

Nesting and reproductive biology of *Platythyrea* sp. (*parallela*-group) in the Bogor Botanic Gardens, West Java, Indonesia (Hymenoptera: Formicidae)

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ABSTRACT. I report the colony composition and nesting biology of *Platythyrea* sp. (*parallela*-group) in the Bogor Botanic Gardens, West Java. This species, which always nests in trees, reproduces through both dealated queens and mated workers. Among 13 collected colonies, dealated queens reproduced in only one colony, which also contained six mated workers, of which three had active ovaries. In the queenless colonies, the percentage of mated workers among the worker population was high, while there were many non reproductive mated workers. Observations in the laboratory indicated that mating occurred inside the nest and that males could mate with more than one worker.

Keyword: ant, arboreal, *Platythyrea*, reproduction

INTRODUCTION

The ponerine genus *Platythyrea* is distributed in the tropics and contains 38 extant species (Brown 1975; Bolton 2014). Their colonies' reproductive structures vary greatly among species. Colonies of the African species, *Platythyrea* cf. *cribrinodis*, *P. schultzei*, and *P. lamellosa* reproduce by mated workers without morphologically distinctive queens (Villet et al, 1990, Villet 1991ab) while the African *P. arnoldi* and Malaysian *P. quadridenta* show sexual reproduction by both workers and dealated queens (Villet 1993; Ito 1994). The Malaysian *P. tricuspidata* also possibly reproduces via both castes (Ito 1994). Molet and Peeters (2006) reported ergatoid queen reproduction in *P. conradi* in Africa. Furthermore, the American species, *P. punctata*, shows thelytoky in which virgin workers lay diploid eggs that will become workers (Heinze & Hölldobler 1995). Thus, comparative studies of reproductive structure and ecology in *Platythyrea* are important for understanding the diversity of reproductive biology in ants.

Platythyrea parallela, distributed in the Oriental tropics, is a relatively small species. Wilson (1958) revised the small *Platythyrea* in the Oriental tropics and several species were treated as synonyms of *P. parallela*. However, Brown (1975) indicated that more than one species might be included in *P. parallela*. In the Bogor Botanic Gardens, there are at least two clearly distinct species of the *P. parallela* species group. To date, biological information of the *P. parallela* species group has been reported only for the daily activity pattern observed in Peninsular Malaysia (Ashikin & Hashim 2015). In this paper, I report on the nesting and reproductive biology of one species of this group in the Bogor Botanic Gardens, Indonesia.

MATERIALS and METHODS

Ants

There are two apparently distinct species of the *P. parallela* group in the Bogor Botanic Gardens. Because taxonomic study of this species

group is inadequate, I treated the two species as *Platythyrea* sp. 2 and sp. 3 (species code of F. Ito). *Platythyrea* sp. 2 has blackish tibia, while the tibia of *Platythyrea* sp. 3 is pale brown (Fig. 1). The color of the tibia is uniform among workers, queens and males of each species. Body size of the two species is significantly different: the head width of workers of *Platythyrea* sp. 3 ($0.76 \text{ mm} \pm 0.03 \text{ mm}$, $n = 32$) is significantly smaller than that of those of *Platythyrea* sp. 2 ($0.86 \text{ mm} \pm 0.01 \text{ mm}$, $n = 15$; Welch two sample t-test, $t = -35.0$, $df = 43.8$, $p < 0.0001$). The small, blunt teeth in the propodeal angles in *Platythyrea* sp. 3 are less prominent than these of *Platythyrea* sp. 2. These morphological characteristics readily distinguish the two species in the botanical garden. Voucher specimens were deposited in Bogor Zoological Museum.

Platythyrea coxalis var. *javana* was described from Bogor (Forel, 1905) and, based on its description by Brown (1975) and photographs of the type specimen shown in Antweb (2015), it corresponds to *Platythyrea* sp. 2, which was called *P. parallela*, by Ito *et al.* (2001). *Platythyrea parallela* studied in Peninsular Malaysia by Ashikin and Rosli (2015) seems to be *Platythyrea* sp. 3.

Only data for *Platythyrea* sp. 3 are reported here because *Platythyrea* sp. 2 is relatively rare and the number of colonies collected is not yet adequate to characterize the reproductive organization of the species.

Study site and methods

Observation and colony collections were carried out in the Bogor Botanic Gardens, West Java, Indonesia from August to January of 1994, 1995, 1997 and 2000. Fourteen nests of *Platythyrea* sp. 3 were discovered by following foraging workers on tree trunks. The composition of all but one colony was assessed just after collection, and most individuals were dissected under a binocular microscope to check reproductive condition.

The maximum widths of the head and the 4th abdominal segment of workers and queens were measured using an ocular micrometer on a binocular microscope. One colony (FI00-6) was kept in the laboratory for observation of mating biology. All 30 adult workers were marked individually with paint. The colony had ca. 20 cocoons. During the month after collection, nine

workers and two males eclosed from the cocoons. All of the workers were dissected after three weeks when both males died.

RESULTS

Foraging behavior and nests

Foraging workers of *Platythyrea* sp. 3 were only found on the trunk of standing trees. Twenty foragers that emerged independently from their nest entrances were followed for 10 to 30 minutes and all walked on tree trunks only and never foraged on the ground.

All but one of the 14 nests recovered was found under bark or in small cavities on the trunk of large standing trees (Fig. 2a). The one remaining nest was found in a dead bamboo branch attached to a standing bamboo plant. Nest entrances were usually covered with particles of prey remnants that had probably been consumed by the ants (Fig. 2b). In intensive collecting of ants in Bogor over 10 years (Ito *et al.*, 2001), no nests of *Platythyrea* sp. 3 have been found in dead trees fallen on the ground nor under ground.

Colony composition

The head width of queens was slightly but significantly larger than that of workers (Fig. 3, head width of workers = 0.76 ± 0.03 , $n = 32$; head width of queens = 0.80 ± 0.02 , $n = 11$; Welch two sample t-test, $t = -4.46$, $df = 23$, $p < 0.001$), while abdomen width of queens was larger than that of workers (abdomen width of workers = 0.66 ± 0.03 , $n = 32$; abdomen width of queens = 0.73 ± 0.02 , $n = 11$; Welch two sample t-test, $t = -7.89$, $df = 24.8$, $p < 0.00001$).

Colony size varied between 7 and 26 workers (17.2 ± 5.5 SD; Table 1). Both queens and workers had six ovarioles/individual. Three colonies had one dealated queen each, but only one (FI94-127) of the queens was mated and laid eggs, while the other two were virgins without developing oocytes. All colonies including the queenright colony had mated workers.

The percentage of mated workers was remarkably high at 21-95% (average 64%). In colony FI97-7, 20 out of 21 dissected workers were mated. Of the 141 mated workers, 81 did not have developed ovaries, while virgin workers

Table 1. Colony composition of *Platythyrea* sp. 3 collected in Bogor, West Java. Number of females having active ovaries was shown in parentheses. -: not counted.

P = Pupae; L = Larvae; E = Eggs.

Colony Code	Number of Individuals								
	Dealate Queens	of Mated	Workers	Of mated	Alate Queens	Alate Males	P	L	E
FI 94-89	0		7	4 (1)	2	4	11	0	0
FI 94-161	0		8	6 (6)	11	2	2	-	-
FI 94-127	1	1(1)	13	6 (3)	0	0	5	16	8
FI 94-91	0		16	8 (3)	1	0	2	4	0
FI 95-535	1	0	16	8 (2)	0	1	13	5	-
FI 95-461	0		16	12 (1)	0	0	-	-	-
FI 94-92	0		17	10(0)	0	0	2	13	19
FI 95-503	0		17	16 (2)	0	1	15	3	-
FI 94-152	0		18*	12 (7)	4	1	24	52	17
FI 95-464	0		21	11 (3)	0	0	4	9	22
FI 94-90	0		23	5 (4)	5	2	23	17	11
FI 95-465	1	0	25	23 (21)	3	1	19	3	-
FI 97-7	0		26*	20 (7)	6	4	-	-	-

*Two workers of FI94-152 and five workers of FI97-7 were not dissected.

never had developed oocytes. Most colonies had multiple egg layers.

In the queenright colony (FI94-127), ovary development of the queen was better than that of three gamergates (mated and egg-laying workers) in the colony: the dealated queen had 10 developing oocytes with dense yellow bodies, while the gamergates had just one or two developing oocytes and their yellow bodies were small and pale. In all but two queenless colonies, ovary development was not remarkably different among gamergates. In colonies FI95-464 and FI97-7, one gamergate per colony had well-developed ovaries with many yellow bodies. Alate queens were produced in seven colonies that reproduced through gamergates.

Intracolony mating and multiple mating by males

Two males of *Platythyrea* sp. 3 survived two and three weeks, respectively, under laboratory con-

ditions. The males often left the nest chamber, but they often stayed near the cocoon pile. Dissections of all individuals after the death of the two males showed that four of nine callow workers which had emerged in the laboratory were inseminated, and three of the four mated callow workers had a few developing oocytes. One of them had well-developed ovaries with fine yellow bodies. These results indicate that intracolony mating occurs and that males can mate more than once with workers

DISCUSSION

Nesting and foraging

Nests of ponerine ants are mostly found underground or on fallen dead branches, and arboreal nesting is not common. A *Diacamma* species was found to nest facultatively in the cavity of standing trees in SE Asia, but, its foraging activity is

mostly on the ground (Ito, pers. obs). In the Neotropics, *Neoponera luteola* nests in *Cecropia* trees and interacts mutualistically with ant-plants (Verhaagh 1994), and *Odontomachus hastatus* nests in root clusters of epiphytic bromeliads (Camarago & Oliveira, 2012). Most *Platythyrea* species studied so far also nest under ground or in dead branches (Wilson 1958; Villet 1991ab; Ito 1994) whereas *P. conradti* and *P. modesta* are arboreal (Djieto-Lordon *et al.* 2001; Molet & Peeters 2006). Wilson (1958) wrote in his revision of *P. parallela* that “All of the authors’s collections consisted of stray workers found in leaf litter and rotting wood”. However, as reported by Ashikin and Hashim (2015), nests of *Platythyrea* sp. 3 in this study were always found in standing trees and were never discovered in the ground nor in fallen dead branches on the ground. Observation of foraging activity indicated that *Platythyrea* sp. 3 searches for prey only in trees. In a quantitative survey of leaf litter ants in the botanical garden, the species was never collected from 110 quadrats (Ito *et al.* 2001). Furthermore, I have had no opportunity to collect underground nests of *P. parallela* group in several places in Southeast Asia during the past 26 years. In my experience, all small-sized *Platythyrea* specimens in the Oriental tropics have been collected from the tree trunks of standing trees (Ito, unpub). These observations suggest that this species group has an obligately arboreal life style. Arboreal nesting seems to be a common characteristic in the *P. parallela* species-group at least in Indonesia and Malaysia.

Reproduction

Platythyrea sp. 3 reproduces by both dealated queens and gamergates (AQ+G, according to the classification by Peeters & Ito 2001), in accordance to two species of Malaysian *Platythyrea* (Ito 1994) and *Platythyrea* sp. 2 in Bogor (Ito, unpub.). Thus, AQ+G is a common social system in the Oriental *Platythyrea* species. As in *P. quadridenta* (Ito 1994, unpub), the number of colonies reproduced by mated dealated queens was very small, with only one of 14 in *Platythyrea* sp. 3. The one colony with a mated dealated queen included six mated workers, of which three were gamergates. These results suggest high turnover of reproductive females and/or less occurrence of colony foundation by alate queens. Among

AQ+G species, the ratio of queen reproducing colonies varies greatly among species. For example, more than 50% of colonies have a dealated queen in *Harpegnathus saltator* (Peeters & Hölldobler 1995), while it is less than 5% in *Gnamptogenys menadensis* (Gobin *et al.* 1997) and this state is very rare in *Rhytidoponera metallica* (Ward 1986). This variation among species may be affected by several environmental conditions, especially habitat heterogeneity, resource availability, degree of disturbance and competition (Ward 1983; Cronin *et al.* 2016). Factors corresponding to the low ratio of queen colonies in *Platythyrea* sp 3 are still unknown. Detailed investigations on their ecology and behavior will be necessary for understanding the effects of environmental conditions on their social organization. *Platythyrea* sp.3 is principally a polygynous species. One of the remarkable features of its biology revealed in this study is the high percentage of mated workers. One possible reason is the occurrence of intracolony mating, as shown in this paper. Males can mate with more than one young worker, resulting in high percentages of mated workers. However, many mated workers were not egg layers. The occurrence of such non-reproductive mated workers has been shown in *Platythyrea tricuspoidata*, *Pl. quadridenta*, *Pseudoneoponera tridentata*, *Ps. sp.* (aff. *insularis*) and *H. saltator* (Ito 1993, 1994; Peeters & Hölldobler 1995; Sommer & Hölldobler 1992). In the two species of *Pseudoneoponera* and *H. saltator*, dominance hierarchies based on aggressive antennation among workers seems to be one mechanism for the occurrence of non-reproductive mated workers. The mechanisms regulating ovary development of mated workers in the four *Platythyrea* species in the Oriental tropics are unknown. So far I never observed aggressive interactions among nestmates in the four *Platythyrea* species (Ito, unpub). Further laboratory observation is necessary.

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Fig. 1. Fore legs of two *Platythyrea* species. Upper: *Platythyrea* sp.2, Lower: *Platythyrea* sp.3

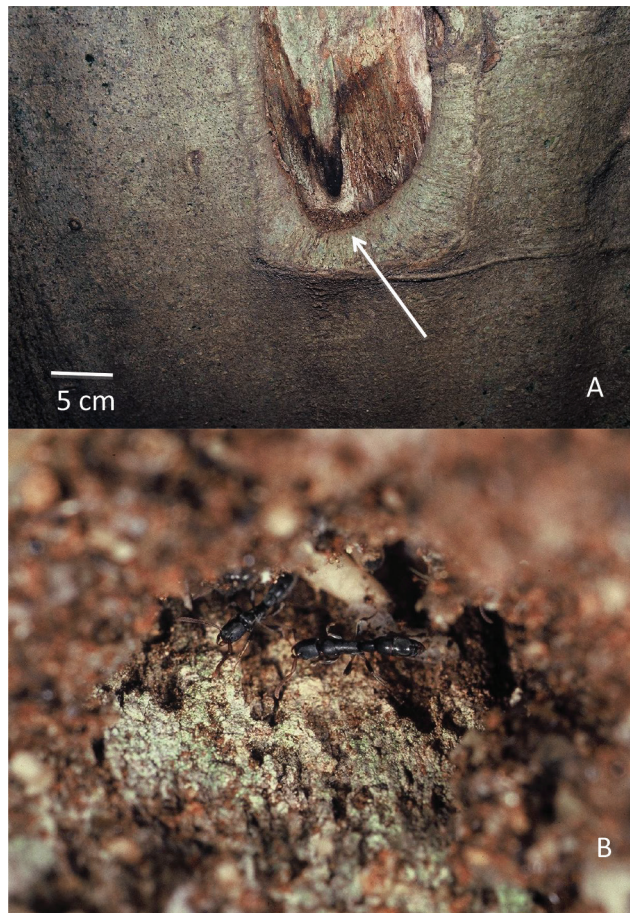


Fig. 2. Nest entrance of *Platythyrea* sp. 3 (a) on tree trunk of *Ficus albipila* and (b) close up.

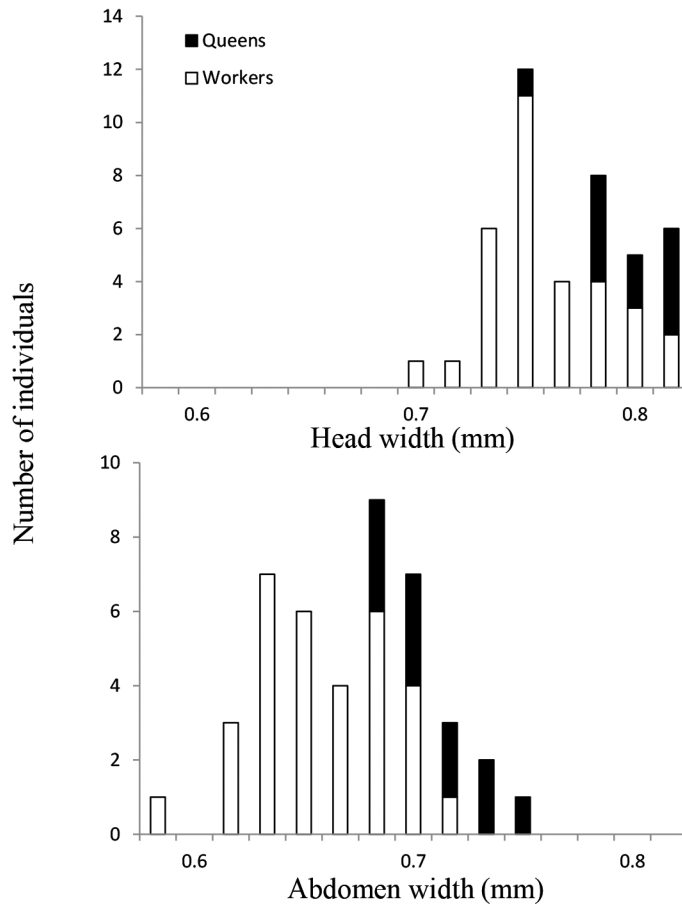


Fig. 3. Size distribution of queens and workers of *Platythyrea* sp. 3. Upper. Head width, Lower. Width of IVth abdominal segment.

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