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Weight changes in adult hornets, *Vespa affinis* (Hymenoptera: Vespidae)

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Summary

After sexuals emerge from their cells, they remain within the nest for 8–11 days (males) or 13–14 days (queens). During this time their weight increases (males 38%, queens 40%) due to the laying down of fat in the gaster. The weight of workers does not change over the same period. The fat is utilized by the queen during the 4–5 month overwintering period. When queens emerge in spring their weight is at its lowest, and they feed on nectar. Ovarian development, which was delayed during winter, now begins. During summer, queens again gain weight but this is now due to the development of the ovaries. The queen lives for about 1 year.

Introduction

Hornets (*Vespa* spp.) in both temperate and tropical regions have annual nesting cycles, with the process of colony development basically the same in both regions (Matsuura, 1991). In temperate areas all hornets have a period of quiescence which permits the queens to survive the winter, when food is scarce. During this time queens utilize fat stores built up after they emerge and prior to overwintering (Matsuura, 1966; Spradbery, 1973). After overwintering, queens feed on the nectar of various plants (Martin, 1992) or tree sap (Matsuura and Yamane, 1990). The queen then seeks out a suitable nest site and initiates the nest. During this time the ovaries, which have been inactive during the winter, start to develop, eventually packing the gaster. The queen dies in the autumn at about one year of age.

This paper investigates in detail these changes in the adult subtropical hornet *Vespa affinis affinis* (L.).

Methods

All observations are from 134 colonies of *V. affinis* on Ishigaki Island, Ryukyu, in southern Japan, between July 1989 and March 1992. The climate is typical of a subtropical island with hot summers (25–31 °C) and warm winters (15–25 °C).

All weights are fresh weights, measured using an electronic balance accurate to 0.01 g.

To measure changes in weight while in the nest, adults eclosing from the combs of collected nests were weighed and marked on the thorax with 'Qpaque' colour pens. Marked adults were then placed into an active nest during the night following emergence. After a known number of days the nest was removed and marked adults retrieved and reweighed. This method was also used to determine how long the sexuals remained in the natal nest before departing.

To measure weight loss in queens during overwintering, seven queens taken near the end of the year (late Nov.–Dec.) were weighed and placed individually into small cardboard boxes. These were kept at ambient temperature in a dry, dark place, and the queens removed each month for weighing.

During the nesting season the mother queen from each collected nest was weighed and the number of oocytes was determined by counting all oocytes equal to, or larger than, the nurse cells ("ovariole index", Cumber, 1949). During April–June queens caught on the wing away from the nest were used to supplement the data collected from queens taken in the nest.

Results

1. Length of time sexuals remain in nest before leaving

A total of 109 marked males and 96 marked queens were placed into 17 host nests for periods of 2–16 days, where they apparently were accepted into the colony and developed normally. Figure 1 shows that males remained for 8–11 days while queens

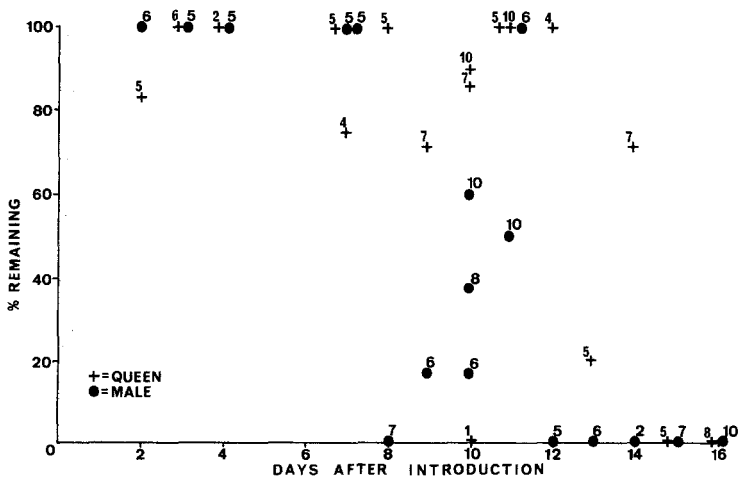

Figure 1. Percentage of marked *Vespa affinis* sexuals remaining within the host nests after a specified number of days. The number of sexuals introduced into each host nest is given above each point

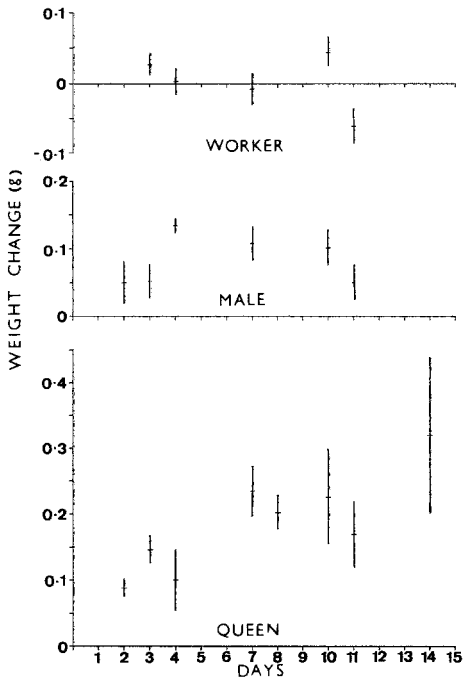

Figure 2. Weight changes of *Vespa affinis* adults during the time within the nest since their eclosion. The vertical lines indicate $\pm$S.D.

remained for 13–14 days in the nest after they eclosed. Several queens were seen leaving a nest around midday on 14 and 15 November 1990. Many queens had their heads out of the entrance, waving their antennae, but were ignored by the workers. Some queens made short sorties onto the envelope and instead of re-entering the nest suddenly took off. The queens left in different directions and with no evident orientation flight. Queens caught leaving the nest (n = 4) had gasters distended with fat deposits and weighed 0.91, 0.90, 0.90 and 0.87 grams.

2. Weight changes in the adults while in the nest

Changes in the weights of 140 adults (60 queens, 46 males, 34 workers) placed into 8–10 host nests were determined. Fresh weights at eclosion were $\bar{x} = 0.64$ grams, S.D. = 0.08, $n = 52$ queens, $\bar{x} = 0.34$ grams, S.D. = 0.05, $n = 112$ males and $\bar{x} = 0.33$ grams, S.D. = 0.07, $n = 61$ workers. Figure 2 shows that sexuals gained weight while within the nest, while the weight of the workers showed little change. Dissection of the gaster indicated that the weight increase in sexuals could be attributed to fat deposition, which was absent from workers.

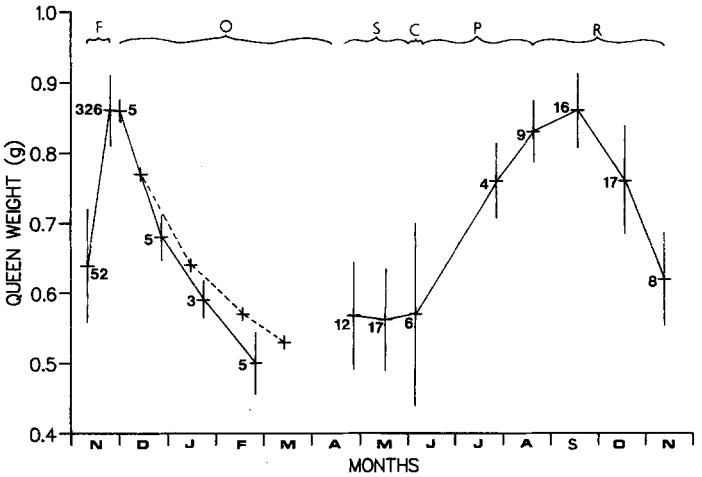

Figure 3. Weight changes of *Vespa affinis* queens during adult life. The vertical lines indicate ±S.D. The dotted line indicates the weight loss of the queen while in the typical hibernation posture. Sample sizes are given next to each mean point. F = fat buildup. O = overwintering period. S = solitary period. C = cooperative period. P = polyethic period. R = reproductive period

3. Weight loss in the queens during overwintering

Overwintering sites of *V. affinis* have been found in dry dead wood (T. Fukishi, pers. comm.). The number of autumn queen and male sightings was very small, and only one queen was caught while apparently seeking an overwintering site. The six other queens used in the experiment were taken from a collected nest (enforced overwinterers). Weight loss during the winter is shown in Figure 3. Only the queen looking for an overwintering site assumed and kept the typical overwintering posture with wings tucked under the gaster (Matsuura and Yamane, 1990), and did not move within its box during the winter.

Enforced queens did not assume this posture and were occasionally heard moving around within boxes. This movement probably accounts for the greater rate of weight loss than the queen which assumed the hibernation posture. The rate of weight loss was around 0.09 g/month. However, all queens died before they were due to emerge.

4. Post-overwintering queens

When the queens emerged from overwintering they were at their lowest weight and died within 12–24 hours without food. Dissection of the gaster showed that they had no fat deposits. During the spring, queens are often seen visiting flowers (Martin, 1992). Body weight remained low during the solitary period, but as the nest expanded the queens' weights increased to a peak in September before decreasing as they aged (Fig. 3). Figure 4 shows that these weight changes paralleled ovarian development.

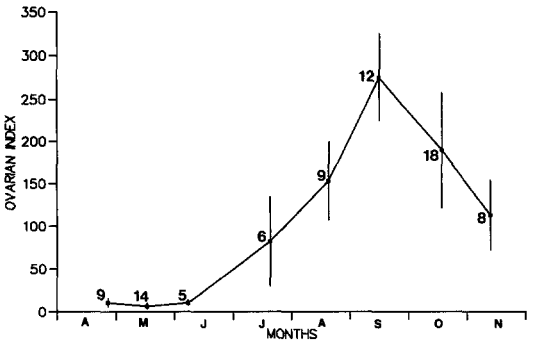

Figure 4. Changes in the ovarian index of *Vespa affinis* queens during the year. Vertical lines indicate ±S.D. Sample sizes are given next to each mean point

Discussion

Although the Ishigaki Island population of *V. affinis* lives in a subtropical environment with mild winters, queens build up extensive fat stores and enters a 4–5 month overwintering period. Workers of *V. affinis* were able to survive well into January (pers. obs.), so that overwintering is evidently not forced on queens by a lack of food. It is not yet known whether *V. affinis* enters a period of quiescence and delayed ovarian development in the tropical part of its range. However, well developed, light yellow fat-body in the gasters of new queens of *V. philippinensis* Saussure in the Philippines (Starr, 1987) and *V. velutina* Lepeletier in Malaya (pers. obs.), have been found. Overwintering under subtropical climates helps wasps synchronize the production of sexuals and rear the sexual larvae when food is most abundant.

There is little information on the length of time the sexuals remain in the nest in *Vespa* spp. Matsuura and Yamane (1990) give a figure of 1–2 weeks. Matsuura (1966) found that the weight of *V. mandarinia* Smith queens increased by 20% between eclosion and departure from the nest. It then dropped to 74% of eclosion weight by the end of hibernation. Spradbery (1963) noted that in new Vespula queens fat is more than 40% of dry weight, with 30% of this fat utilized during hibernation.

Winter mortality is thought to be very high in social wasps. Archer (1984) calculated that in *V. vulgaris* (L.) and *Dolichovespula sylvestris* (Scopoli) only 2.2% of queens survive the winter. Depletion of fat deposits before spring may well be a key factor in this mortality. The crop contents of the males were not investigated, although Archer (pers. comm.) has found the crops of male *Vespula* full of carbohydrates. Fat stores built up by males may prolong their life and so improve the chances of finding mates.

The pattern of ovarian development in *Vespa affinis* is very similar to that describing by Spradbery (1973) for *Vespula vulgaris*, and is probably similar in all long cycle nesting wasps. Long-cycle species have nesting periods of around 7 months as opposed to short-cycle species, which have nesting periods of 4 months (Matsuura and Yamane, 1990). Queens reach two weight peaks, once just prior to overwintering

and again at maximum of ovarian development. At both times the gaster is similarly distended, its physical size probably being the limiting factor.

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