

A COLONY OF THE HORNET *VESPA PHILIPPINENSIS*  
(HYMENOPTERA : VESPIDAE)

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Reçu le 19 décembre 1985

Accepté le 14 novembre 1986

SUMMARY

The composition of a single colony of *Vespa philippinensis* Saussure from Leyte island, Philippines is described. Workers and gynes can be distinguished by size. There appear also to be two size modes of males, much less distinct. In each sex, head-width is isometric with forewing-length. The colony contained 700 adults.

Dissection of 58 % of the gynes showed none with developed ovaries, suggesting that the colony had a single queen or was queenless. In a smaller sample of workers, 6 % without wing-wear and none with wing-wear had developed ovaries. Fat-body was more developed in gynes than workers.

No gyne or male showed wear to the ends of the forewings, while 44 % of workers showed at least some wear, independently size. Workers returning to the nest had significantly greater wing-wear but showed the same size distribution. The division of labor within the worker caste is probably age-based.

The colony included 838 immatures beyond the fourth larval instar, with a fresh biomass of 1.2 and dry biomass of 0.3 kg. About 1,480 new adults had been produced in the nest. Unlike in temperate and subtropical *Vespa*, cells were not reutilized to produce a second cycle of brood.

The colony's production schedule of workers and sexuals did not fit the *bang-bang* model.

ZUSAMMENFASSUNG

**Beschreibung einer Kolonie der Hornisse *Vespa philippinensis*  
(Hymenoptera : Vespidae)**

Die Zusammensetzung einer Kolonie von *Vespa philippinensis* von der Insel Leyte, Philippinen, wird beschrieben. Arbeiterinnen und Königinnen können durch die Körpergröße unterschieden werden. Auch bei den Männchen gibt es zwei Größenklassen, die jedoch weniger deutlich unterschieden sind. Bei beiden Geschlechtern ist die Kopfbreite positiv mit der Vorderflügelänge korreliert. Die Kolonie bestand aus 700 adulten Tieren.

Bei der Präparation von 58 % der Königinnen wurden keine entwickelten Ovarien gefunden; das könnte darauf hindeuten, daß die Kolonie nur eine eilegende Königin hatte oder weisellos war. 6 % der Arbeiterinnen ohne Flügelabnutzung hatte entwickelte

Ovarien, aber keine Arbeiterin mit abgenutzten Flügeln. Bei den Königinnen war der Fettkörper bedeutend stärker entwickelt als bei den Arbeiterinnen.

Weder Königinnen noch Männchen zeigten Abnutzungserscheinungen an den Enden der Vorderflügel, während bei 44 % der Arbeiterinnen zumindest eine geringe Beschädigung der Flügel festzustellen war; dieses konnte nicht zu der Größe der Arbeiterinnen in Beziehung gesetzt werden. Arbeiterinnen, die zum Nest zurückkehrten, zeigten die gleiche Größenverteilung wie die übrigen Arbeiterinnen, hatten aber signifikant stärker abgenutzte Flügel. Daher ist die Arbeitsteilung wahrscheinlich altersabhängig.

Das Nest enthielt 838 präimaginale Individuen nach dem 4. Larvenstadium mit einem Gesamtfrischgewicht von 1,2 kg und einem Trockengewicht von 0,3 kg. Ungefähr 1480 Imagines wurden aufgezogen. Im Gegensatz zu *Vespa*-Arten in gemäßigten und subtropischen Klimazonen wurden die Zellen nicht noch einmal zur Brutaufzucht benutzt.

Die Aufzucht von Arbeiterinnen und Geschlechtstieren in dieser Kolonie stimmt nicht mit dem "bang-bang"-Modell überein.

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## INTRODUCTION

*Vespa philippinensis* Saussure is one of two hornet species endemic to the Philippines (KOJIMA, 1982). Its exact range is uncertain, but Kojima's tentative distribution places it on all major islands of the Philippines except Palawan, where it is fairly certainly absent (pers. obs.), and perhaps Mindoro. I have not found it abundant anywhere.

*V. philippinensis* was until recently treated as a subspecies of *V. tropica* (L.) (e.g. EDWARD'S, 1980 checklist of the Vespinae). KOJIMA'S (1982) treatment of it as a separate species is clearly correct, though, as the range of *V. philippinensis* is mostly and quite likely entirely contained in that of *V. tropica*. Both species are present at the locality mentioned here.

The present report is a description of a single colony of *V. philippinensis* from the island of Leyte. It represents the first biological information published on the species. I expect to describe the nest separately along with those of some other philippine *Vespa*.

## MATERIALS AND METHODS

The described colony nested underground on a coconut-farm hillside at ViSCA, Baybay, Leyte, the Philippines.

Collection was begun before dawn on 27 September 1982, at a time when wasps were neither leaving nor entering the nest. We stayed at the site for more than three hours, long after wasps had stopped returning; the collection therefore seems to be

complete. At about 05:15 the colony was anesthetized with chloroform, the minimum necessary to incapacitate the adults. This dosage led to no apparent damage to adults or large larva. The nest was excavated as soon as the adults were quiet, with occasional reapplication of chloroform as needed. Wasps returning to the nest were counted, and most were collected.

All adults were preserved in 70 % ethanol or Dietrich's solution within a few hours of collection. All from which external measurements were later taken were first air-dried.

Wing measurements were with an ordinary ruler, to the nearest half-millimeter. Forewing length used here is from the edge of the tegula to the wing tip. Where the tip was worn, the measurement was to one end of the marginal cell, and a correction factor added. In some cases the wing was bent or twisted in preservation, so that it could not be confidently measured; the length was then estimated from the corresponding head-width. Headwidth was measured with an ocular micrometer in a dissecting microscope. The maximum width was taken, at a level slightly below the antennal sockets in face-on view. Wing-length and head-width are among the size-indices commonly used with social wasps (Reed and Akre 1982).

Each forewing was ranked as follows for amount of wear :

0. No apparent wear at the tip.
1. Slight fraying of the tip.
2. Marked fraying of the tip, but not extending into the marginal or submarginal cells.
3. Extensive wear, such that the marginal or 3rd submarginal cell is broken open.

Added together, the values from the two forewings give a wing-wear index from 0 to 6. Wasps whose ovaries were dissected were separated into those with "significant" wing-wear and those without, before this index was established. For this purpose "significant wing-wear" is approximately equivalent to an index of 2 or more.

Ovaries were characterized as developed if they had several clearly visible oocytes, at least one of which appeared near mature size. Undeveloped ovaries were those with thread-like ovarioles and no conspicuous oocytes. In this colony there was no need to adopt a finer scale.

To count prepupae and pupae, each pupal cap was cut open enough to see the wasp inside. Final-instar larvae were recognized by the large head-capsule. Brood samples were extracted on the day of collection, weighed, oven-dried for 24 hours, and then weighed again.

Except where a deliberate choice-basis is indicated, all samples were on a haphazard basis. Weighed samples of brood were each of 3-10 individuals. Haphazard samples for all other measurements were larger, usually comprising a majority of the total. In order to estimate the number of adult wasps which had been produced in the nest, every 10th cell was checked for either an empty cocoon or a fecal pellet. About one-third of the cells with a cocoon or fecal pellet were examined more closely for additional ones. Especially where a hornet cell has two or more fecal pellets, these tend to be readily distinguished and can commonly be cleanly separated from each other.

Voucher specimens are deposited at the Visayas State College of Agriculture, University of the Philippines at Los Banos, and in the collection of Michael E. Archer. These may be recognized by the accompanying nest-series number 533.

## RESULTS

Forewing-length varied from 21 to 30 mm in females, and from 21.5 to 27 mm in males. *Figure 1* shows the frequency distribution of lengths. In females, there is a very clear separation into two size-classes, such that we may confidently call them workers and gynes (potential or actual queens). In males, the pattern is not so striking. There is a strong suggestion of a

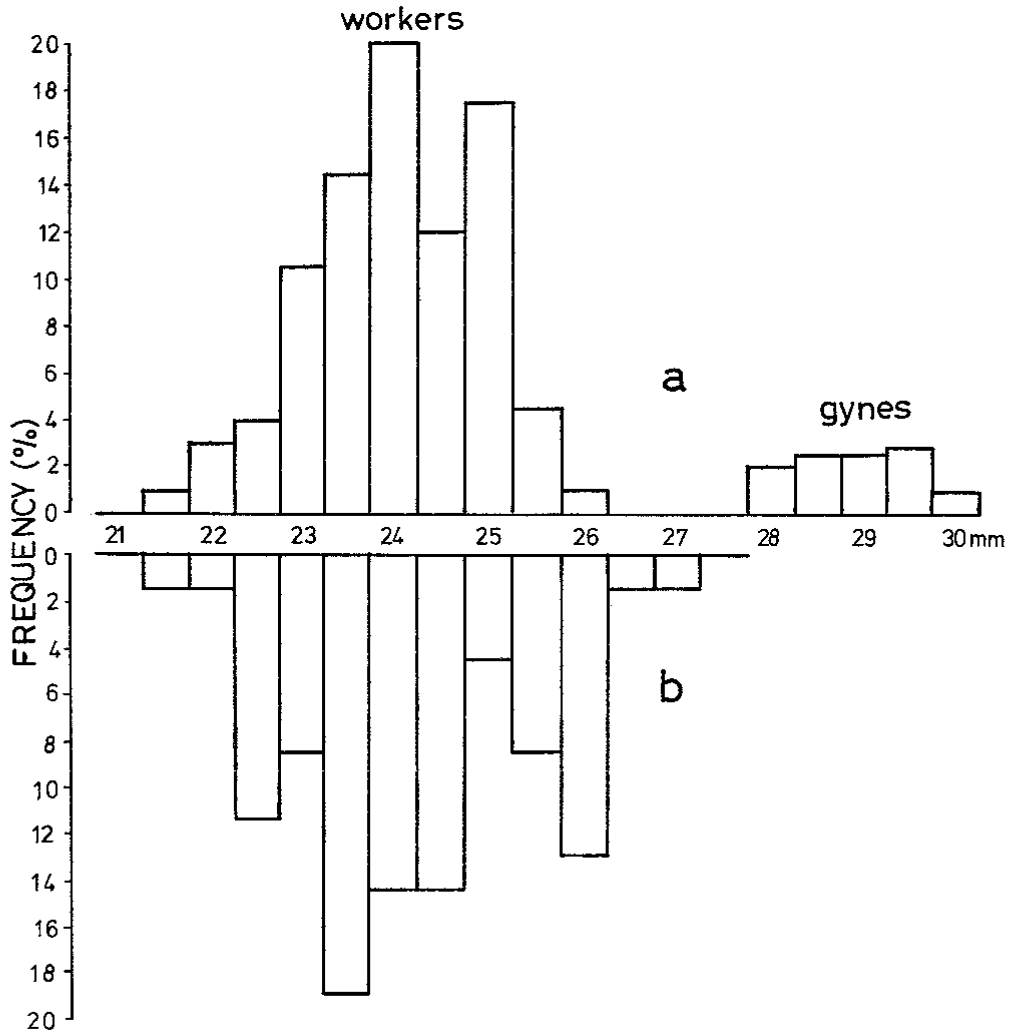


Fig. 1. — Frequency distribution of forewing-length in (a) 490 females and (b) 69 males in a colony of *Vespa philippinensis*.

Abb. 1. — Häufigkeitsverteilung der Vorderflügelänge von (a) 490 Weibchen und (b) 69 Männchen einer Kolonie von *Vespa philippinensis*.

second mode at 26 mm. but this is complicated by a weaker third mode at 22,5 mm.

The head-widths from a smaller sample of wasps are consistent with the forewing-length pattern for females and males. As seen in *figure 2*, the relationship of the two measurements is isometric. It can be fitted to the line  $y = 1.65 + 0.20x$  in females, and  $y = 2.74 + 0.15x$  in males.

At the time of collection, the colony contained 640 adult females and 60 adult males. Given a 89 : 11 ratio of workers : gynes (*fig. 1*), this leads to an estimate of 570 workers and 70 gynes. If we suppose a bimodal distribution of males into those with forewings shorter than 25 mm and those with forewings longer, and if we divide those few males of forewing length 25 mm proportionally between the two groups, we arrive at a 74 : 26 ratio of small : large males (*fig. 1*) or about 45 small and 15 large males in this

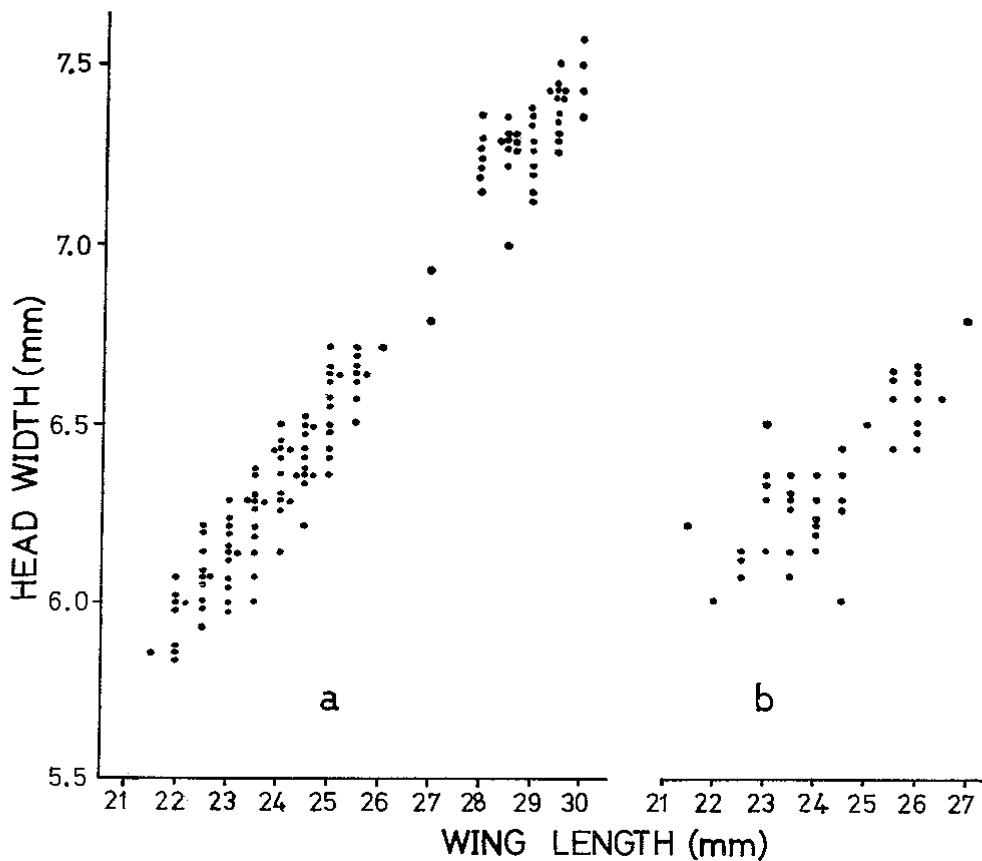


Fig. 2. — Relationship between forewing-length and head-width in samples of (a) females and (b) males from a colony of *Vespa philippinensis*.

Abb. 2. — Beziehung zwischen Vorderflügelänge und Kopfbreite bei (a) Weibchen und (b) Männchen einer Kolonie von *Vespa philippinensis*.

colony. Color markings (orange on a black ground) appear uniform within each sex.

Of 38 gynes dissected, none had developed ovaries. The ovaries were well developed in 2 of 35 workers without significant wing-wear and in 0 of 39 with wing-wear.

The one intermediate (forewing-length 26.5—27.5 mm; representing just 2/490 individuals measured) female dissected was remarkable for having both well-developed ovaries and the most severe wing-wear of any. Not only was the hind edge badly tattered, but the front edge was worn to the obliteration of the marginal and submarginal cells. This suggests that the wings had been chewed by another, rather than worn down in the course of normal work.

The one striking internal difference between castes was the consistently well-developed, light yellow fat-body of gynes. Worker abdomens showed at most a thin, discontinuous fat-body.

All gynes and males had a wing-wear index of 0. Of 288 workers, 163 (56 %) likewise showed no wing-wear (*table I*). No significant relationship was found between size and wing-wear in workers.

Table I. — Degree of wing-wear in 288 workers, of which 20 were foragers returning to the nest. Wing-wear index explained in the text.

Tabelle I. — Grad der Flügelabnutzung von insgesamt 288 Arbeiterinnen, von denen 20 Sammlerinnen waren, die zum Nest zurückkehrten. Der Grad der Flügelabnutzung wird im Text beschrieben.

	Wing-Wear							Total
	0	1	2	3	4	5	6	
Returning Foragers	3	4	3	2	1	3	4	20
Other Workers	160	33	21	20	21	6	7	268
Total	163	37	24	22	22	9	11	288

At the nest, we saw 23 females returning between 05:20-08:00. The majority of these arrived within the first hour. Inasmuch as we had noticed no wasps leaving the nest in the dark in the time before we closed it, the arriving wasps had probably been in the field throughout the night. Of the 20 such wasps collected, all were workers and may be presumed to be foragers. Their mean forewing-length was identical to that of workers in general, 24.4 mm. However, they had highly significantly greater wing-wear overall than did 268 other workers (*table I*; Mann-Whitney U test,  $p < 0.01$ ).

Brood cells in vespine nests are usually of two fairly distinct sizes (SPRADBERY, 1973; EDWARDS, 1980). In this colony these had mean widths at

the mouth (measured from side to side of the hexagon, not corner to corner) of 9.4 and 11.1 mm. At the time of collection, these contained 838 final-instar larvae, prepupae and pupae. Their distribution among small and large cells is shown in *table II*, along with the mean fresh and dry weights of the six types of brood. The total fresh brood-biomass is conservatively estimated at 1,175 g fresh and 304 g dry. This leaves out the eggs and younger larvae, which would appear to contribute little to the total. The brood is perfectly palatable (pers. obs.) and presumably nutritious.

Of the cells examined, 95 % gave evidence that a larva had pupated inside and an adult had probably emerged. None had apparently produced more than one pupa. The colony therefore is estimated to have produced 1,480 adults in its 1,557 cells.

## DISCUSSION

Although females show a clear statistical separation into two size-classes, workers and gynes, it is only a moderate separation. While the size frequency-distribution for males suggests a similar separation, this is much less decisive. This would seem to make good economic sense, as the colony should have no reason to produce two castes of males, so that male larvae in large cells should not receive added investment comparable to what females in large cells (future gynes) receive. The data-set for male *V. philippinensis* is small, though, so that any such interpretation must be received with caution.

The size frequency-distributions of both females and males closely resemble those taken from a colony of *V. crabro* (POTTER, 1964; illustrated by EDWARDS, 1980: 256). EDWARDS (1980) reports a general trend of greater size-separation in *Vespula* (s.l.) and temperate *Vespa* than in tropical *Vespa*. VECHT (1957) reported that intermediate-size females are so common in *V. tropica* that the castes cannot reliably be separated. My casual observations on *V. tropica deusta* and *V. tropica anthracina* are in full agreement with this. On the other hand, the separation is very definite in *V. luctuosa* (pers. obs.).

The isometric growth of forewing-length and head-width in *V. philippinensis* females and males is consistent with that found by BLACKITH (1958) in three *Vespula* spp.

The data from ovary dissections are hard to interpret. The fact that a small number of workers had developed ovaries (and presumably were laying eggs) suggests a reproductive competition within the colony, as does the appearance of severe mauling in the intermediate-size female with developed ovaries. The data do not allow a conclusion about the presence

or absence of a functioning queen, only tentatively that there was not more than one queen.

Comparisons between returning foragers and workers collected from inside the nest yield two conclusions: a) known foragers were on average the same size as those which are not necessarily foragers, and b) as expected, known foragers had greater average wing-wear. Consistent with these is the finding that among workers from inside the nest the different sizes had the same average wing-wear. These lead to the limited inference that at least in this colony the division of labor within the worker caste was not size-biased. From what is known in social insects in general, an age-bias seems likely in this case (e.g. see BRIAN, 1983).

The absence of more than one fecal pellet or cocoon in cells of this fairly large nest showed that cells had not been reutilized. In a very large nest of *V. affinis nigriventris* from the Philippines I likewise found very little reutilization of cells (unpublished). Cells of the first comb are commonly utilized two or three times in at least some *Vespa* spp. in Japan (MATSUURA and SAKAGAMI, 1973; YAMANE and MAKINO, 1977) and Taiwan (MATSUURA, 1973), and EDWARDS (1980) implies that this is general for temperate vespines. It is hard to see why it should not also be so in tropical *Vespa*. Any suggestion that this inhibits pathogen-infection or parasitism of second-cycle brood should be accompanied by evidence that this is a special problem in the tropics. I have not noticed any indication of disease or parasitism in any philippine *Vespa*.

The data in *table II* and the emergence of both workers and sexuals together show that the production-schedule of the colony did not follow a simple *bang-bang* model (OSTER and WILSON, 1978; GREENE, 1985).

Table II. — Numbers and mean individual weight of brood from small and large cells. The figures for pupae include resting adults, i.e. those which had shed the pupal cuticle but had not yet emerged from the cell.

Tabelle II.— Anzahl und Durchschnittsgewicht der Brut aus kleinen und großen Zellen. Die Anzahl der Puppen enthält auch adulte Tiere, die die Puppencuticula schon abgestreift hatten, aber noch nicht aus der Zelle geschlüpft waren.

	Small Cells		Large Cells	
	Fresh weight	Dry weight	Fresh weight	Dry weight
Final-Instar Larvae	0.94 g n = 265	0.27 g	1.25 g n = 70	0.26 g
Prepupae	1.18 g n = 71	0.30 g	1.97 g n = 48	0.57 g
Pupae	0.99 g n = 260	0.24 g	1.84 g n = 224	0.46 g



ACKNOWLEDGEMENTS. — Fred GODOY assisted me throughout in excavating the nest, which we found through the courtesy of Tony ESQUIVEL. Thanks also to Maite MIGUEL for volunteer typing, Gabby VALLAR for statistical advice and Ludwig NAGEL and Pr. RÖSELER for the German. As usual with my papers, peer review has led to much improvement.

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