Microstigmus comes Wasps have a Method of Nest Construction Unique Among Social Insects[1]

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ABSTRACT

As many as six females of the Neotropical wasp, *Microstigmus comes,* cooperate to gather and silk a single ball of material derived from the underside of fronds of the host palm, *Chryosophila guagara.* They mold this into a bag, then lower it on a silked petiole which is finally given a characteristic spiral. Construction averaged 36.8 hours of working time performed over four days. Orphaned wasps initiated new nests on their original host plant 75 percent of the time. Heavy rain and winds destroyed 28.6 percent of newly established units.

THE NEOTROPICAL WASP, *MICROSTIGMUS COMES* Krombein, is the most socially advanced member of the Sphecidae (Matthews 1968a), with as many as 18 adults of both sexes sharing a nest. Members of this species nest only on the undersides of fronds of the palm *Chryosophila guagara* Allen, which occurs abundantly in the lowland rain forests of the Osa Peninsula of Costa Rica. Unique, pendent, bag-like nests, each suspended by a narrow petiole, are constructed from waxy vestiture scraped from the underside of the palm frond and bound together with silk that female wasps secrete from abdominal glands (Matthews 1968b). While the details of nest initiation are well established for most social vespid wasps, the manner of *M. comes* nest construction has been heretofore unobserved.

At Sirena, Corcovado National Park, Costa Rica, we observed various stages in the construction of 25 *M. comes* nests during October 1980, March 1981, and September 1981. These were discovered in the course of monitoring over 200 active nests as part of a long-term study of the social biology of this species. In August 1982, we observed and filmed the complete construction sequence for five nests, which wasps initiated after their original nests were destroyed. All behavioral observations were made in the natural setting, and details of some rapid behaviors were determined with motion or still photography.

RESULTS

OBSERVATIONS.—Although both sexes of *M. comes* often occur in active mature nests, we observed only females constructing nests. Incipient nest construction is indicated by the presence of one to six wasps walking about a small area beneath a palm frond. As they walk, the wasps repeatedly peck at the surface with their mandibles, loosening the whitish vestiture which coats the frond's underside. Intermittently they touch the substrate with the tips of their abdomens, in a motion which applies silk to bind the loosened plant material. Gradually, an oval area about 10 × 15 cm becomes raised and roughened by their repeated pecking (Fig. 1A and B). Such rasped areas are very conspicuous on the underside of young fronds. After completely loosening the surface material from the entire oval, the foundresses roll it inward from the periphery, silking the material continually as they proceed (Fig. 1B). Facing outward, they tug at the loosened material, using their forelegs and jaws to pull and their jaws to cut away the last adhering fibers. In this way, they gradually gather a large, undifferentiated, fluffy mass in the approximate center of an area now scraped clear.

Once the mass has been gathered from the substrate and hangs from a single spot (Fig. 1C), the wasps begin the process of lowering it. Through repeated bouts of chewing and silking beginning at the point of connection, they form a rope-like stalk (Fig. 1D), from which the bulk of accumulated nest material hangs. Compacted material added from the nest ball to the stalk's base gradually increases its length until ultimately the fibrous ball hangs from a relatively straight petiole, 14–19 mm long.

Toward the end of this suspension phase, one or more wasps burrow into the nest ball. Within the undifferentiated mass, these females turn and somersault, silking as they go, until a small cavity is gradually created in its upper portion. Exiting from the newly formed space, these wasps form a small hole about two mm in diameter near the junction of the petiole and bag. With repeated enterings and exits, an entrance takes shape and its rim becomes extensively silked.

Next, a wasp moves a short way up onto the straight petiole, stops, and pulls part of the petiole into a loop with her middle and hind legs while pushing vigorously against it with her abdomen. After silking this area, she moves part way around and slightly up the petiole and repeats this behavior. By continuing this loop-forming process as she moves up and around the petiole, she

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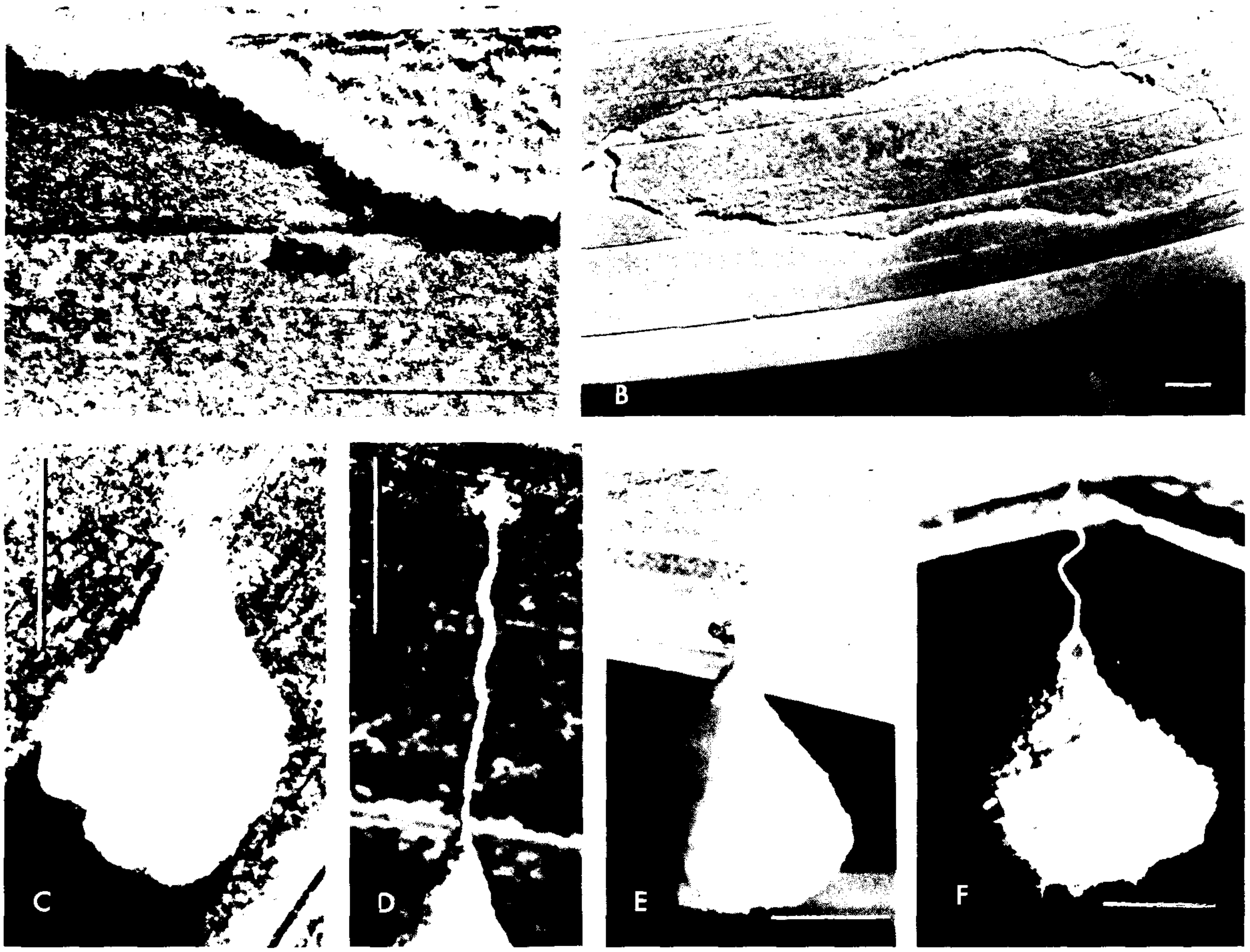

FIGURE 1. (A) A female *M. comes* (center) rests on the underside of a *Chryosophila guagara* palm frond, upon the scraped area from which she has loosened and removed the waxy pubescence (visible above). (B) Foundresses have begun to roll the raised pubescence inward, forming an irregular doughnut-like ring. (C) An undifferentiated ball of nest material has been formed in the approximate center of the scraped area on the frond. (D) The nest ball has been lowered on a straight petiole. (E) A female wasp silking a newly formed left-handed petiole spiral; completed petioles invariably have 1.5–1.75 revolutions (540–630°). (F) An older active nest with the entrance plainly visible at the base of the right-handed tightly coiled petiole. Scale bars, one cm.

gradually imposes a spiral coil upon the petiole (Fig. 1E). Although the form of the spiral is evident after the first trip up the petiole, several such spiralling runs are made in succession, always upward; on return runs down, no silk is applied. With each upward trip (typically requiring just under two minutes), the petiole becomes more distinctly coiled and more uniform in diameter (Fig. 1F). Finished petioles may spiral in a right-handed direction (like the spiral of the alpha DNA helix), a left-handed direction, or may reverse at some point along their length. In a sample of 542 nests, the overall ratio of these spiral types, respectively, was not significantly different from 2: 2:1 (χ^2 test).

Until this point in construction, which may require several days, the wasps apparently return to other nests each night. However, once the spiral is completed, the foundresses take up residence in the new nest. Over the next few days, pocket-like cells are consecutively excavated from the lower portion of the nest bag, their walls being reinforced and given shape by silking.

Experimental results.—On 29 August 1982, 15 palms with only a single nest were randomly selected. The nests were each briefly exposed to ethyl acetate vapor; this caused all adult wasps present to exit hurriedly and become temporarily trapped in a vial where they were counted and sexed prior to full recovery and release. Eight nests, randomly chosen from this group, were then completely removed before the wasps were released. Six served as controls; the remaining nest was lost during a storm. Over

TABLE 1. *The numbers of cells, numbers of females, and the durations (in hours) of selected stages of nest construction by* Microstigmus comes *females following experimentally caused nest loss. Stages recognized here intergrade into one another rather than being discrete steps.*

Nest no.	No. of cells in original nest	No. of females: In original nest census[a]	No. of females: Cooperating in construction[b]	Latency to begin[c]	Construction stage (hr): Pecking/rasping	Construction stage (hr): Rolling	Construction stage (hr): Suspension/hollowing	Minimal total time (hr) to construct new nest[f]
1	9	2	5	<10	50	4	2¼	56¼
2	8	3	5	<10	32	4	2½	38½
3[d]	7	3	4	<12	10	3	4+	17+
4	—	—	3	<10	21	11	4	36
5	8	7	6	<10	22	16	10	48
6	4	1	2	<25	15½	6	3½	25
7	4	1	1	<30	50+[e]	—	—	>50

[a] Since censuses were taken during the day when some females may have been away from the nest, these numbers are probably underestimates.
[b] These figures represent the *most* females observed at any one time; however, not all females participated continuously in the construction process.
[c] Latency to begin equals elapsed time (in hours) between destruction of original nest and initiation of pecking. A value <10 means that the first pecking was noted within one day following nest destruction.
[d] Nests 3 and 4 were constructed sequentially on the same plant presumably by the same group of females. Nest 3 broke off at the late suspension stage during a storm; Nest 4 was initiated on a different frond the following day.
[e] Female still pecking/rasping when experiment terminated.
[f] Nests were considered constructed when the first petiole spiral was made immediately following suspension/hollowing.

the next eight days, each plant was checked at least once daily for the presence of newly initiated pecked or rasped areas indicative of nest initiation.

Results were dramatic. While no new pecked/rasped areas appeared on any of the six control plants, pecking began on six of the eight experimental plants within three days of nest removal (Table 1). In three cases, the new pecked area was situated immediately next to the scraped area of the original nest. In three others, nest initiations occurred on newer fronds elsewhere on the same plant. Two experimental plants had no new nests, but a new nest appeared on an adjacent plant less than two meters from where one nest had been removed, and was presumed to be constructed by the dispossessed females.

We timed selected events in nest construction by the dispossessed females (Table 1). These data reveal that new nest construction began almost immediately, on the following day in four of the seven cases. Pecking and rasping occupied the bulk of the construction time (range = 46–89%, $\bar{x}$ = 66.3%). Total construction time averaged less than four days (36.8 working hours).

Four of the new nests were collected at the end of the experiment, eight days after the original nest had been removed. In all cases, a single cell had been excavated in the lower portion of the nest bag and provisioning had begun (1–41 Collembola prey stored). All these nests had been occupied for between two and three days at this point. Thus dispossessed females were capable of fully reestablishing their nests within about eight days.

Once nest construction was initiated, wasps worked more or less continuously during daylight hours. Occasional heavy rain showers did not cause any work interruption because the umbrella-like palm fronds fully protected nests except for spatter from adjacent or lower fronds.

An unexpected but noteworthy finding of the experiment was the discovery of the vulnerability of new nests to weather. Occasionally we had noted nests to be knocked off following storms, but a surprisingly high proportion of the experimentally induced nests (two of seven) were destroyed by weather. One nest fell in a heavy rain two days after completion. The other was destroyed in the late suspension stage, breaking at the junction of the petiole and nest bag. Thus heavy rain and wind, particularly during the early existence of a nest, may constitute a major mortality source. Wasps appear to respond to such catastrophies by beginning anew. For example, nest 4 in Table 1 was initiated following loss of the nearly finished nest 3. Interestingly, construction of the second nest required about twice as long as the first by this group of females. Because frequent sudden heavy rains are a constant feature of the rainforest habitat of *M. comes,* the adaptiveness of rebuilding is apparent.

How a group of females "decide" where to initiate a nest remains to be determined. Some form of communication may exist among foundresses. Indirect evidence for this came when we attempted to lower a frond to photograph an area where a group of foundresses had been pecking for the previous two days. After it was lowered, pecking on this area nearly ceased, but we simultaneously noted a new aggregation of females walking about on an unused frond that branched to the opposite side of the plant. The following day, however, pecking resumed at the original location where the new nest was eventually built.

DISCUSSION

Nest construction in social insects is characteristically accomplished in piecemeal fashion from individual loads of pulp and/or mud or other material (Wilson 1971). However, this study reveals that females of *Microstigmus comes* cooperatively loosen a single sheet of plant material from the substrate and then use silken fibers secreted from abdominal glands to mold it into a complete nest. This topological feat is unparalleled in any other social insect. Weaver ants (*Oecophylla* sp.) use larval silk in nest construction, weaving leaves together to form large arboreal nests (Hölldobler and Wilson 1977). *Dendromyrmex* tree ants similarly use larval silk in construction of arboreal carton nests (Wilson 1981). However, use of fibrous "silk" produced by adult hymenopterans in nest construction is apparently unique to *Microstigmus.*

The manner of nest construction in *M. comes* seems appropriately termed the "whole cloth" technique,[3] for the full amount of nest material (excepting silk) to be used is garnered *before* the nest is made. This method of establishment limits the wasps' opportunities for subsequent nest alteration and/or expansion, and ultimate nest size depends on the amount of material gathered during the scraping stage. Should the nest be damaged, its inhabitants do not undertake any repair that requires additional raw material. They will, however, patch damage with silk. Thus, if a portion of the nest is lost, the repaired nest is smaller.

Microstigmus contains about 50 species (West-Eberhard 1977). Members of species belonging to the *bicolor* group construct particulate nests of irregular bits of such materials as wood, moss, or feces, bound together with secreted fibers. Nests are not exclusively associated with particular host plants. (Interestingly, their nest petioles also lack any evidence of a spiral.) A crucial unanswered question is whether these species construct nests in a manner analagous to *M. comes,* or alternatively, in a piecemeal fashion like the more socially successful vespid wasps.

For some time, *M. comes* females have been known to cooperate in provisioning (Matthews 1968a, b). This study indicates that females cooperate from the earliest stages of nest construction. *Microstigmus comes* females also appear to possess some form of communication by which they agree on the location of the new nest. Whether cooperating foundresses all contribute eggs to the colony or whether one female becomes reproductively dominant remains to be determined.

[3] Whole cloth is defined as a piece of cloth of the full size as manufactured, as distinguished from a piece that may be cut out of it (*Oxford English Dictionary,* v. 112, p. 92, 1961).

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