Insectes soc. 45 (1998) 79–83
0020-1812/98/010079-05 $ 1.50+0.20/0

Insectes Sociaux

Research article

Colony composition and specialized predation on millipedes in the enigmatic ponerine ant genus *Probolomyrmex* (Hymenoptera, Formicidae)

F. Ito

Laboratory of Biology, Faculty of Education, Kagawa University, Takamatsu 760, Japan, e-mail: ito@ed.kagawa-u.ac.jp

Key words: Probolomyrmex, Ponerinae, specialized predation, millipede, Formicidae.

Summary

Colonies of *Probolomyrmex dammermani* Wheeler were collected in West Java, Indonesia. The nests contained a few millipedes of the family Polyxenidae, all of which were completely divested of their covering setae. Laboratory experiments showed that the ants fed only on polyxenids. The following bionomic characteristics were also noted: colony size was small (14 workers on average; range 8–21) with one dealate queen who was mated and laid eggs; pupae were necked; and both workers and queens had only one ovariole per ovary, which is the lowest ovariole number for ant queens.

Introduction

The genus *Probolomyrmex* consists of 14 species, and is found in each of the major tropical areas of the globe: Africa, Indo-Australia, and America (Taylor, 1965; Agosti, 1994; Bolton, 1995). Despite the wide distribution, this genus belongs to one of the rarest ant groups in the subfamily Ponerinae (Taylor, 1965). Taylor (1965) noted only 57 specimens in his revision of the genus and most described species were only known from the type localities. Colonies of *Probolomyrmex* have rarely been collected: colony composition has only been reported for one colony of *P. boliviensis* (= *angusticeps*) (Taylor, 1965). Bionomics, therefore, are almost unknown to date.

Probolomyrmex is a member of the tribe Platythyreini, together with the genus *Platythyrea*, which has been very important in the understanding of the diversity of the reproductive structure in ants. *Platythyrea* contains species that reproduce by means of gamergates (mated, egg-laying workers) without morphologically distinctive queens, species that reproduce by means of both queens and gamergates, and species that reproduce parthenogenetically by virgin workers (Villet, 1992; Ito,

1994; Ito and Ohkawara, 1994; Heinze and Hölldobler, 1994). Thus, the study of their most closely related genus *Probolomyrmex* is important. This paper describes the colony composition and some biological characteristics of *Probolomyrmex dammermani* collected in Indonesia.

Study area and methods

Colonies of *Probolomyrmex* were collected in the Bogor Botanic Garden (6°35′S, 106°47′E), West Java, during the rainy season in December 1995 and February 1997. The specimens were identified as *P. dammermani* Wheeler, a species described from Buitenzorg (Dutch name of Bogor). Colony composition was assessed just after sampling. Some of the females were dissected under a binocular microscope to check their reproductive condition. Three colonies were cultured in artificial nests in the laboratory in order to observe their general behavioral characteristics. Voucher specimens were deposited in the Bogor Zoological Museum.

Results

P. dammermani colonies were collected from soil at a depth of 3 to 5 cm. Since nest chambers collapsed during collection, a precise nest description is not possible. Colony composition is shown in Table 1. In addition to these colonies, one mated dealate queen was also collected from under a stone. It was uncertain whether the queen foraged or nested there. Four colonies produced sexuals; thus, they might have been mature colonies. The mean colony size was 13.8 workers (SD = 5.9). Four of five colonies had one dealate queen each, three of which were inseminated and had yellow bodies and one was virgin.

One ovariole per ovary was found in both queens and workers (number of dissected individuals: 5 dealate queens, 4 alate queens, 20 workers). Workers had no spermatheca. Both males and females had wings. According to the classification by Ito and Ohkawara (1994), this species belongs to the AQ type in which only dealate queens are mated and lay eggs, while workers are always virgin. Morphology of

Table 1. Colony composition of *Probolomyrmex dammermani* collected in the Bogor Botanic Garden, Indonesia. DQ: dealate queens, W: workers, AQ: alate queens, M: males, P: pupae, L: larvae, E: eggs

Colony code	Number of individuals								
	DQ	W	AQ	M	AQP	MP	WP	L	E
FI95-517	1	19	3	16	4	18	0	16	3
FI95-588	0	9	2	0	2	1	0	3	–
FI95-717	1*	21	4	0	4	2	5	10	5
FI95-749	1	8	0	0	0	0	0	2	4
FI97-45	1	12	1	0	0	0	–	–	–

* virgin, –: not counted.

larvae and pupae was similar to *P. bolivensis* (Taylor, 1965): larvae had a peculiar median suspensory tubercle on the terminal segment of the abdomen and pupae were naked without cocoons. In the artificial nests, larvae and pupae were attached to the glass ceiling of the brood chamber. As observed in *P. bolivensis* (Taylor, 1965), larvae were always attached by the tubercle of the abdominal tip, while pupae were attached by the head.

Four of five nests of *P. dammermani* contained one to six millipedes of the family Polyxenidae. The body length of these polyxenids was ca. two or more times that of the ants. All 11 polyxenids in the nests were completely divested of their covering setae, including caudal tufts as shown by Brandao et al. 1991, (Fig. 5) for the millipede prey of the ponerine ant *Thaumatomyrmex*. Two individuals in colony FI95-717 were alive although they were without setae. One polyxenid of colony FI95-517 had no setae and some legs had already disappeared. To discover food preference, several soil arthropods were given to laboratory colony FI95-517, including centipedes, termites, earwigs, spiders, isopods, and polyxenids. Only two polyxenids were brought into the nest chamber and were actually eaten by the adult ants and larvae. This result was consistent with the field observation that *P. dammermani* are specialized predators of Polyxenidae. In addition to the polyxenids, workers, males, and queens also fed on dead pupae and larvae of nestmates.

Hunting and the subsequent behavior were observed six times for three colonies in the laboratory. Foraging was always performed by single workers. When they encountered a polyxenid in the foraging arena, they approached it slowly from the side with the abdomen bent forward underneath the thorax. Then, the worker dashed toward the polyxenid, grasped its body, and stung. The worker then retrieved the paralyzed prey by pulling its antennae or legs or by holding the front part of the ventral appendages of the millipede and carrying the prey underneath its body. In the nest chamber, the prey was immediately stripped of setae by workers. Two or three workers frequently performed this task together. In general, a worker repeatedly grasped and pulled the setae with its mandibles for 1 to 3 minutes. Then, she went to the entrance or the corner of the nest chamber, where she abandoned the setae and frequently groomed her mandibles with the forelegs. Thus, the setae accumulated in the corner of the nest chamber and near the entrance. This behavior was repeated for 30 to 60 minutes, until stripping of the prey was completed. In colony FI95-717, a virgin dealate queen also showed this behavior with one of the two polyxenids. Alate queens, mated queens, and males never removed setae. After the prey were completely stripped, adult ants, together with the alate queens and the dealate queen started to feed; up to eight individuals fed on the prey together. After several minutes, the prey was separated into several small pieces. When the adults finished feeding, the workers gave the remains to the larvae.

Discussion

Unlike the related genus *Platythyrea, Probolomyrmex dammermani* never showed sexual reproduction by workers. The other two congeneric species collected in Java (unidentified species, hereafter *Probolomyrmex* sp. 1) and Sumatra (*Probolomyrmex* sp. 3), Indonesia, also reproduced by dealate queens only (Ito and

Okhawara, 1994; unpubl. obs.). Besides these species, alate and/or dealate queens have been known in at least six species in this genus (Agosti, 1994; Terayama et al., 1994; Bolton, 1995), suggesting that the reproductive stucture in *Probolomyrmex* principally corresponds to the AQ type.

The millipedes of the family Polyxenidae have remarkably abundant setae and caudal tufts, which is regarded as an effective anti-predator strategy. In fact, Eisner et al. (1996) showed that the caudal tufts of the polyxenid *Polyxenus fasciculatus* serve as a mechanical defense against ants. During contact, the ants become contaminated with the bristles and die (Eisner et al., 1996). Predation on the polyxenids by ants has been only known in the Neotropical ponerine ant *Thaumatomyrmex* (Brandao et al., 1991). The present study reveals that *P. dammermani* is the second specialized predator of polyxenids. *Probolomyrmex* sp. 3 also shows similar feeding habits (unpubl. obs.), suggesting that the specialization in polyxenid predation may be common in this genus. It is not certain how *P. dammermani* and *T. contumax* avoid the spraying tufts of polyxenids. *Thaumatomyrmex* has bizarre pithforked mandibles. The workers of *T. contumax* use these pecular mandibles to strip the bristles from the polyxenids before eating then (Brandao et al., 1991). The mandibles of *Probolomyrmex* do not have a special shape like those of *Thaumatomyrmex*, suggesting that the peculiar mandibles in the latter genus are not necessary for eating polyxenids.

Unlike derived subfamilies, many ponerine queens have three or four ovarioles per ovary (Villet et al., 1991; Peeters, 1993; Ito and Ohkawara, 1994), which are the commonest numbers of ovarioles in Aculeata (Iwata, 1955). *P. dammermani* is exceptional as both queens and workers have only one ovariole per ovary. This is also true for *Probolomyrmex* sp. 1 and sp. 3 and the ectatommine species *Gnamptogenys dammermani* in West Java (unpubl. obs.). An increase in the number of ovarioles in reproductive females from the regular number is common in social species and is associated with an increase in fecundity (Iwata, 1955). The significance of only one ovariole per ovary, however, is unknown. A large number of ovarioles is not necessary for small colony-sized species such as *P. dammermani* and the two undescribed species, which also had about ten workers per colony. This reduced ovariole number may be a specialization for small colony size. However, other ant species with a comparable colony size, such as *Pachycondyla* sp. and *P. sublaevis* (Ito, 1993; Peeters et al., 1991) conserve the regular number, indicating that there are other reasons for the exceptionally small ovariole number in *Probolomyrmex*.

Acknowledgements

I thank K. Nakamura, W. Noerdjito, and S. Wirjeatnodjo for their kind help during the work in Indonesia. Sk. Yamane for species identification, J. Billen and anonymous referees for their valuable advice and criticism of the manuscript, and LIPI for research permission. This work was supported by the Japan Ministry of Education, Science and Culture Grant for Overseas Research (Nos. 0541086 and 08041141).

References

Agosti, D., 1994. A revision of the South American species of the ant genus *Probolomyrmex* (Hymenoptera: Formicidae). *J. New York Entomol. Soc. 102*:429–434.

Bolton, B., 1995. *A new general catalogue of the ants of the world.* Harvard University Press, Cambridge, Mass.

Brandao, C.R.F., J.L.M. Diniz and E.M. Tomotake, 1991. *Thaumatomyrmex* strips millipedes for prey: a noval predatory behavior in ants, and the first case of sympatry in the genus (Hymenoptera: Formicidae). *Insectes soc. 38*:335–344.

Eisner, T., M. Eisner and M. Deyrup, 1996. Millipede defense: use of detachable bristles to entangle ants. *Proc. Natl. Acad. Sci. USA, 93*:10848–10851.

Heinze, J. and B. Hölldobler, 1995. Thelytokous parthenogenesis and dominance hierarchies in the ponerine ant, *Plathythyrea punctata*. *Naturwissenschaften 82*:40–41.

Ito, F., 1993. Functional monogyny and dominance hierarchy in the queenless ponerine ant *Pachycondyla* (= *Bothroponera*) sp. in West Java, Indonesia (Hymenoptera, Formicidae, Ponerinae). *Ethology 95*:126–140.

Ito, F., 1994. Colony composition of the two Malaysian ponerine ants, *Platythyrea quadridenta* and *P. tricuspidata*: sexual reproduction by workers and production of queens. *Psyche 101*:209–218.

Ito, F. and K. Ohkawara, 1994. Spermatheca size differentiation between queens and workers in primitive ants-relationship with reproductive structure of colonies. *Naturwissenschaften 81*:138–140.

Iwata, K., 1955. The comparative anatomy of the ovary in Hymenoptera. Part 1. Aculeata. *Mushi 29*:17–34.

Peeters, C., S. Higashi and F. Ito, 1991. Reproduction in ponerine ants without queens: monogyny and exceptionally small colonies in the Australian *Pachycondyla sublaevis. Ethol. Ecol. Evol. 3*:145–152.

Peeters, C., 1993. Monogyny and polygyny in ponerine ants with or without queens. In: *Queen number and sociality in insects.* (L. Keller, Ed.), Oxford University Press, Oxford, pp. 234–261.

Taylor, B., 1965. A monographic revision of the rare tropicopolitan ant genus *Probolomyrmex* (Hymenoptera: Formicidae). *Trans. R. Ent. Soc. Lond. 117*:345–365.

Terayama, M., H. Sakai, S. Kubota and H. Takamine, 1994. Description of the female and male in *Probolomyrmex longinodus* Terayama and Ogata, 1988. *Ari 17*:12–13.

Villet, M., 1992. Exploring the biology of obligate queenlessness: social organization in Platythyreine ants. In: *Biology and evolution of social insects* (J. Billen, Ed.), Leuven Univ. Press, Leuven, pp. 291–294.

Villet, M.H., R.M. Crewe and F.D. Duncan, 1991. Evolutionary trends in the reproductive biology of ponerine ants (Hymenoptera: Formicidae). *J. Nat. Hist. 25*:1603–1610.

Received 3 July 1997;
revised 7 October 1997;
accepted 14 October 1997.