey. As far as the authors' observations go, workers of *V. t. pulchra* carried the prey always after swallowing. On the other hand, workers of *V. t. soror*, according to SONAN, transported it by seizing between the mandibles after repeated chewing for about 5 minutes. It must be further studied, whether this difference means a racial distinction or merely an individual variation in behaviour. Furthermore, TAKAHASHI (1952) wrote that, in the Malay Peninsula, *V. tropica* attacks the nests of *Ropalidia* spp. and causes the extinction of numerous colonies. Hence, attacking the lesser social vespids and robbing their immature stages appears to be a specific character of this hornet.

On the other hand, TAKAHASHI reported from the Malay Peninsula one case where this hornet attacked a nest of the giant honeybee, *Apis orsata* FABRICIUS. But, as described above, the attacking of honeybee hives by *V. t. pulchra* and, according to SONAN, by *V. t. soror* is yet

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1) SONAN (1929) wrote that this hornet is an important enemy of the honeybee. But in a personal communication, to SAKAGAMI he says that this statement was cited from a popular book on beekeeping and that he had not observed such attack actually.

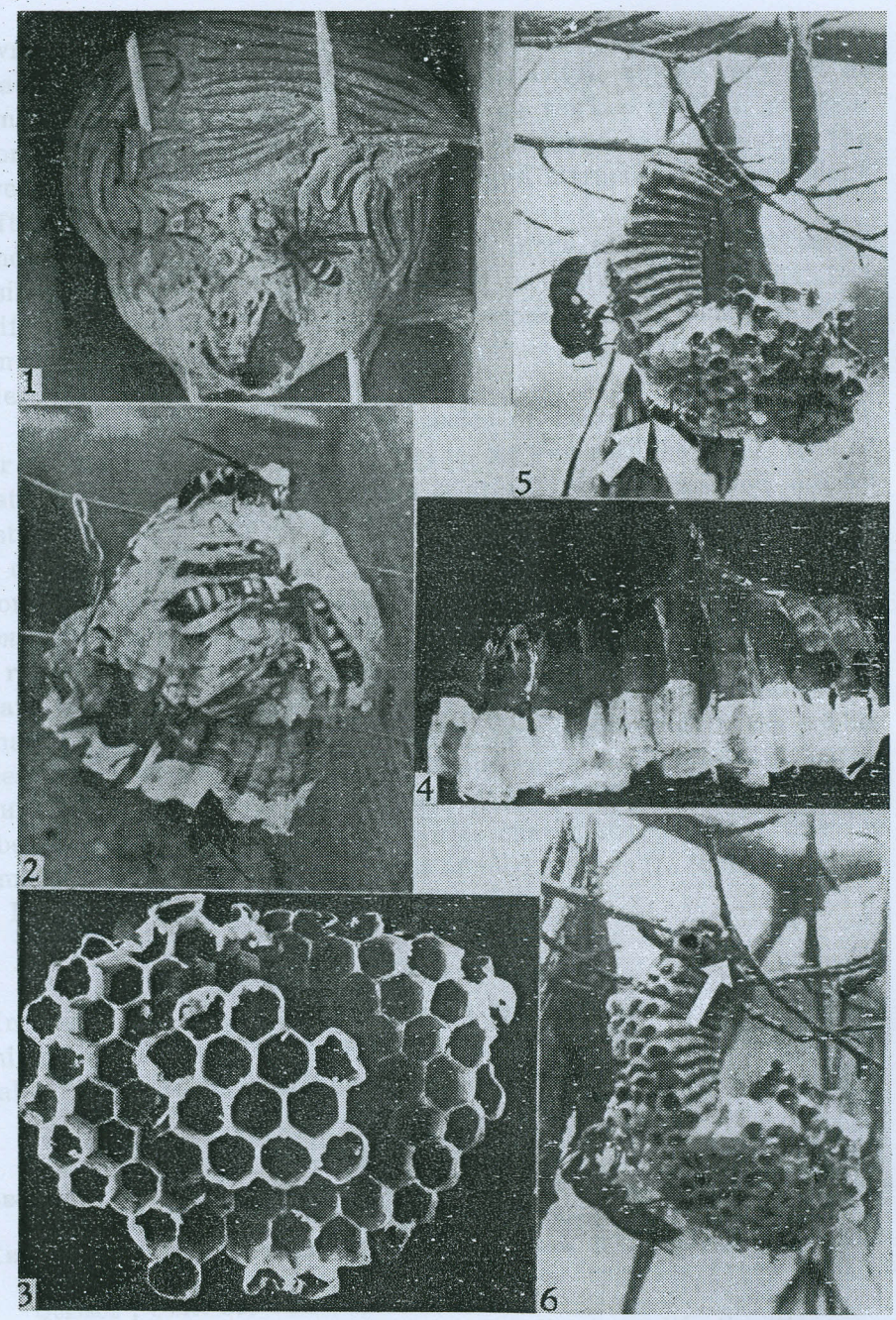

Fig. 1. A nest located in a transport hive, showing the reconstructed outer envelope. Fig. 2. Ditto, soon after the transplantation. Fig. 3-4. Combs with snowy white cocoons. Fig. 5-6. Extracting (5) and chewing (6) of a prepupa at a nest of *Polistes snelleni*. White arrows indicate a male *Polistes* remaining at the nest.

wn. Recently, in examining the specimens of *V. mandarinia*, which caught by Mr. Y. MATSUDA (Yamaguchi City), at the very act of ting a bee hive, SAKAGAMI found a large worker of *V. t. pulchra*. conceivable, however, that this means no direct attack against the ive, but a mere wandering near the apiary, attracted by honey odour often observed in *Vespula lewisii*.

Though the general pattern of the life mode of this species seems similar throughout the wide range of its distribution, the detailed difference in life-cycle, especially in seasonal shift of colony develop-, maximal colony size etc., need the further investigations in various ties.

It is well known that various species of hornet often attack the ler social vespids and steal the larvae. At any rate, however, it is of est that *V. tropica*, in spite of its relatively mild disposition, posses-. strong preference to their lesser cousins. Here is found an example ıe combination of two major interspecific relations, namely *biosocial* tion between species belonging to allied ecological niches and *bio-ominal* prey-predator relationship. Among social insects, such com-d relationship is represented by the so-called social parasitism on the hand and the specialization of food-habit on the other. Needless to that *V. tropica* belongs to the latter type, together with the robber gless bee, *Lestrimelitta limao* SMITH, and various ant species classified WHEELER (1923) under the category of compound colonies. This type ' be further subdivided into categories characterized by the thieving mmature individuals (*V. tropica*) or of food storage (*L. limao*, SCHWARZ 8, NOGUEIRA-NETO 1949, KERR 1951).

Summary

In this paper, the biology of *Vespa tropica pulchra* (DU BUYSSON) Shimoina District, Nagano Pref., Japan, was described briefly, with cial reference to its nutritional dependence on *Polistes* wasps.

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