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Supplementary Notes on the Nest Architecture and Biology of Some *Parischnogaster* Species in Sumatera Barat
(Hymenoptera, Vespidae)

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Abstract Two nest types Ps_4 and Ps_5 of genus *Parischnogaster* from Sumatera Barat, both attaching directly to the flat substrate but differing in arrangement of cells (somewhat unilateral in Ps_4 and concentric in Ps_5, OHGUSHI *et al.* 1983) are connected with intermediate types, so that they are regarded as intraspecific variation. Another similar type Ps_6, hanging from thin supports, probably represents a distinct species, judging from differences in nesting habit and coloration and size of adults from those of Ps_4.

In a previous paper (OHGUSHI *et al.* 1983), we reported 17 types of stenogastrine nests from the Province of Sumatera Barat. Most of these types nearly or completely correspond with types reported from other districts of Southeast Asia (WILLIAMS 1919, 1928, SAUSSURE 1927, SCHULTHESS 1927, PAGDEN 1958, IWATA 1967, SAKAGAMI and YOSHIKAWA 1968, YOSHIKAWA *et al.* 1969). Among species of the *striatula*-group (VAN DER VECHT, pers. comm.) of genus *Parischnogaster*, types Ps_4, Ps_5 and Ps_6 have so far been recorded only from Sumatra, and they seem to be new to science. These types are closely similar each other in structural characteristics and seem to form a subgroup of the *striatula*-group, if the nest architecture alone is considered.

Through further observations on the nest architecture, taxonomic characteristics of

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adults and general biology of the population representing the three types in Sumatera Barat, we came to the following provisional conclusion: (1) Ps_4 and Ps_5 represent two architectural extremities within the same taxon. (2) Ps_4 (including Ps_5) and Ps_6 are closely related, but possibly correspond to two distinct species.

In the present paper, we describe more in detail the architecture of these types to show the developmental process and examine the biology, especially nesting habits and distribution based on observations made near Padang in August 1983. Finally a possible occurrence of speciation caused by the specialization in the utilization of two different kinds of nesting substrates, i. e., flat one (Ps_4) and thin supports as hanging rootlets (Ps_6), is suggested.

Nests of Types Ps_4 and Ps_5

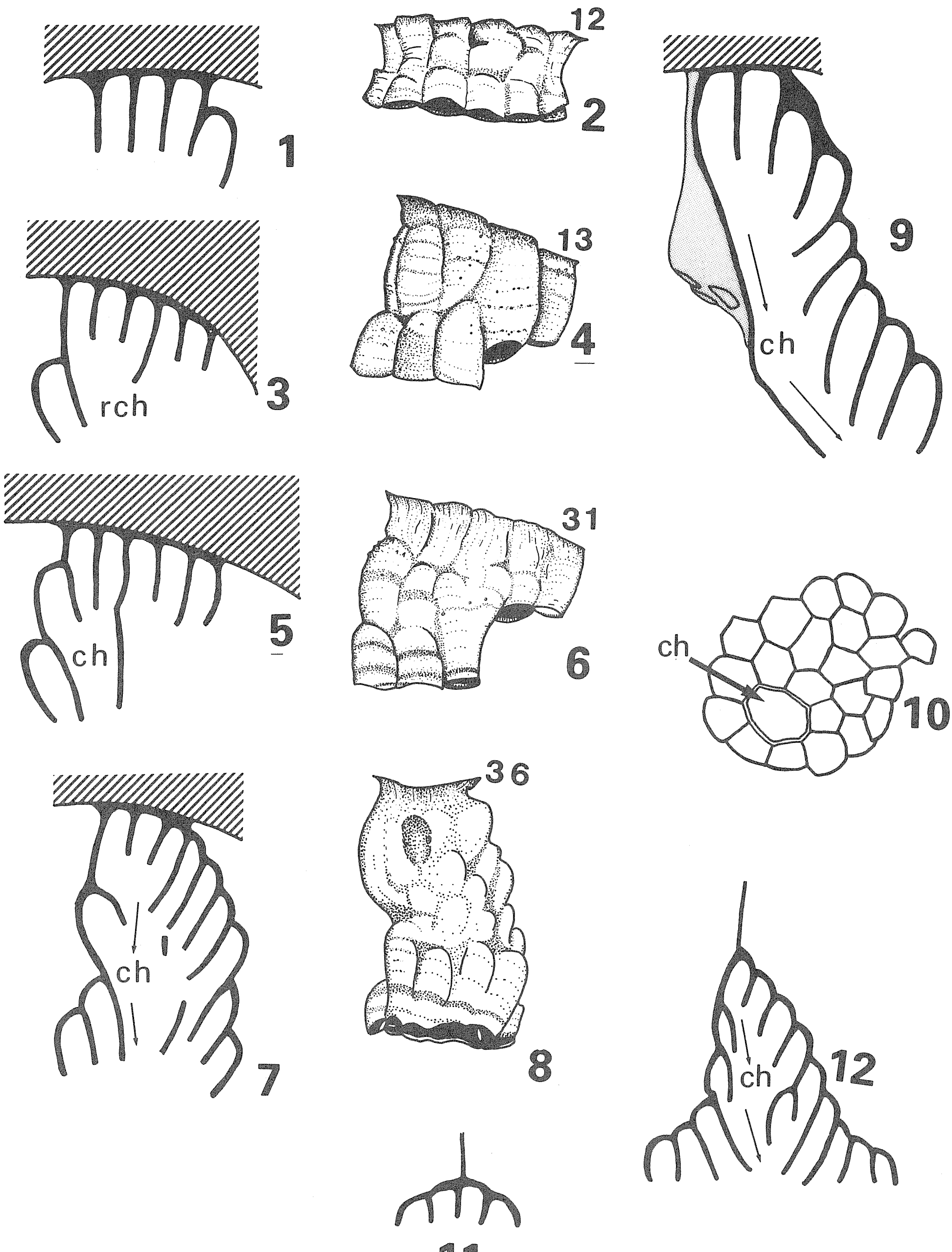
These types were discovered inside concrete cement tunnels used for watercourses. The nests are always attached directly on the ceiling of the tunnels (Fig. 13,16,17). Both types are constructed with blackish brown carton. Ps_4 grows somewhat unilaterally and is slanting, with a common hall (=passage-way) at one periphery of the comb (Figs. 9,10), while Ps_5 grows concentrically downwards and cells open to a common hall which penetrates the center of the comb (Figs. 7, 8).

Since these two types coexist in the same nest aggregation, we have suspected that they represent two extremities of the same species. During the present survey, we gave much attention on this problem and collected many nests of various developmental stages with inhabiting adults, as well as examined the nesting sites. We found various intermediate types at one nesting site, which interconnected the two extremes. Therefore, Ps_4 and Ps_5 are regarded here as mere architectural variations within the same population, and hereafter the both will be designated with the code Ps_4.

Table 1 shows data of collection and nest compositions for some selected nests taken from an aggregation at Signtur Tua. The average number of cells per nest was 27.9 (max. 41) and that of female adults was 4.8 (max. 10).

Developmental process of nests: In a previous paper (OHGUSHI *et al*. 1983), the nest architecture was illustrated only by general views and some cross sections. In this paper, we examine the inner structure by some vertical sections of various stages of nests to better show the developmental process .

Several cells with proper bottoms are built by the sessile initiation (cf. JEANNE 1973), before some first cells have been fully elongated. All cells look downwards (Figs. 1, 2). Walls of some peripheral cells are elongated, followed by addition of some cells to the elongated walls of initial cells at slightly lower positions by means of lateral initiation (Fig. 3). Then walls of central cells are also elongated to form a common hall togehter with inner walls of lower peripheral cells. Nearly all cells open to the common hall. Thus the basic structure of this type is established (Figs. 5, 6). In bigger nests, some cells are further



Figs. 1-12. Various developmental stages of nests Ps_4 (1-10) and Ps_6 (11, 12). 1, 2. Young comb of Ps_4 with one layer of cells, common hall not yet initiated, 3, 4. Comb with a rudimentary hall (rch) at the left hand, 5, 6. More developed comb with a common hall (ch), 7, 8. Mature comb with a central hall (vertical type= Ps_5 in the previous classification), 9, 10. Ditto, with peripheral hall (slanting type), 11. Young comb of Ps_6, and 12. Mature comb with a common hall. 1, 3, 5, 7, 9, 11, 12. Vertical sections, 2, 4, 6, 8. Lateral views, and 10. Frontal view showing the opening of the hall. Numerals in 2, 4, 6, 8 indicate the number of cells built.

Table 1. Size and compositions of Ps_4 (16 cases) and Ps_6 nests (4 cases).

Nest codes	Size (mm)		No. of cells	No. of adults collected		No. of immatures present		
	Diameter	Height	(Empty cells)	Females	Males	Eggs	Larvae	Pupae
Type Ps_4								
Ps-8302	16	14	26 (7)	6	5	3	8	8
8303	24	14	40 (6)	7	5	10	12	12
8304	19	20	40(11)	8	2	7	14	8
8305*	15.5	15.5	36(14)	5	4	5	15	2
8307	15	15	28(16)	8	1	2	6	4
8308	20	14	27(25)	2	0	0	1	1
8310**	24.5	12.5	41(32)	2	0	6	2	1
8312	26	20	28 (7)	3	1	0	9	12
8314	17.5	13	12 (8)	4	0	4	0	0
8315**	24	21	31(29)	3	0	0	2	0
8316	18	15	13 (7)	3	0	1	4	1
8345	22	36	37(15)	10	7	8	6	8
8346*	21	36	40(12)	10	7	18	4	6
8350	12	14	14 (5)	3	0	3	1	5
8351	19	31	15 (0)	2	1	5	6	4
8352	19	19	18(17)	1	0	1	0	0
Type Ps_6								
Ps-8021	24	24.6	24 (5)	5	3	6	9	4
8022	19.5	23.5	20 (3)	5	2	5	7	5
8023	41	32	40(11)	12	10	6	15	8
8104	20	7.5	8 (6)	2	0	2	0	0

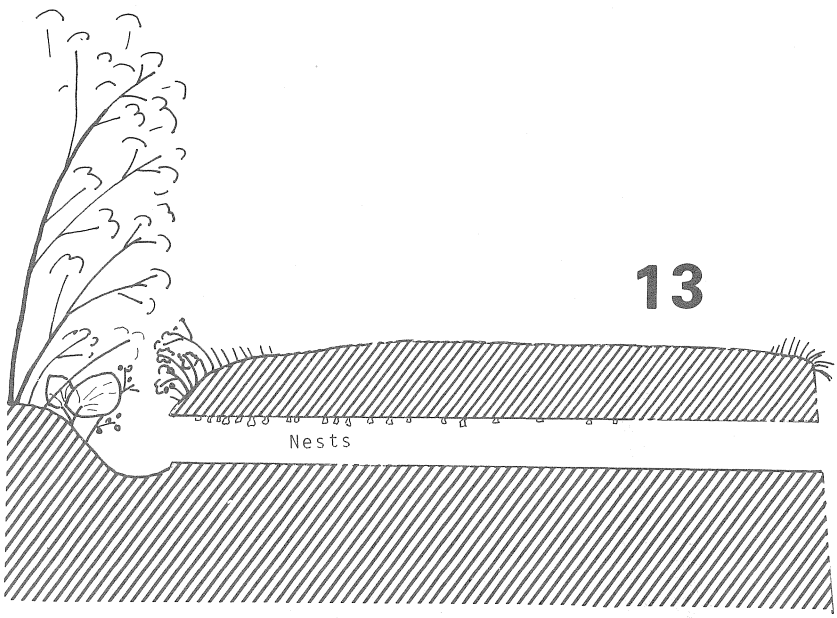
* and **. Typical Ps_4 and Ps_5 nests in the previous classification, respectively.

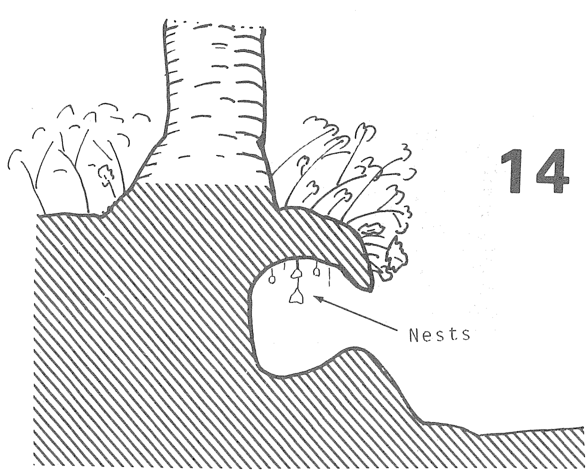
added to the outer surface with independent openings on the outside. Therefore, when the nest is seen from below, it looks like a normal comb, with a big hole at the center or occasionally periphery, which is the opening of the common hall (Fig. 10). In big nests, more than 30 cells open to the central common hall. In this way fully matured nests like straight or slanting cylinders (Figs. 7, 8 *vs*. 9).

Cells are usually arranged concentrically with some irregularities around the common hall. But they are occasionally added unilaterally. In an extreme case, the hall completely lies at the periphery (Fig. 9) exhibiting a pattern similar to that of *Parischnogaster alternata* of the *striatula*-group, except that cells in Ps_4 are not arranged in two regular rows (cf. YOSHIKAWA *et al*. 1969, Fig. 1, I).

Cells are left unclosed after pupation as in other species of the *striatula*-group. But we confirmed that the openings of independent cells outside the main body are occasionally narrowed or rarely perfectly closed as the larvae have become to be matured. This rudimentary closure is the first discovery in this species group. It is interesting if it is compared with the *mellyi*-and the *jacobsoni*-groups of the genus *Parischnogaster*, which customary close the opeing at the time of pupation.

Nesting site and size of nest aggregation: Nests of Ps_4 have been discovered in huge





Figs. 13, 14. Vertical sections of nesting sites for types Ps_4 (13. Concrete cement tunnel for a watercourse) and Ps_6 (14. Stump hollow).

aggregations in two out of five checked concrete tunnels for watercourses (1m wide, 1.0—1.3m high, 10—12m long), which cross under a submontane road traversing steep slopes covered with secondary forests and cultivated fields (Figs. 13, 16). The inside was cooler, moister and darker than the outside. It was darker towards the upstream entrance caused by dense bushes on this side (Fig. 15). The humidity was seemingly saturated by the presence of water current. Normal water level was 5—10cm during the dry season. But the tunnel seemed to be occasionally immersed partially or completely in flood water during rainy season from September to January. In this occasion, whole or at least part of nests should be swept away, and a new population will settle after the withdrawal of the flood. No invasion of foraging ants and hornets were found inside the tunnels during the observations.

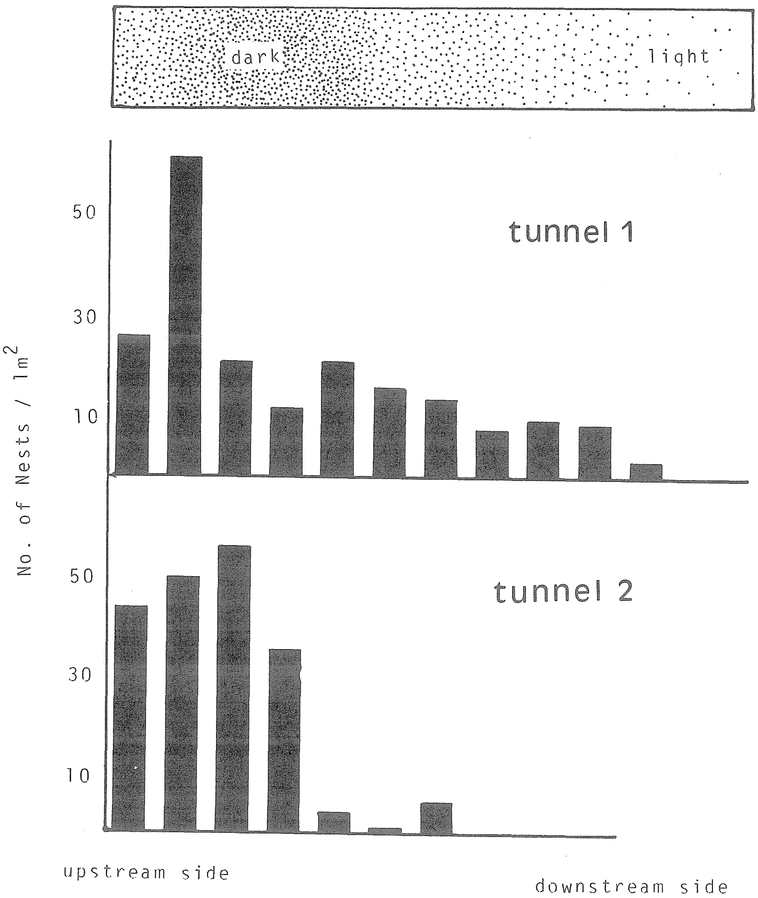


Fig. 15. Distribution of Ps_4 nests inside two watercourse tunnels.

In T_1 (tunnel 1) were found about 200 living nests, most of which concentrated at the upstream side (=darker end), with the highest density (72 nests/m²) at slightly inside the entrance. The same situation was also confirmed in T_2 (tunnel 2) (Fig. 15). This suggests that wasps of Ps_4 build nests gregariously and rather prefer dark habitats. In T_2 nests of an unidentified species of genus *Liostenogaster* (type L_1) were intermingled with Ps_4 and they were more predominant than Ps_4 nests in 1981, but we could find only one living nest of the former in the present survey. For some unknown reason, the *Liostenogaster* nests in T_2 have been replaced by Ps_4 in two years. The downstream (lighter) end was completely occupied by many muddy nests of eumenids instead of stenogastrine nests.

Nest of Type Ps_6

Nests of this type are structurally closely similar to those of Ps_4, except that they are hung from thin dead rootlets in stump hollows or concavities at roadsides.

Nest size, number of cells built and those of adults and immature stages present at the collection are shown in Table 1. Data involve those adopted in the previous report and additional ones taken during later surveys, but the data are far less than those for Ps_4 for smaller size of each nest aggregation.

Developmental process of nests : Young nests have a flat or a slightly conical-topped comb with several shallow cells, which quite resembles a young nest of *Polistes* (Fig. 11). This indicates that cells are successively constructed before the completion of the preceding ones. It also likes early nests of *Parischnogaster* sp. (Ps_3) and some species of *Eustenogaster* and *Liostenogaster*, though the latter two genera build bigger cells.

In mature nests, walls of peripheral cells are elongated to surround the comb as in Ps_4. The surrounded space becomes to be a common hall to which cells open. Nests are bell-shaped, but bigger ones have peripheral cells so arranged that they form a flat brim (Fig. 12). These peripheral cells open independent of the common hall. Some cells are later built irregularly outside the main body. Their openings are often narrowed as in Ps_4.

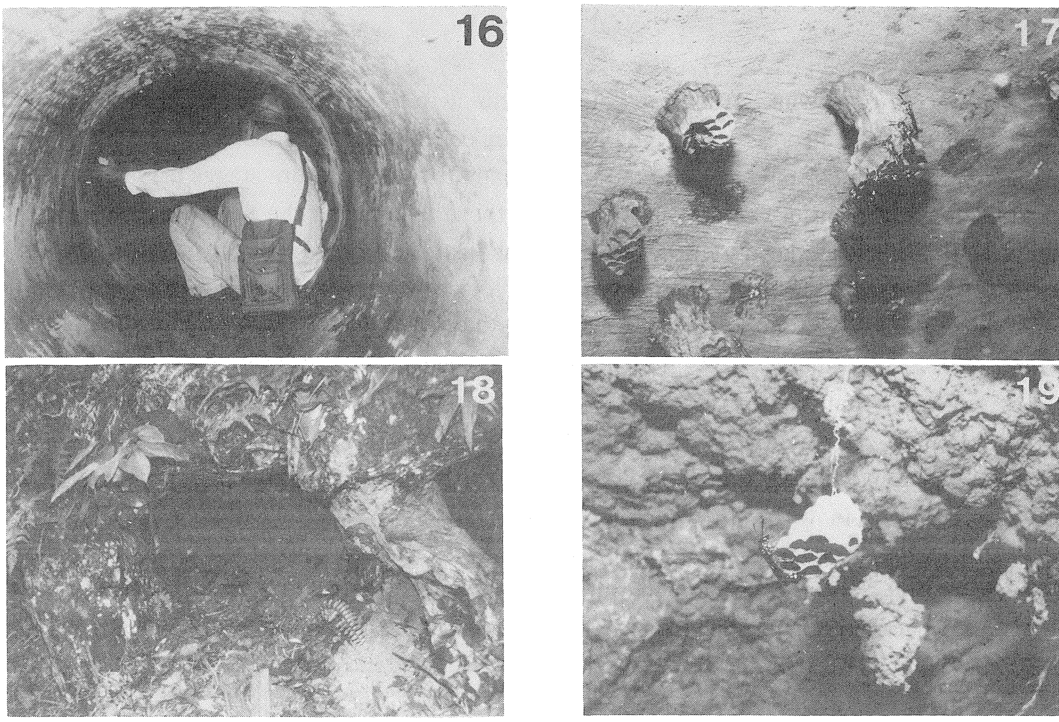
Nesting site and nest aggregation : Nests of this type have been found hanging from thin dead rootlets of trees exposed in various kinds of semiclosed places as follows : stump and muddy hollows along roadsides, hollows formed at outcurves of rivers by strong water currents, and rarely under rock overhangs which can intercept rains. These habitats provide environmental conditions intermediate between open and closed sites, being apparently less dark and humid than in the concrete tunnels where nests of Ps_4 are preferably built.

The size of a nest aggregation was several to twenty nests per hollow, sometimes even only one nest in a hollow. This figure is far smaller than that of Ps_4. Nests in big aggregations are often built with close distances of about 10cm one another. We found a case where 4 nests were built serially on one rootlet.

Some other species, *Parischnogaster* sp. (Ps_3) *Eustenogaster* sp.(E_2) have been found to coexist in the same hollows with Ps_6. In such cases Ps_6 nests always occupied the innermost part of the hollow.

Do Types Ps_4 and Ps_6 Correspond to Two Distinct Species ?

At first, these types could be separated only by the kind of substrates which results in different construction process. They inhabit the same localities. The closest distance was 300m between their nesting sties, and they were thought to be sympatric in a common sense. Therefore we considered that the above difference is not interspecific, but only manifesting intraspecific variations in building behaviors.



Figs. 16-19. Nests and nesting sites of Ps_4 and Ps_6. 16. Inside of concrete cement tunnel with gregariously constructed nests of Ps_4, 17. Nest of Ps_4 enlarged, 18. Stump hollow for Ps_6 from outside, and 19. Early nest without common hall of Ps_6.

Further observations from various aspects, however, have revealed some additional differences which may be a clue to their taxonomic relations. The environmental conditions preferred for nesting and some biological features differ between the two forms (Table 2). The differences are not so striking that someone might interpret those as a range torelable for the same species. But adults from two types of nests are seemingly different in size and coloration. Females of Ps_4 are slightly larger than those of Ps_6, and black vertical bar on the clypeus of females is more perfect in Ps_4 (Sk. YAMANE, pers. comm.). Based upon these facts, we tentatively regard them as representing two distinct species arised from a common stock until attaining the final conclusion.

Considering the above, we can expect some similar cases of behavioral differentiation corresponding to the choise of substrates. For example, two pair-types which do not differ except for attachment of the base are recognized in so-called *Parischnogaster alternata* (attaching type in YOSHIKAWA *et al*. 1969 ; hanging type Ps_3 in OHGUSHI *et al*. 1983). Another case refers to the so-called *Liostenogaster flavolineata*, whose nests can be distinguished at least into three types (PAGDEN 1958, IWATA 1967, YOSHIKAWA *et al*. 1969, OHGUSHI *et al*. 1983).

The stenogastrine wasps do not construct the petiole, therefore they must choose the nesting substrates which are less frequently attacked by cursorial predators, especially ants. The selection of safer substrates is thus important for increasing the survival rate of vulnerable colonies. The choice of flat surfaces (rock surfaces and something like that) and

Table 2. Comparisons of biological characteristics between types Ps_4 and Ps_6.

Items	Ps_4	Ps_6
Nesting sites	Inside of concrete tunnel for watercourse and probably places with similar conditions, dark, cool and moist	Hollows of stumps and roadcuts, less dark and humid than in concrete tunnels
Colony formation	Big colonies with ca. 200 nests, gregarious	Solitary or small colonies with less than 20 nests, sometimes gregarious
Cohabiting wasps	*Liostenogaster* sp. (L_1)* and two unidentified eumenid species. Ps_4 occupies the darkest place.	*Parischnogaster* sp. (Ps_3)* and *Eustenogaster* sp. (E_2)*. Ps_6 occupies the innermost part.
Collection localities	Signtur Tua (near Padang)	Signtur Tua, Muko Muko (Maninjau), Batang Palpuh (Bukittinggi)

For descriptions of each nest type see OHGUSHI *et al.* (1983).

thin supports (rootlets), might causes the differentiation in behavioral and biological disruption corresponding to different initiation methods to be adopted and environmental conditions of the sites. Further, it is not precluded that this might ultimately led to the speciation, if some proper isolating mechanism worked sufficiently between the populations.

At any rate, the data are not yet enough to give any taxonomic conclusion.

Comparisons of Ps_4 and Ps_6 with Other Types of the *Striatula*-Group

As stated above, Ps_4 and Ps_6 are structurally closely similar each other and they share a common characteristics with other members of the *striatula*-group in possessing a single hall (for Ps_4 and Ps_6) or a passage-way (for other types) which is completely surrounded by cells and/or their extended walls. Therefore cells, as a rule, open first to the hall and then reach the opening outside. We call it as a primary structure. Thanks to this structure, immature stages are better protected than those of other species groups of the *Parischnogaster*.

Types Ps_4 and Ps_6, however, are well distinguished from the other types by the possession of many additional cells built towards the apex on the outer surface of the main body (=secondary structure). This realizes larger number of brood cells (30—40 cells) built than in *Parischnogaster striatula* (Ps_1) and *P. alternata* which make very slender combs and never have the secondary structure. Correspondingly the number of associating females is larger (5—6 inds. with max. of 12) than other species (2—3 inds.). The above, however, does not mean that Ps_4 and Ps_6 are more advanced types than *P. striatula* and *P. alternata* types, which lack the secondary structure. Evolutionary process of these structure should be discussed elsewhere after closer comparisons among more species of the group.

Another interest is placed on the evolutionary aspects of a habit of gregarious nesting and associated social organization.

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