

The Ants of the Genus *Proceratium* (Hymenoptera: Formicidae) in Japan

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Abstract. The ant genus *Proceratium* in Japan is taxonomically revised. All castes (worker, queen, and male) of the four species, *P. itoi*, *P. japonicum*, *P. morisitai* new species, and *P. watasei* are described or redescribed, keyed, and illustrated with ecological notes. The first descriptions for the queen of *P. itoi* and the males of *P. japonicum* and *P. watasei* are given. All the four species have olfactory sensilla basiconica distributed on a particular area of the apical antennal segment and appendages of peculiar form on the galea. Palp formulae are surveyed and discussed. Wing venation is studied and a key based on the wings only is given. Male genitalia and subgenital plates are examined and illustrated.

Key words: *Proceratium*, Japan, new species, taxonomy, Formicidae, ant, male.

Introduction

The ant genus *Proceratium* belongs to the tribe Proceratiini (Wheeler & Wheeler, 1985; Lattke, 1994; Bolton, 1995) of the subfamily Ponerinae. Our current concept of *Proceratium* is mostly based on Brown's (1958) comprehensive work and further elucidated by Lattke (1994). *Proceratium* is characterized in the external morphology by the strongly vaulted gaster, the dentate mandible, and the apically incrassate funiculus. Bolton (1995: 366) listed 29 valid, extant species names of *Proceratium* in the world.

Sonobe (1974) gave a key to and illustrations of workers of three species of Japanese *Proceratium*. Only three species have been believed to occur in Japan until 1980. Onoyama (1980) listed the three species names in his check list of ants of Japan and recognized four species in Japan, but no further information was given. Ogata (1987) gave a generic synopsis of *Proceratium* for three castes, and males of the Japanese species were first studied and illustrated. Onoyama & Ogata (1989) gave a key to four species in the worker and a brief description of the fourth species, but the one has been remained unnamed. Only brief descriptions including original ones have been hitherto given, except for *P. japonicum*, which is re-described under the name *P. formisicola* by Terayama (1985), a synonym of the former (Onoyama, 1991).

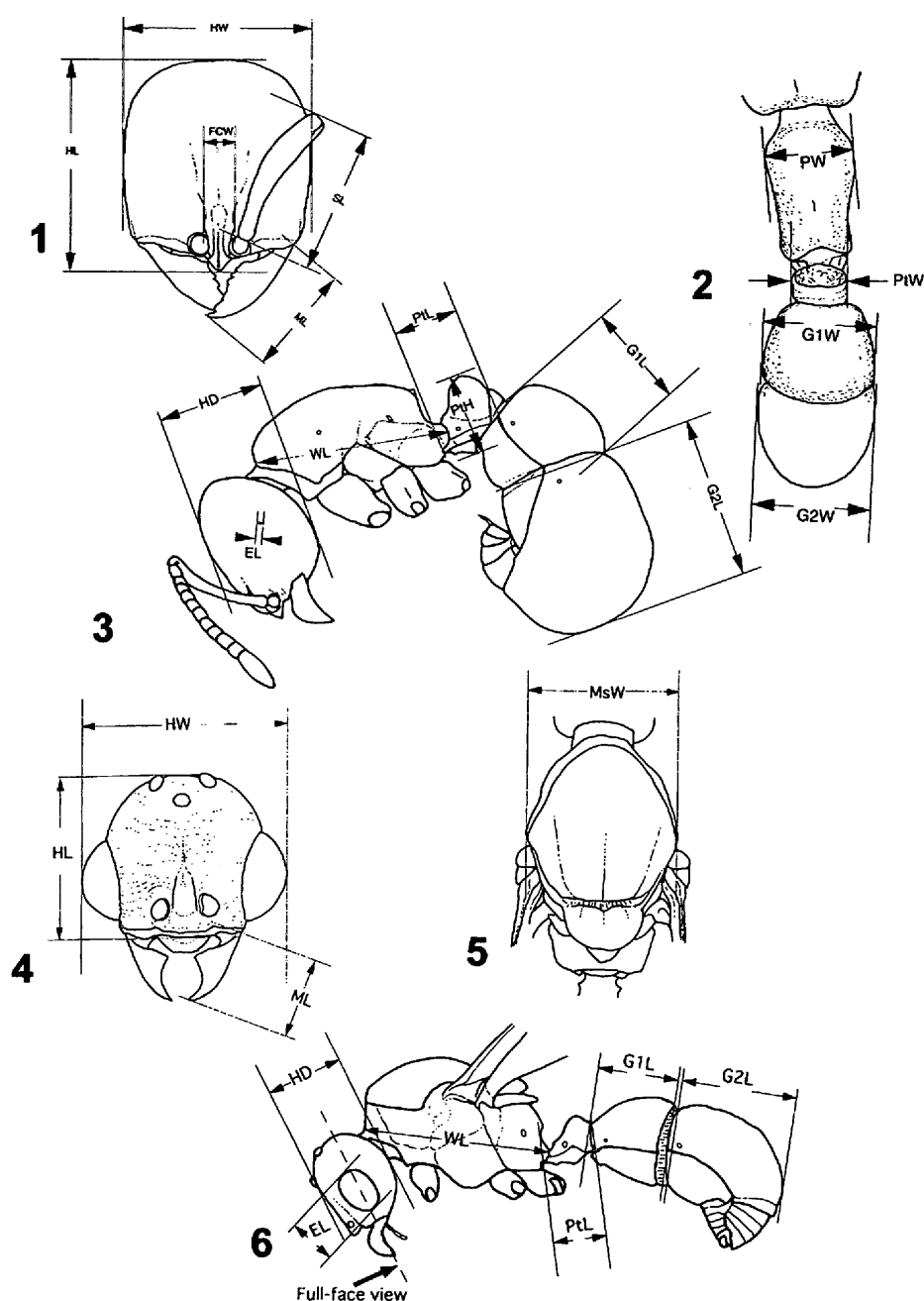
To understand the species taxa, comparable, detailed descriptions are necessary.

In the present paper we describe a new species and give the keys, detailed descriptions, and scanning electron micrographs of all castes of the four species, including the first descriptions for the queen of *P. itoi*, the male of *P. japonicum*, and the male of *P. watasei*. We have found in the all four species sensilla basiconica distributed on a particular area of the apical antennal segment and appendages of peculiar form on the galea. Palp formulae are surveyed for all castes of all Japanese species and the formulae in *Proceratium* are discussed. Wing venation is studied and a key based on the wings only is given. Male genitalia and subgenital plates are examined and illustrated. Ecological notes are also given.

Terminology, Measurements and Indices

Terminology for general morphology follows Bolton (1994: 191) except for the alitrunk; instead, we use the term "mesosoma" (see Taylor, 1965: 346). Terminology for wing venation follows Brown & Nutting (1950) and Ogata (1991) for the fore wing, and Gauld & Bolton (1988: 69) for the hind wing.

Measurements and indices are defined as follows, and illustrated in Figs. 1–3 for the worker and in Figs. 4–6 for the male.



Figs. 1-6. Illustration of measurements for *Proceratium*. — 1, 3, *Proceratium morisitai* sp. nov. (worker); 2, *Proceratium japonicum* (worker); 4-6, *P. japonicum* (male). 1, 4, full-face view; 2, 5, dorsal view; 3, 6, lateral view.

Head length (HL): maximum length of head in full-face view from the anteriormost point of clypeus to the posteriormost point of posterior margin (excluding ocelli in the male).

Head width (HW): maximum width of head in full-face view (including eyes in the male).

Cephalic index (CI): $HW/HL \times 100$.

Head depth (HD): maximum depth of head in lateral view measured perpendicular to the full-face view plane.

Mandible length (ML): maximum length of mandible, from the visible outer basal point to the apex.

Scape length (SL): length of scape excluding radicle.

Scape index (SI): $SL/HW \times 100$.

Width of frontal carinae (FCW): maximum width between the outermost margins of frontal carinae in full-face view.

Eye length (EL): maximum length of eye.

Pronotal width (PW): Maximum width of pronotum in dorsal view (worker).

Mesoscutum width (MsW): maximum width of mesoscutum in dorsal view (queen and male).

Weber's length of mesosoma (WL): maximum diagonal distance in lateral view, from the base of anterior slope of pronotum (namely excluding cervix) to the propodeal lobe (=metapleural lobe).

Petiole length (PtL): Maximum longitudinal length of petiole in lateral view, from the anterior base to the posterior border.

Petiole width (PtW): maximum width of petiole in dorsal view.

Petiole height (PtH): maximum height of petiole in lateral view including subpetiolar process.

Length of gastral tergite I (G1L): maximum longitudinal length of gastral tergite I (=abdominal tergite III) in lateral view.

Width of gastral tergite I (G1W): maximum width of gastral tergite I in dorsal view.

Length of gastral tergite II (G2L): maximum length of gastral tergite II (=abdominal tergite IV) in lateral view, from the anterior margin to the posterior extremity, taken perpendicular to a line drawn through anteroventral and anterodorsal margins of the gastral segment II, excluding the pretergites (=acrosclerites; see Bolton, 1990) (Ward, 1988).

Width of gastral tergite II (G2W): maximum width of gastral tergite II in dorsal view.

Measurements were carried out with a digital (or analog for syntypes), direct reading micrometer apparatus (Sokubi-keisoku-souchi made by Kogaku Co.; reading unit for the digital: 0.001 mm, reading error for the analog: ± 0.005 mm) attached to a stereoscopic microscope under a magnification 80 \times to 120 \times , using an insect holder to get an accurately vertical view. Measurement figures are rounded into the nearest 0.01 mm and given in mm \times 100.

Genus *Proceratium* Roger

[Japanese name: Kagibara-ari-zoku (Morisita *et al.*, 1988)]

Proceratium Roger, 1863: 171. Type species: *Proceratium silaceum* Roger, 1863: 172, by monotypy.

Sysphingta Roger, 1863: 175. Type species: *Sysphingta micrommata* Roger, 1863: 176, by monotypy. [Synonymy by Mayr, 1886: 437.]

Sysphincta: Mayr, 1865: 12. [Incorrect subsequent spelling.]

Proceratium (*Sysphincta*): Forel, 1913: 212.

Proceratium: Brown, 1958: 241. [*Proceratium*=*Sysphingta* confirmed.]

Both *Proceratium* and *Discothyrea*, the constituent, extant genera of the tribe Proceratiini, are found in Japan. For the character synopsis of Proceratiini, see

Lattke (1994: 112), although his character 6 (=clypeus with an anterior median projection) does not always applicable, which was discussed by Brown (1958: 241) in synonymizing *Sysphingta* with *Proceratium*.

The two genera, *Proceratium* (indicated below by 'a') and *Discothyrea* ('b'), are separated by any one of the following worker characters 1 to 6, constructed on the basis of Brown (1958) and Lattke (1994). Character 4 is described by Brown (1958: 330), and has been further confirmed in all castes (worker, queen, and male) of the four Japanese species (Figs. 55, 56). Character 7 is an important one easy to observe, though the separation is not complete. *Discothyrea* species in Japan have 8- or 9-segmented antennae (Ogata, 1987; Kubota & Terayama, 1999), therefore so far as the Japanese species are concerned the separation is complete.

1a. Mandibles dentate (toothed or denticulate).

1b. Mandibles edentate.

2a. Mandibles not small, at most in small part overhung by clypeus.

2b. Mandibles small, at least largely overhung by clypeus.

3a. Funiculus apically incrassate; apical segment not longer than the rest of the funiculus together.

3b. Funiculus apically clubbed (=clavate); apical segment large, about as long as the rest of the funiculus together.

4a. Second segment of maxillary palp attaching to the first segment by a slender lateral neck.

4b. Second segment of maxillary palp attaching to the first segment longitudinally.

5a. Posterior petiolar foramen with invaginations where the tergum meets the sternum.

5b. Posterior petiolar foramen without an invagination where the tergum meets the sternum.

6a. Sternum of helcium small and overlapped by tergum.

6b. Sternum of helcium as large as tergum.

7a. Antenna 12-segmented.

7b. Antenna 6- to 12-segmented.

Key to the Species of *Proceratium* in Japan (Worker and Queen)

- Petiole scale-like, much higher than long (Figs. 11, 23). Clypeus not projecting anteriorly in the middle (Figs. 12, 24). Dorsal margin of gastral tergite in lateral view moderately curved, its end forming a nearly right angle with the posterior margin (Figs. 10, 22).*P. japonicum*

- Petiole nodiform, about as long as or longer than high or a little higher than long (Figs. 8, 14, 17, 20, 26, 29). Clypeus projecting anteriorly in the middle (Figs. 9, 15, 18, 21, 27, 30). Dorsal margin of gastral tergite in lateral view strongly curved, its end forming an obtuse angle with the posterior margin (Figs. 7, 13, 16, 19, 25, 28).
.....2
- 2. Anterior and posterior slopes of petiolar node in lateral view forming an angle of more than 110 degrees (Figs. 17, 29). Anterior margin of median clypeal projection straight in full-face view (Figs. 18, 30). Body relatively large (worker WL > 1.35 mm, queen WL > 1.70 mm). ..*P. watasei*
- Anterior and posterior slopes of petiolar node in lateral view forming an angle of less than 90 degrees (Figs. 8, 14). Anterior margin of median clypeal projection triangular in full-face view. Body relatively small (worker WL < 1.20 mm, queen WL < 1.50 mm).3
- 3. Frontal carinae much raised vertically, narrow between (Figs. 15, 27). Anterior slope of petiole in lateral view concave at anterior 1/3 (Figs. 14, 26). Petiole in dorsal view margined anteriorly by a transverse carina.
.....*P. morisitai* sp. nov.
- Frontal carinae moderately raised vertically, moderately wide between (Figs. 9, 21). Anterior slope of petiole in lateral view nearly straight (Figs. 8, 20). Petiole in dorsal view not margined anteriorly by a carina.*P. itoi*

Key to the Species of *Proceratium* in Japan (Male)

1. Basal margin of mandible forming an angle of 90–100 degrees with the masticatory margin (Figs. 38, 46).2
- Basal margin of mandible forming an angle of 130 degrees with masticatory margin (Figs. 34, 42).3
2. Mandible dentate on masticatory margin (Fig. 46). Frontal carinae diverging posteriad (Fig. 45). Mesoscutellum without a median longitudinal carina. Petiole in lateral view longer than high (Fig. 44).*P. watasei*
- Mandible edentate on masticatory margin (Fig. 38). Frontal carinae running nearly parallel (Fig. 37). Mesoscutellum with a median longitudinal carina. Petiole in lateral view higher than long (Fig. 36).*P. japonicum*
3. Mandible edentate on masticatory margin (Fig.

- 34). Anterior slope of petiolar node in lateral view nearly straight (Fig. 32). Petiole in dorsal view without a transverse carina anteriorly. R vein absent in hind wing (Fig. 68).*P. itoi*
- Mandible dentate on masticatory margin (Fig. 42). Anterior slope of petiolar node in lateral view concave (Fig. 40). Petiole in dorsal view with a transverse carina anteriorly. R vein present in hind wing (Fig. 76).
.....*P. morisitai* sp. nov.

Key to the Species of *Proceratium* in Japan Based on Wings (Queen and Male)

1. Rsf3 vein present in fore wing*P. watasei*
- Rsf3 vein absent in fore wing2
2. m-cu vein absent in fore wing*P. japonicum*
- m-cu vein present in fore wing3
3. Rsf5 vein distally connected to R vein in fore wing. R vein present in hind wing
.....*P. morisitai* sp. nov.
- Rsf5 vein not connected to R vein in fore wing. R vein absent in hind wing*P. itoi*

Proceratium itoi (Forel)

[Japanese name: Itou-kagibara-ari (here revised)]
(Figs. 7–9, 19–21, 31–34, 47–48, 57–59, 65–68)

Sysphincta itoi Forel, 1918: 717–718. Worker. Type locality: Koishikawa, Tokyo, Japan (syntype workers, no date, Ito leg.). [3 syntype workers in Muséum d'Histoire Naturelle in Geneva examined.]

Proceratium itoi: Brown, 1958: 247.

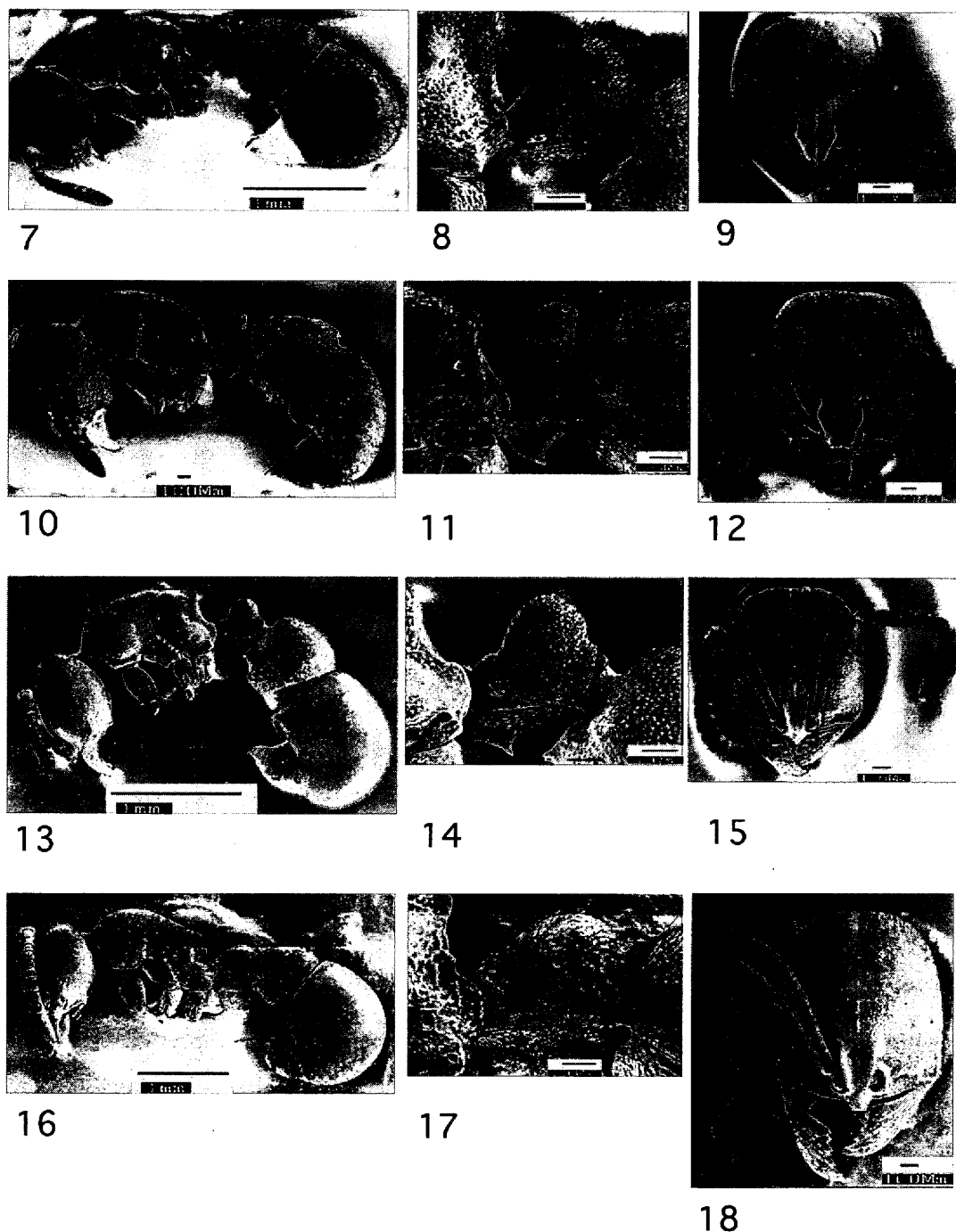
Proceratium itoi: Ogata, 1987: 106, figs. 17–18, 20–21, 23–28. Worker, male, male wing, genitalia.

Proceratium itoi: Onoyama & Ogata, 1989: 15, figs. 3.23b, 3.25b, 3.26a. Worker.

Worker. HL 82–87, HW 71–77, CI 85–91, HD 55–57, SL 49–50, SI 65–69, Scape Thickness 12–14, FCW 20–23, EL 3, PW 53–58, WL 96–110, PtW 30–33, PtH 36–42, G1W 56–66, G2W 68–75. (3 syntypes measured.)

HL 76–88, HW 71–80, CI 87–101, HD 56–62, ML 42–51, SL 49–54, SI 64–70, FCW 20–25, EL 2–4, PW 47–60, WL 95–111, PtL 38–47, PtW 28–34, PtH 38–43, G1L 51–63, G1W 55–71, G2L 71–98, G2W 65–85. (10 measured.)

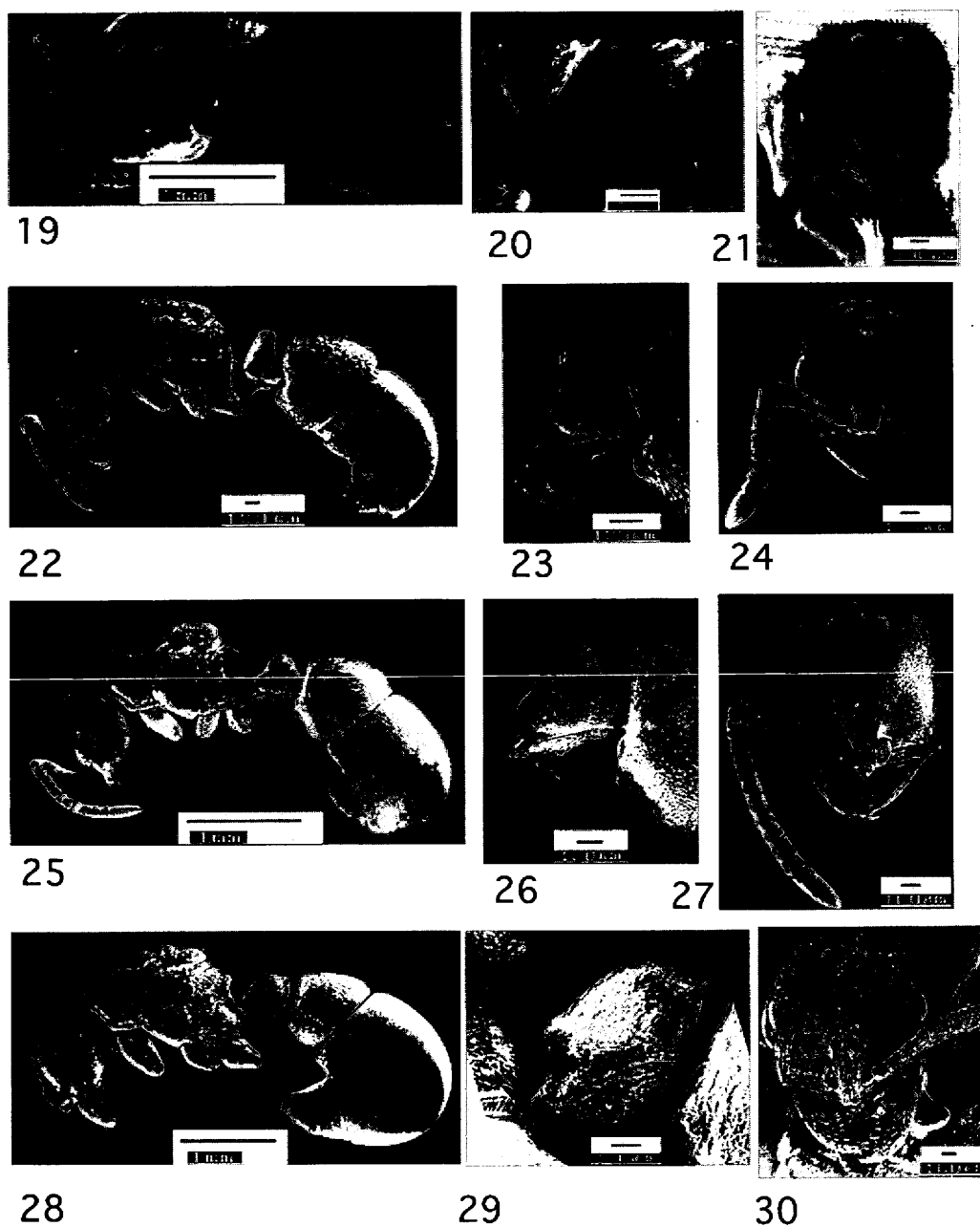
Head to gaster in lateral view are shown in Fig. 7. Head (Fig. 9) in full-face view subrectangular, sides convex, broadest at midlength; posterior margin nearly straight, or slightly convex. Mandible subtriangular with 3 large teeth on masticatory margin,



Figs. 7-18. Workers of Japanese *Proceratium*. — 7-9, *P. itoi*; 10-12, *P. japonicum*; 13-15, *P. morisitai* sp. nov.; 16-18, *P. watasei*. 7, 10, 13, 16, head to gaster in lateral view; 8, 11, 14, 17, petiole in lateral view; 9, 12, 15, 18, head in full-face view.

excluding the basal angle. Basal margin of mandible forming an angle of about 130 degrees with masticatory margin. Palp formula (maxillary, labial) 4, 3 (3 dissected and 1 observed on SEM). Anterior margin of clypeus in full-face view projecting in the middle, and the projection acutely triangular with a median carina. Frontal carinae moderately raised, but wide between at midlength and broadest at about posterior

1/3, antennal insertions 1/2 to 3/4 exposed. Scape relatively short, not reaching the posterior margin by 2.5 times its thickness. Apical segment of antenna with long peg-like structures (sensilla basiconica; a pore is observed at the tip of sensillum) arranged in 2 to 3 rows on the transitional area between upper and outer surfaces (Fig. 48). Eye very small, with 1 or rarely 3 facets, which are light to blackish brown,



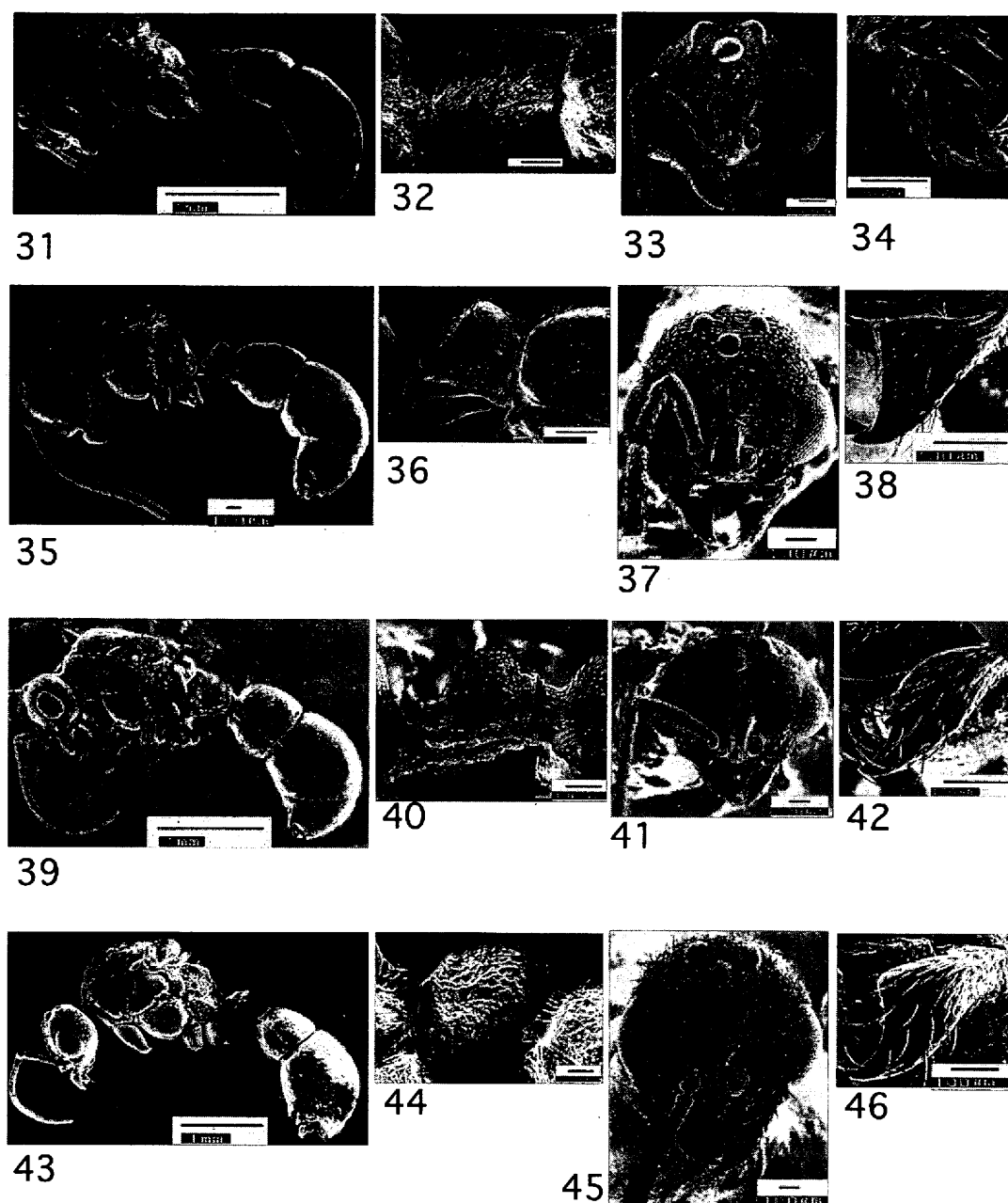
Figs. 19–30. Queens of Japanese *Proceratium*. — 19–21, *P. itoi*; 22–24, *P. japonicum*; 25–27, *P. morisitai* sp. nov.; 28–30, *P. watasei*. 19, 22, 25, 28, head to gaster in lateral view; 20, 23, 26, 29, petiole in lateral view; 21, 24, 27, 30, head in full-face view.

mostly transparent.

Dorsal surface of mesosoma in dorsal view relatively long, twice as long as wide, moderately narrowing posteriad; dorsal margin in lateral view gently curved, metanotal groove not impressed. Posterior margin of propodeal dorsum not carinate or weakly carinate. Propodeal corner without a tooth or with a developed lamellate tooth. Declivity slightly concave; the lateral margin in lateral view straight or slightly concave excluding propodeal lobe. Propodeal lobe situating at the same plane of the propodeal corner. Each leg with

a broadly pectinate tibial spur and an arolium.

Petiole (Fig. 8) nodiform, in lateral view about as long as high, the anterior slope of node nearly straight, and the summit well rounded, the anterior slope forming an acute angle with the posterior slope; the node a little wider than long; anterodorsal margin in dorsal view not carinate. Subpetiolar process small, in lateral view obtusely triangular or rarely trapezoidal, occupying anterior 1/3 to nearly 1/2 of the ventral margin of petiole, the apex situating between anterior 1/4 and 1/3 of petiole, directing ventrally or rarely pos-



Figs. 31-46. Males of Japanese *Proceratium*. — 31-34, *P. itoi*; 35-38, *P. japonicum*; 39-42, *P. morisitai* sp. nov.; 43-46, *P. watasei*. 31, 35, 39, 43, head to gaster in lateral view; 32, 36, 40, 44, petiole in lateral view; 33, 37, 41, 45, head in full-face view; 34, 38, 42, 46, mandible in full-face view.

teroventrally. Gastral segment I a little wider than long and a little higher than long; in lateral view anterior and dorsal margins of the tergite convex; anteroventral corner of sternite in lateral view rounded. Gastral segment II 1.5 times as long as high and 3 times as long as the length of ventral margin; in lateral view, dorsal margin of tergite very strongly curved, and at its posterior end forming an angle of 120 degrees with the posterior margin and situating distinctly anterior to the posteriormost point of tergite.

Sculpturation and hair conditions similar to *P. mo-*

risitai, but head not rugulose, only reticulate-punctate.

Body color yellow, brownish yellow, yellowish brown, brown, or reddish brown.

Queen (undescribed). HL 90-93, HW 83-89, CI 91-98, HD 54-68, ML 47-51, SL 50-58, SI 58-65, FCW 24-32, EL 17-18, PW 67-74, WL 121-136, PtL 45-51, PtW 35-40, PtH 43-53, G1L 71-75, G1W 76-84, G2L 106-115, G2W 86-93. (8 measured.)

Generally similar to the worker with the usual caste differences (Figs. 19-21). Mandible with 4 teeth of decreasing size based on masticatory margin, includ-

ing the basal tooth. Palp formula 4, 3 (1 observed on SEM). Eye medium-sized relative to head and slightly convex, with numerous hairs which are 2 to 2.5 times a facet diameter in length. Antenna with long sensilla basiconica on the apical segment (Fig. 47). Head posteriorly with 3 relatively large, transparent ocelli.

Mesoscutum distinctly longer than wide. Mesoscutum and mesoscutellum without a median longitudinal carina. Mesoscutellum in lateral view slightly overhanging metanotal dorsum. Metanotum without a median longitudinal carina. Propodeal corner slightly angled, not lamellate. Each leg with a broadly pectinate tibial spur and an arolium. Petiole slightly more compressed anteroposteriorly than in workers.

In fore wing (Fig. 65), Rs (Rsf5) reaching the anterior margin of wing membrane so that connecting to R, free abscissa of third radial sector (Rsf3) absent, m-cu present, and M (Mf4) considerably extending apically and not reaching the apical margin of wing membrane by 1/3 length of Mf4. In hind wing (Fig. 66), R absent. Hamuli with 5–6 hooks (4 individuals examined).

Body color yellowish brown to brown.

Male. HL 56–59, HW 73–80, CI 125–138, HD 45–51, ML 21–31, SL 35–37, SI 46–49, FCW 10–20, EL 29–35, PW 65–75, WL 115–126, PtL 44–47, PtW 25–27, PtH 30–32, G1L 49–57, G1W 51–56, G2L 75–81, G2W 63–69. (7 measured.)

Head to gaster in lateral view are shown in Fig. 31. Head (Fig. 33) a little wider than long, with 3 convex and white, transparent ocelli. Median ocellus directing anterodorsally. Mandible (Fig. 34) subtriangular, edentate. Basal margin of mandible forming an angle of about 130 degrees with masticatory margin. Palp formula 4, 3 (3 examined *in situ*, 1 dissected, 1 observed on SEM). Anterior margin of clypeus in the middle slightly convex in full-face view without or rarely with a median carina. Frontal carinae strongly diverging posteriad and relatively wide between at midlength. Antenna 13-segmented, without sensilla basiconica on the apical segment. Scape relatively short, when laid back, reaching the anterior margin of median ocellus. Eye distinctly more than 1/2 as long as head length; in lateral view its anterior margin situating very near the anterior clypeal margin and 1/8 eye length apart from it, and its posterior margin 1/2 eye length apart from the posterior margin of head.

Mesoscutum 1.5 times as long as wide. Mesoscutum and mesoscutellum without a median carina. Metanotum with a low median carina. Propodeal declivity not carinate at sides. All legs each with a broadly pectinate tibial spur and an arolium, the spur

on middle leg smaller and the pectination considerably reduced. Petiole (Fig. 32) longer than high, with a median carina from the nodal summit to the posterior margin of petiole; the node about as long as wide or a little wider than long, the anterior slope of node nearly straight in lateral view; the anterodorsal margin in dorsal view not carinate. Petiolar sternite without a lamella. Gastral segment I longer than high, and in dorsal view as long as wide or slightly longer than wide. In gastral segment II in lateral view, the outline length of dorsal margin is twice as long as that of the ventral margin.

Genitalia as in Figs. 57 and 58; paramere long, in ventral view angularly curved inward at the apical portion. Subgenital plate as in Fig. 59, the posterior margin deeply trilobed and the median lobe long and slender with long hairs, and the anterior median projection wide and short, about as long as the paired lateral projections.

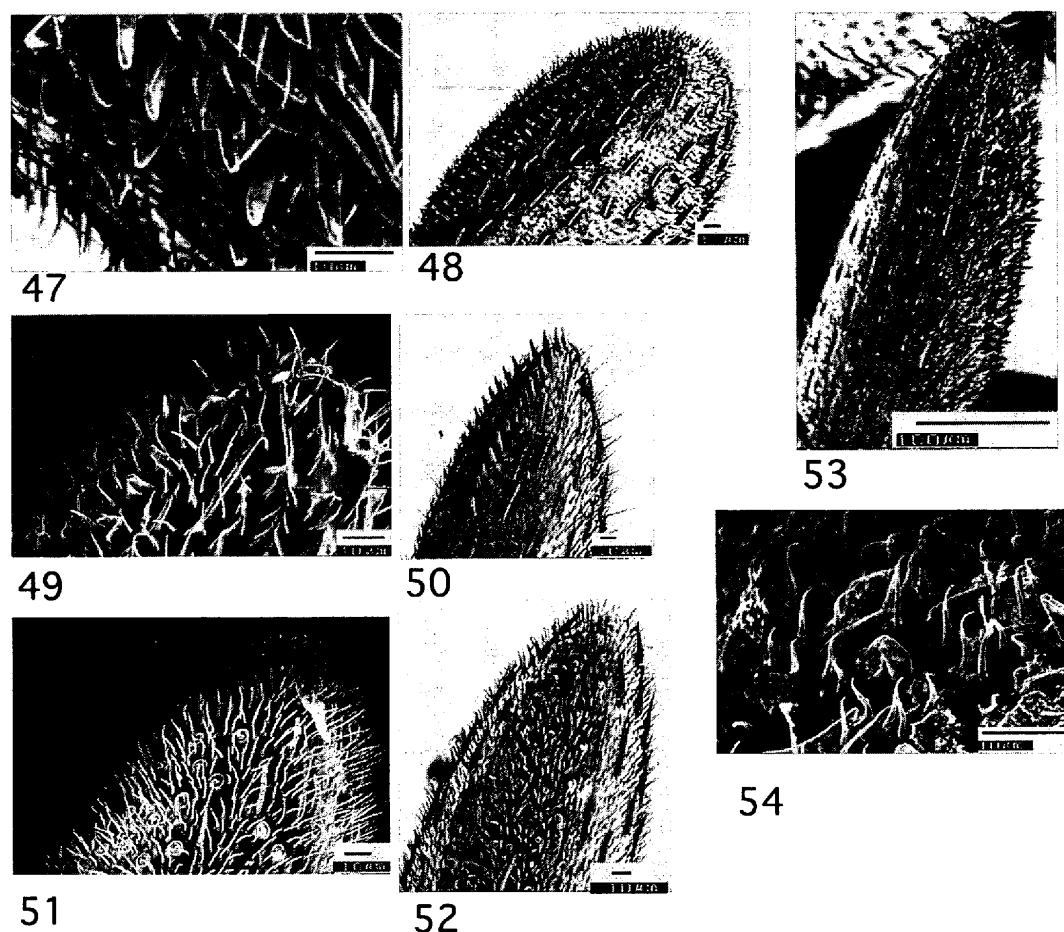
Wing venation (Figs. 67, 68) as in the queen. The number of hamuli is 6–7 (8 examined).

Mandible smooth and shining, with very sparsely distributed punctures (as hair pits). Head very densely reticulate-punctate with rugulae. Mesosoma and petiole rugulose, but mesoscutum weakly punctate or punctate-rugulose. Gastral segment I punctate, or mostly smooth and shining. Gastral segment II smooth and shining.

Body densely covered with short, yellowish, mostly subdecumbent pubescence, and with sparsely scattered, long suberect to subdecumbent hairs. Mandible with long, decumbent hairs. Eye with numerous erect hairs which are twice a facet diameter in length.

Head black or blackish brown, mesosoma to gaster blackish brown or brown. Mandible, antenna, and legs brownish yellow to yellow.

Material examined. 2 alate queens, 2 males, Manazurumisaki, Kanagawa Pref., 14. ix. 1981, K. Masuko leg.; 3 workers, 2 alate queens, 2 males, Odawara, Kanagawa Pref., 27. viii. 1980, M. Kubota leg.; 1 worker, Kanmuriyama, Maizuru Bay, Kyoto Pref., 10 m altitude (=above sea level, hereafter abbreviated as 'alt.'), 19. viii. 1974, K. Onoyama leg.; 1 worker, Botanical Garden of Kyoto University, Kitashirakawanishimachi, Sakyo-ku, Kyoto Pref., 70 m alt., 14. v. 1973, K. Onoyama leg.; 1 worker, same locality, 16. vi. 1973, K. Onoyama leg.; 3 workers, same locality, under a brick, 60 m alt., 8. v. 1974, K. Onoyama leg.; 1 queen (dealate, unless noted as 'alate'), same locality, 60 m alt., 11. i. x. 1974, K. Onoyama leg.; 1 queen, same locality, 70 m alt., 29. vii. 1975, K. Onoyama leg.; 1 worker, same locality, 70 m alt., 10. v. 1988, S.



Figs. 47-54. Apical segment of antenna showing peg-like or button-like structures. — 47, 48, *P. itoi*; 49, 50, *P. japonicum*; 51, 52, *P. morisitai* sp. nov.; 53, 54, *P. watasei*. 47, 49, 51, 54, queen; 48, 50, 52, 53, worker.

Ikeda leg.; 1 male, Kitashirakawaoiwake-cho, Sakyo-ku, Kyoto Pref., 60 m alt., captured with a light trap, 29. viii. 1974, K. Onoyama leg.; 1 male, same locality, 60 m alt., captured with a light trap, 30. viii. 1991, A. Taki leg.; 5 workers, Yoshidayama, Sakyo-ku, Kyoto Pref., 100 m alt., 23. v. 1973, K. Onoyama leg.; 1 worker, same locality, 80 m alt., 20. v. 1975, K. Onoyama leg.; 1 worker, same locality, 80 m alt., 6. vi. 1975, K. Onoyama leg.; 1 worker, same locality, 80 m alt., 9. vi. 1975, K. Onoyama leg.; 4 workers, same locality, 80 m alt., 1. vii. 1975, K. Onoyama leg.; 1 worker, Kyoutanabe, Kyoto Pref., 80 m alt., 21. vii. 1993, K. Onoyama leg.; 1 worker, same locality, 80 m alt., 24. vii. 1993, K. Onoyama leg.; 1 worker, same locality, 90 m alt., 21. ix. 1993, K. Onoyama leg.; 1 worker, same locality, 80 m alt., 23. v. 1994, K. Onoyama leg.; 1 queen, Takarazuka, Hyogo Pref., 1. x. 1972, M. Tanaka leg.; 1 worker, same locality, 14. vi. 1975, M. Tanaka leg.; 1 worker, Nushima I. near Awajishima I., Hyogo Pref., 10 m alt., 10. v. i. 1999, K. Onoyama leg.; 1 worker, Fukuoka Pref., 8. ix. 1983, K. Ogata leg.; 5 workers, 2 males, the summit of Mt.

Yuwandake, Amami-oshima I., Kagashima Pref., 690 m alt., 5. viii. 1982, H. Takamine leg.; 1 worker, Mt. Maesedake, Ishigaki I., Okinawa Pref., 160 m alt., 10. iv. 1987, K. Onoyama leg.

Remarks. Ogata (1987: 107) perhaps miscounted the male palp formula as 3, 2, but correctly 4, 3.

We propose to change the Japanese name to correspond to the Japanese name of the generic name from the currently used "Itou-hari-ari" to "Itou-kagibara-ari".

Distribution. JAPAN (Honshu, Shikoku, Kyushu, Amami Is., Sakishima Is.); KOREA (Choi, 1986), CHINA (Tang *et al.*, 1995; Wu & Wang, 1995). The northernmost localities are Tochigi and Ibaraki Prefectures (Terayama *et al.*, 1994), and the southernmost Ishigaki Island. The figures and descriptions given by both of Tang *et al.* (1995) and Wu & Wang (1995) are too rough to judge whether their specimens are *P. itoi* or not.

Habitat. *P. itoi* workers are found under stones and in litters of glossy-leaved evergreen, deciduous broad-leaved, and bamboo forests. In Kyotanabe, Kyoto

Prefecture, the workers were collected by a Berlese funnel from litters of *Pinus densiflora*, *Quercus serrata*, and *Phyllostachys pubescens* forests. A nest was found in a rotten log buried in the soil (Masuko *et al.*, 1985).

Colony size. Okamoto (1972) obtained 3 queens and 116 workers from a $30 \times 30 \times 30$ cm³ soil sample by a Berlese funnel; perhaps these were from a single colony. Masuko *et al.* (1985) reported a colony size of 1 queen, 202 workers, and 174 larvae.

Nuptial flight. As the records above in Kyoto, the flight dates of males were 29 and 30 August.

Proceratium japonicum Santschi

[Japanese name: Yamato-kagibara-ari (Morisita *et al.*, 1988)]

(Figs. 2, 4-6, 10-12, 22-24, 35-38, 49-50, 55, 60, 69-72)

Proceratium japonicum Santschi, 1937: 362-363, fig. 1.

Worker. Type locality: Oshima Iya Hunshiu, Japon (4 syntype workers, 10. vii. 1928, Kisato leg.). [4 syntype workers in Muséum d'Histoire Naturelle in Geneva examined.]

Proceratium japonicum: Ogata, 1987: 106, figs. 15-16, 19.

Worker, queen wing.

Proceratium japonicum: Onoyama & Ogata, 1989: 15, figs.

3.23a, 3.24. Worker.

Proceratium formosicola Terayama, 1985: 406-408, figs. 1-4.

Worker, queen. Type locality: Lushan, Nantou Hsien, Taiwan (holotype worker, 15. viii. 1980, M. Terayama leg.). [Synonymy by Onoyama, 1991: 695.]

Worker. HL 73-75, HW 66-71, CI 90-95, HD 48-50, SL 46-50, SI 70-72, Scape Thickness 12-13, FCW 19-23, EL 2-4, PW 50-51, WL 85-92, PtW 30-33, PtH 46-48, G1W 61-66, G2W 65-71. (4 syntypes measured.)

HL 59-77, HW 56-77, CI 86-103, HD 36-56, ML 32-42, SL 41-53, SI 67-75, FCW 15-25, EL 2-4, PW 43-55, WL 72-100, PtL 20-31, PtW 28-37, PtH 37-53, G1L 42-59, G1W 53-71, G2L 57-73, G2W 58-74. (10 measured.)

Head to gaster in lateral view are shown in Fig. 10. Head (Fig. 12) in full-face view subrectangular, sides convex, broadest at posterior 1/4; posterior margin broad and nearly straight, or slightly concave in the middle. Mandible triangular with 3 apical large teeth and following 5-8 blunt denticles, excluding the basal angle. Basal margin of mandible forming an angle of about 100 degrees with masticatory margin. Palp formula 2, 2 (4 dissected; 1 observed on SEM, Fig. 55). Galea distally with several long, spatulate appendages of peculiar form, the tips strongly bent like ear picks (Fig. 55). Anterior margin of clypeus not

projecting in the middle. Frontal carinae moderately raised, wide between, broadest at about posterior 1/3, antennal insertions 1/2 to 3/4 exposed. Scape relatively short, not reaching the posterior margin by twice its thickness, and much thickened from basal 1/2 to near the distal end (Fig. 12). Apical segment of antenna with eminent, long sensilla basiconica arranged in 2 rows on the transitional area between upper and outer surfaces (Fig. 50). Eye very small, with 1 light-brown to black pigmented facet.

Dorsal surface of mesosoma relatively short, less than twice as long as wide, slightly narrowing posteriorly; dorsal margin in lateral view gently curved, metanotal groove not impressed. Posterior margin of propodeal dorsum not carinate. Propodeal corner without a tooth or with a much reduced lamellate tooth. Declivity slightly concave; the lateral margin in lateral view straight or slightly concave excluding propodeal lobe. Propodeal lobe situating interior to the plane of propodeal corner. All legs each with a broadly pectinate tibial spur (which is relatively small on middle legs), but without an arolium.

Petiole (Fig. 11) scale-like, in lateral view much higher than long, the anterior slope of node nearly straight, and the summit a little rounded, anterior and posterior slopes subparallel; the node more than twice as wide as long; anterodorsal margin in dorsal view not carinate. Subpetiolar process moderately large, in lateral view subtriangular with anteroventral margin convex and posteroventral margin concave, occupying a little more than anterior 1/3, the apex situating at anterior 1/3 of petiole, directing posteroventrally. Gastral segment I a little less than 1.5 times as wide as long and a little higher than long; in lateral view anterior and dorsal margins of the tergite convex; anteroventral corner of sternite in lateral view rounded. Gastral segment II 1.5 times as long as high and twice as long as the ventral margin length; in lateral view, dorsal margin of tergite strongly curved, and at its posterior end forming an angle of 90 degrees with the posterior margin and situating at the posterior-most point of tergite.

Sculpturation and hair conditions similar to *P. morisitai*, but punctation shallower and more spaced and in mandible striae seen at the basal 1/2.

Body color yellow, brownish yellow, yellowish brown, or brown.

Queen. HL 64-84, HW 63-84, CI 96-106, HD 43-61, ML 32-45, SL 44-55, SI 64-73, FCW 17-25, EL 12-22, PW 53-75, WL 89-118, PtL 25-38, PtW 30-42, PtH 42-60, G1L 50-71, G1W 59-84, G2L 65-83, G2W 67-87. (10 measured.)

Generally similar to the worker with the usual caste differences (Figs. 22–24). Mandibular dentition similar to that of workers. Basal margin of mandible forming an angle of about 90 degrees with masticatory margin. Palp formula 2, 2 (1 observed on SEM). Eye large relative to head and most convex among the four species, with numerous (but sparser than in *P. itoi*) hairs of length of 4 to 5 times the facet diameter. Antenna with long sensilla basiconica arranged in 2 rows on the apical segment (Fig. 49). Head posteriorly with 3 transparent ocelli.

Mesoscutum as long as wide, with a median carina at posterior half. Mesoscutellum with a median carina throughout. Mesoscutellum in lateral view not overhanging metanotal dorsum. Metanotum with a median carina, which is lamellate at the posterior half and protruding posteriorly. Propodeal corner carinate and slightly lamellate. Each leg with a broadly pectinate tibial spur and without an arolium.

In fore wing (Fig. 69), Rs5 failing to reach the anterior margin of wing membrane by its 1/2 length, Rs3 absent, m-cu absent, and Mf4 short. In hind wing (Fig. 70), R absent. Hamuli with 5–6 hooks (6 examined).

Body color yellowish brown to reddish brown.

Male (undescribed). HL 59–65, HW 68–70, CI 106–118, HD 44–46, ML 25–29, SL 31–32, SI 44–46, FCW 11–13, EL 29–30, PW 62–71, WL 101–120, PtL 29–31, PtW 24–30, PtH 30–34, G1L 49–53, G1W 52–57, G2L 65–73, G2W 62–69. (3 measured.)

Head to gaster in lateral view are shown in Fig. 35. Head (Fig. 37) slightly wider than long, with 3 convex and yellowish, transparent ocelli. Median ocellus directing rather dorsally. Mandible (Fig. 38) subtriangular, edentate. Basal margin of mandible forming an angle of about 90 degrees with masticatory margin. Palp formula 5, 2 (1 examined *in situ*, 2 observed on SEM). Anterior margin of clypeus in the middle straight or slightly convex in full-face view without a median carina. Frontal carinae nearly parallel and wide between. Antenna 13-segmented, without sensilla basiconica on the apical segment. Scape short, not reaching the anterior margin of median ocellus. Eye less than 1/2 of head length; in lateral view its anterior margin situating 1/4 eye length apart from the anterior clypeal margin, and its posterior margin 3/4 eye length apart from the posterior margin of head.

Mesoscutum slightly longer than wide. Mesoscutum with a median longitudinal carina at posterior 1/3. Mesoscutellum with a median longitudinal carina throughout. Metanotum with a well developed, post-

eriorly protruding, lamellate median carina. Propodeal declivity not carinate at sides. Each leg with a broadly pectinate tibial spur and an arolium. Petiole (Fig. 36) higher than long, without a median carina dorsally; the node twice as wide as long, the anterior slope of node slightly concave in lateral view; the anterodorsal margin in dorsal view not carinate. Petiolar sternite without a lamella. Gastral segment I about as long as high, and in dorsal view as long as wide. In gastral segment II in lateral view, the outline length of dorsal margin is 4 times as long as that of the ventral margin.

Subgenital plate as in Fig. 60, the posterior margin entire and rounded with short hairs, and the anterior median projection slender and very long, about 2.5 times as long as the paired lateral projections.

Wing venation (Figs. 71, 72) as in the queen. Hamuli with 5–7, or 9 hooks (6 examined).

Mandible mostly smooth and shining, basally with a few weak striae. Head mostly transversely rugulose. Mesoscutum punctate, posteriorly with longitudinal rugulae; propodeal declivity smooth and shining; the rest of mesosoma longitudinally rugulose. Petiole mostly smooth and shining with a few rugulae. Gastral segments I and II smooth and shining.

Body densely covered with short, yellowish, subdecumbent to appressed pubescence, and with sparsely scattered, long erect to subdecumbent hairs. Mandible with long, decumbent hairs. Eye with numerous erect hairs of length of twice to 3 times the facet diameter.

Head blackish brown, mesosoma to gaster brown. Mandible yellowish light brown. Antenna light brown. Legs light brown to yellowish brown.

Material examined. 4 workers, 1 queen, Tairoike, Miyake I., Izu Is., Tokyo Pref., 4. iv. 1980, K. Masuko leg.; 1 worker, 1 male, Oosarikebana, Hachijou I., Izu Is., Tokyo Pref., 26. viii. 1979, K. Masuko leg.; 1 worker (from a colony of 1 queen and 55 workers), Manazurumisaki, Kanagawa Pref., 60 m alt., nest in a rotten log, 6. i. 1973, members of Myrmecological Society of Japan leg.; 6 workers, same locality, 60 m alt., nest in a rotten stump, 7. i. 1973, members of Myrmecological Society of Japan leg.; 168 workers, 2 queens, 55 larvae, same locality, in a cavity of 1 cm diameter and 4 cm length within a rotten stump, 22. iii. 1978, K. Onoyama leg.; 2 workers, 1 alate queen, 3 males, Warusawa, Odawara, Kanagawa Pref., 27. viii. 1983, H. Kubota leg.; 3 workers, 1 queen, Mt. Yonaha, Kunigami-son, Okinawa I., Okinawa Pref., 320 m alt., 20. x. 1987, Y. Nishikawa leg.; 8 workers, 6 alate queens, 8 males, Mt. Otowadake,

Okinawa I., Okinawa Pref., 240 m alt., in a decaying fallen trunk, 8. vii. 2001, K. Onoyama leg.; 59 workers, 2 queens, 46 larvae, Mt. Furugatsuu, Okinawa I., Okinawa Pref., 310 m alt., in a cavity of 1 cm diameter and 5 cm length within a rotten log, 6. iii. 1984, K. Onoyama leg.; 13 workers, 1 queen, 3 larvae, same locality, 310 m alt., nest in a rotting log, 6. iii. 1984, K. Onoyama leg.; 2 workers, Tano-dake, Hanechi, Nago, Okinawa I., Okinawa Pref., 100 m alt., 25. x. 1987, Y. Nishikawa leg.; 1 worker, Sueyoshinomori, Naha, Okinawa I., Okinawa Pref., 8. vii. 1974, K. Onoyama leg.; 1 queen, same locality, 40 m alt., 8. iii. 1984, K. Onoyama leg.; 1 worker, Ryukyu University, Shuri, Naha, Okinawa I., Okinawa Pref., 26. vi. 1974, K. Onoyama leg.; 5 workers, 1 queen, 12 larvae, 2 eggs, Seifaa-utaki, Okinawa I., Okinawa Pref., nest in a rotten stump, 90 m alt., 29. iii. 1975, K. Onoyama leg.; 1 queen, same locality, 29. iii. 1975, K. Onoyama leg.; 157 workers, 1 queen, 84 larvae, 7 eggs, Shirahama, Iriomote I., Okinawa Pref., 160 m alt., nest in a large rotten stump, 23. iii. 1975, K. Onoyama leg.; 2 queens, same locality, 90 m alt., 6. v. 2000, M. Yoshimura leg.

Remarks. Body size variation is notable, workers and queens from the Ryukyus are smaller than those from Honshu.

Distribution. JAPAN (Honshu, Shikoku, Kyushu, Amami Is., Okinawa Is., Sakishima Is.); TAIWAN. The northernmost locality is Saitama Prefecture (Terayama *et al.*, 1994), and the southernmost in Japan is Iriomote Island.

Habitat. *P. japonicum* nests in rotting stumps and fallen logs of glossy-leaved evergreen forests.

Colony size. From the records above, colony sizes are given as: 2 queens, 168 workers, 55 larvae; 2 queens, 59 workers, 46 larvae; 1 queen, 157 workers, 84 larvae, 7 eggs; 1 queen, 55 workers; 1 queen, 13 workers, 3 larvae; 1 queen, 5 workers, 12 larvae, 2 eggs.

Nuptial flight. In Kyoto males flew in late August

as the records above.

***Proceratium morisitai* sp. nov.**

[Japanese name: Morishita-kagibara-ari (Morisita *et al.*, 1988)]

(Figs. 1, 3, 13–15, 25–27, 39–42, 51–52, 56, 61–63, 73–76)

Proceratium itoi: Sonobe, 1974: 2, fig. 4. Worker. [Misidentification. see Onoyama & Ogata, 1989: 15.]

Proceratium sp. 4: Onoyama & Ogata, 1989: 15, fig. 3.26b. Worker. [Specimens examined.]

Worker. HL 84–90 (87), HW 76–80 (79), CI 86–92 (91), HD 58–65 (62), ML 47–53 (53), SL 58–63 (63), SI 74–82 (80), FCW 12–17 (15), EL 2–4 (3), PW 55–60 (58), WL 101–110 (107), PtL 40–43 (42), PtW 29–32 (31), PtH 44–47 (44), G1L 57–63 (58), G1W 64–69 (69), G2L 92–96 (96), G2W 70–75 (71). (10 measured. Holotype measurements are shown in parentheses.)

Head to gaster in lateral view are shown in Fig. 13. Head (Fig. 15) in full-face view subrectangular, sides slightly convex and nearly parallel at the anterior half, and converging posteriad at the posterior half; posterior margin nearly straight. Mandible subtriangular with 5–6 teeth on masticatory margin, excluding the basal angle (or tooth in some cases): apical 2 large and blunt, the remaining 3–4 small and blunt or somewhat acute. Basal margin of mandible forming an angle of about 130 degrees with masticatory margin. Palp formula 4, 3 (2 dissected; 2 observed on SEM, Fig. 56). Labrum trapezoidal with rounded corners, distal margin broadly concave and incised deeply and very narrowly in the middle, and lateral margins converging distad. Anterior margin of clypeus in full-face view projecting in the middle, and the projection acutely triangular with a median carina. Frontal carinae much raised, relatively narrow between, gradually diverging posteriad or rarely slightly widened at posterior 1/3, and antennal insertions fully exposed.

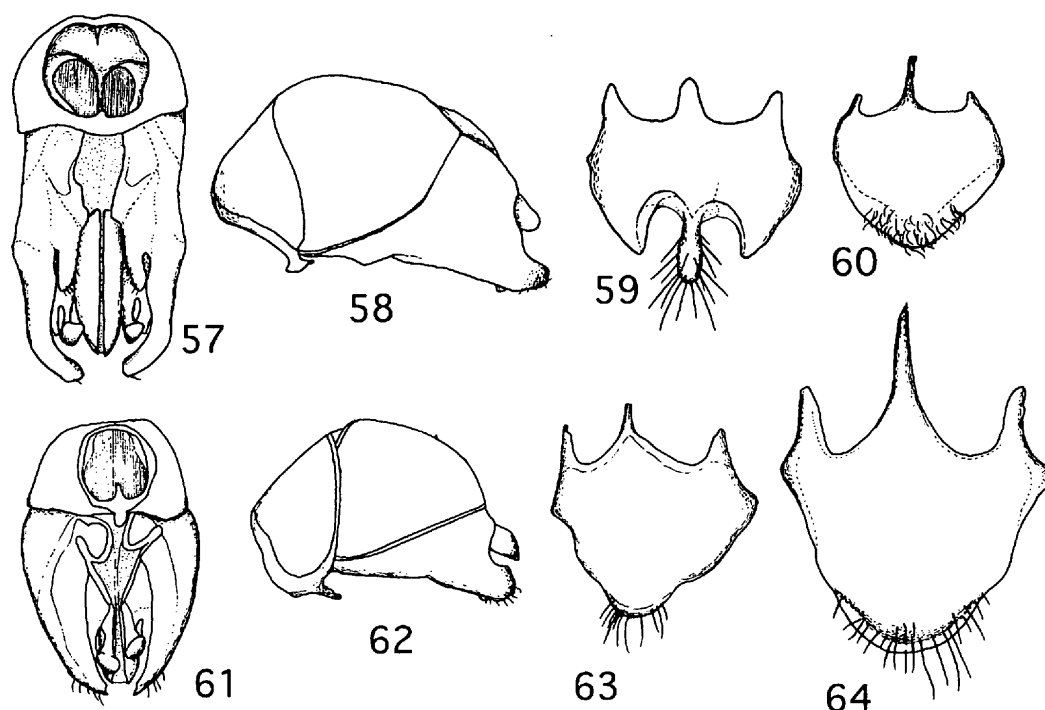


55



56

Figs. 55–56. Mouthparts of *Proceratium* worker. — 55, *P. japonicum*; 56, *P. morisitai* sp. nov.



Figs. 57-64. Male genitalia and subgenital plate of Japanese *Proceratium*. — 57-59, *P. itoi*; 60, *P. japonicum*; 61-63, *P. morisitai* sp. nov.; 64, *P. watasei*. 57, 61, ventral view of male genitalia; 58, 62, lateral view of male genitalia; 59, 60, 63, 64, subgenital plate.

Scape relatively long, about $7/10$ length of head length, not reaching the posterior margin by its thickness. Funicular segment I 1.5 times as long as wide, II as long as wide, III to X wider than long, and XI (apical) 3 times as long as wide and as long as the succeeding 4 segments together. Apical segment of antenna with button-like structures (sensilla basiconica with very short pegs) situating irregularly on the transitional area between upper and outer surfaces (Fig. 52). Eye very small, with 1 black-pigmented facet, situating a little posterior to the midlength of head.

Dorsal surface of mesosoma relatively long, twice as long as wide, convex, moderately narrowing posteriad; dorsal margin in lateral view gently curved, but metanotal groove slightly concave or in some specimens not impressed. Posterior margin of propodeal dorsum not carinate. Propodeal corner with a lamellate tooth. Declivity nearly flat or slightly concave; the lateral margin in lateral view straight or slightly concave excluding propodeal lobe. Propodeal lobe situating at the same plane of the propodeal corner; the margin in lateral view gently curved. Each leg with a broadly pectinate tibial spur and a reduced arolium.

Petiole (Fig. 14) nodiform, in lateral view a little higher than long, the anterior slope of node concave at anterior $1/3$, and the summit well rounded; the node 1.5 times as wide as long; anterodorsal margin in

dorsal view carinate and often dark colored. Subpetiolar process large, in lateral view trapezoidal, occupying anterior $1/2$, posteriorly with in most cases an acute projection, the apex situating a little anterior to the midlength of petiole, directing posteroventrally or in case of a less acute projection directing ventrally. Gastral segment I a little wider than long and a little higher than long; anterior margin of tergite nearly straight, dorsal margin convex; anteroventral corner of sternite in lateral view acutely to rightly angled or rounded. Gastral segment II 1.5 times as long as high and twice to 2.5 times as long as the ventral margin length; in lateral view, dorsal margin of tergite very strongly curved, and at its posterior end forming an angle of 120 degrees with the posterior margin and situating distinctly anterior to the posteriormost point of tergite.

Mandible sparsely punctate and at basal $3/4$ finely and longitudinally striate. Head very densely reticulate-punctate and rugulose. Mesosoma and gastral segment I densely reticulate-punctate. Propodeal declivity very sparsely punctate and almost smooth and shining. Petiole densely reticulate-punctate with short rugulae. Gastral segment II more sparsely reticulate-punctate at anterior $1/4$ than in gastral segment I, and becoming more sparsely punctate, smooth and shining posteriad.

Body densely covered with fine, short, yellow, erect

to decumbent pubescence, and with sparsely scattered, long erect hairs.

Mandible with long, decumbent hairs. Antenna densely with fine, very short, decumbent pubescence, and sparsely with fine erect hairs. Legs with fine, short, decumbent to appressed pubescence, and sparsely with subdecumbent hairs.

Body color brownish yellow to yellowish brown.

Queen. HL 93–97, HW 90–93, CI 93–98, HD 67–70, ML 51–55, SL 62–69, SI 69–76, FCW 15–20, EL 16–20, PW 77–80, WL 132–142, PtL 48–54, PtW 36–39, PtH 52–58, G1L 77–83, G1W 87–90, G2L 116–125, G2W 91–94. (10 measured.)

Generally similar to the worker with the usual caste differences (Figs. 25–27). Mandible subtriangular with 6 teeth on masticatory margin including the basal tooth: apical 2 large and acute, the remaining 4 small and acute. Palp formula 4, 3 (1 dissected, 1 observed on SEM). Eye medium-sized relative to head and slightly or moderately convex, with numerous hairs of length of 2.5 to 3 times facet diameter. Antenna with button-like structures on the apical segment (Fig. 51). Head posteriorly with 3 relatively small, transparent ocelli.

Mesoscutum distinctly longer than wide. Notauli absent. Parapsidal furrows long, slightly more than 1/3 the mesoscutum length. Mesoscutum and mesoscutellum without a median carina. Mesoscutellum not overhanging metanotal dorsum. Metanotum with a median carina, which is lamellate at the posterior half and slightly protruding posteriorly. Propodeal corner carinate and slightly lamellate. All legs each with a broadly pectinate tibial spur and without an arolium or with a much reduced arolium.

In fore wing (Fig. 73), Rsf5 reaching the anterior margin of wing membrane so that connecting to R, Rsf3 absent, m-cu present, and Mf4 considerably extending apically and failing to reach the apical margin of wing membrane by its 1/3 length. In hind wing (Fig. 74), R present and reaching the anterior margin of wing membrane. Hamuli with 6–8 hooks (8 examined).

Body color yellowish brown to brown.

Male. HL 58–61, HW 82–84, CI 138–141, HD 51–53, ML 30–38, SL 53–55, SI 65, FCW 9–15, EL 29–31, PW 70–72, WL 131–135, PtL 41–44, PtW 29–31, PtH 34–37, G1L 56–58, G1W 65–68, G2L 89–91, G2W 75–78. (3 measured.)

Head to gaster in lateral view are shown in Fig. 39. Head (Fig. 41) distinctly wider than long, with 3 convex and whitish, transparent ocelli. Median ocellus directing almost anteriorly. Mandible (Fig. 42)

subtriangular, with 3 teeth on masticatory margin, excluding the apical tooth and the basal angle. Basal margin of mandible forming an angle of about 130 degrees with masticatory margin. Palp formula 4, 3 (2 examined *in situ*, 1 observed on SEM). Anterior margin of clypeus in the middle distinctly produced and angulate in full-face view with a median carina. Frontal carinae a little diverging posteriad and narrow between. Antenna 13-segmented, without button-like structures on the apical segment. Scape long, reaching the anterior margin of lateral ocellus. Funicular segment I 1.5 times as long as wide, II and III 3 times as long as wide, IV and V 2.5 times as long as wide, VI to X twice as long as wide, and XI (apical) 3 to 3.5 times as long as wide. Eye about 1/2 as long as head length; in lateral view its anterior margin situating 1/3 eye length apart from the anterior clypeal margin, and its posterior margin 1/2 eye length apart from the posterior margin of head. Posterior margin of head nearly straight or slightly concave.

Mesoscutum slightly longer than wide. Notauli absent. Parapsidal furrows long, slightly more than 1/3 the mesoscutum length. Mesoscutum and mesoscutellum without a median carina. Metanotum with a blade-like, a little lamellate median carina. Propodeal corner rounded. Propodeal declivity not carinate at sides. Each leg with a broadly pectinate tibial spur and an arolium. Petiole (Fig. 40) about as long as high or a little longer than high, with a median carina from the nodal dorsum to the posterior margin of petiole; the node slightly wider than long, the anterior slope of node concave at anterior 1/3 in lateral view, moderately truncated before the concavity; the anterodorsal margin in dorsal view carinate. Petiolar sternite triangular in lateral view, and lamellate at anterior 1/2. Gastral segment I a little higher than long, and in dorsal view as long as wide. In gastral segment II in lateral view, the outline length of dorsal margin is twice as long as that of the ventral margin.

Genitalia as in Figs. 61 and 62; paramere relatively short, in ventral view gently curved inwardly at the apical portion. Subgenital plate as in Fig. 63, the posterior margin entire and rounded, slightly projecting, with long hairs, and the anterior median projection triangular and moderately long, about 1.5 times as long as the paired lateral projections.

Wing venation (Figs. 75, 76) as in the queen. Hamuli with 6–7 hooks (3 examined).

Mandible very sparsely punctate and at basal 3/4 with weak, longitudinal striae. Head very densely reticulate-punctate with rugulae. Mesosoma to gastral segment I densely punctate; pronotum, mesepistern-

num, and propodeum with rugulae. Gastral segment II smooth and shining.

Body densely covered with short, yellowish, mostly subdecumbent pubescence, with sparsely scattered, long suberect to subdecumbent hairs. Mandible with long, decumbent hairs. Eye with numerous erect hairs of length of 4 times the facet diameter.

Head black, mesosoma to gaster brownish black. Mandible yellowish light brown. Antenna and coxa to tibia blackish brown to brown, tarsus brown to yellowish brown.

Holotype worker: Kamigamo-nakayama-cho, Kita-ku, Kyoto, Kyoto Pref., 100 m alt., 10. x. 1991, A. Taki leg. (Type No. OMNH TI 145, Osaka Museum of Natural History)

Paratypes: 40 workers, 15 alate queens, 4 males, same data as holotype, captured when alates are going to fly, the nest was under a stone (Osaka Museum of Natural History, the Natural History Museum in London, Muséum d'Histoire Naturelle in Geneva, and collection of K. Onoyama at Obihiro University).

Other material examined. 1 queen, Karasuma-kuramaguchi, Ukyou-ku, Kyoto, Kyoto Pref., 60 m alt., no date, O. Kohriba leg.; 1 worker, Botanical Garden of Kyoto University, Kitashirakawa-oiwake-cho, Sakyo-ku, Kyoto Pref., 16. vi. 1973, K. Onoyama leg.; 1 worker, same locality, 21. vi. 1973, K. Onoyama leg.; 1 worker, Yoshidayama, Sakyo-ku, Kyoto, Kyoto Pref., 100 m alt., 22. vi. 1973, K. Onoyama leg.; 1 worker, same locality, 80 m alt., 3. vi. 1975, K. Onoyama leg.; 1 queen, Takarazuka, Hyogo Pref., 2. vi. 1970, M. Tanaka leg.; 1 queen, same locality, 3. vi. 1970, M. Tanaka leg.; 3 workers, Gakunotsuji, Iki I., Nagasaki Pref., 120 m alt., 28. iii. 1978, K. Onoyama leg.

Remarks. *P. morisitai* resembles *P. itoi*, but is distinguished in the worker and queen by the following characters: (1) frontal carinae more raised and narrower between, (2) SI larger, (3) petiole anterodorsally with a (often dark colored) transverse carina, and (4) subpetiolar process more developed, (5) gastral segment I shorter than long; and in the male: (1) masticatory margin of mandible dentate vs. edentate, (2) SI larger, scape reaching the anterior margin of lateral ocellus vs. reaching the anterior margin of median ocellus, and (3) R vein of hind wing present vs. absent.

P. morisitai much more resembles a European species, *P. melinum* (1 worker and 1 male syntypes of *P. europaea* Forel, a synonym of *P. melinum* (Roger), in Muséum d'Histoire Naturelle in Geneva are examined) in the general morphology, especially in the

petiole, but is distinguished in the worker by the following characters: (1) frontal carinae narrower between, (2) eye situating more posteriorly, (3) anterior slope of petiolar node in lateral view at anterior 1/3 more concave, (4) the dorsal midline length from the anteriorly carinate margin to posterior margin of petiole is distinctly greater than the petiole width vs. the dorsal midline length nearly equal to the petiole width, (5) dorsal margin of petiolar node in posterior view more convex, (6) gastral tergite I reticulate-punctate vs. puncticulate, not reticulate; and in the male: (1) frontal carinae narrow between, without a transverse line vs. wide between, with a dark colored transverse line near their midlength, (2) anterior margin of eye situating 1/3 the eye length apart from the anterior margin of clypeus vs. 1/4 the eye length apart, (3) posterior margin of head in full-face view nearly straight or slightly concave vs. a little convex, (4) fore and hind wings hyaline vs. brown colored (smoked), (5) anterior slope of petiolar node in lateral view at anterior 1/3 more concave, (6) the dorsal midline length from the anteriorly carinate margin to posterior margin of petiole is distinctly greater than the petiole width vs. the dorsal midline length nearly equal to the petiole width, (7) dorsal margin of petiolar node in posterior view very convex vs. a little convex, (8) the median carina on the nodal dorsum to posterior margin of petiole distinct vs. undeveloped and obscure, and (9) gastral tergite I with punctate, thus rough integument vs. with almost smooth integument.

The species name is in memory of the late Prof. Emeritus Masaaki Morisita of Kyoto University.

Distribution. JAPAN (Honshu, Kyushu). The northernmost locality is Miyagi Prefecture (Sonobe, 1974), and the southernmost Iki Island.

Habitat. *P. morisitai* workers are collected from litters of glossy-leaved evergreen forests. The holotype nest was found under a stone at the yard of the collector's personal house.

Nuptial flight. O. Kohriba (pers. comm.) reared a dealate queen which was collected at Kita-ku in Kyoto on 5 October 1964 perhaps soon after her nuptial flight, and observed her first oviposition on 24 July next year. Flights from the holotype nest in Kyoto occurred on 10 October.

Proceratium watasei (Wheeler)

[Japanese name: Watase-kabibara-ari (here revised)]
(Figs. 16–18, 28–30, 43–46, 53–54, 64, 77–80)

Sysphincta watasei Wheeler, 1906: 303–304, pl. 41, fig. 5.

Worker, queen. Type locality: JAPAN: Okayama,

Bizen (1 worker, 1 queen, no date, Sho Watasê leg.).

Proceratium watasei: Brown, 1958:248. [Generic change.]

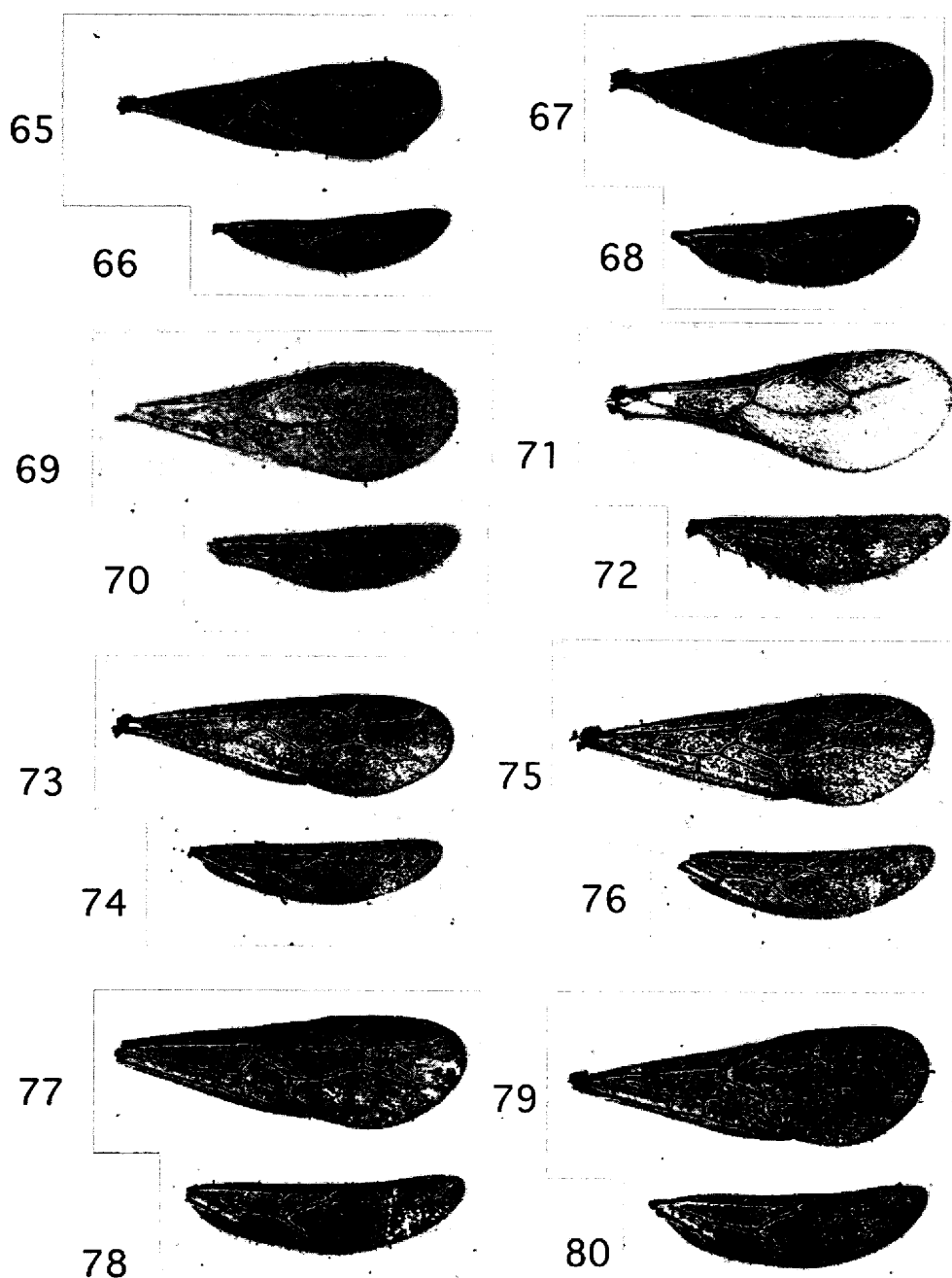
Proceratium watasei: Ogata, 1987: 106, figs. 22, 29. Queen wing [fig. 22, not male wing (K. Ogata, pers. comm.)], male subgenital plate.

Proceratium watasei: Onoyama & Ogata, 1989: 15, figs. 3.22, 3.25a. Worker.

Worker. HL 111–116, HW 93–98, CI 83–86, HD 70–79, ML 60–64, SL 82–89, SI 85–92, FCW 18–22,

EL 4–5, PW 69–75, WL 140–154, PtL 45–57, PtW 40–44, PtH 43–50, G1L 58–67, G1W 70–77, G2L 109–120, G2W 94–102. (7 measured.)

Head to gaster in lateral view are shown in Fig. 16. Head (Fig. 18) in full-face view subrectangular, sides slightly convex and nearly parallel at the anterior half, and converging posteriad at posterior 1/3; posterior margin broadly convex. Mandible subtriangular with 2 apical large teeth and following smaller 4–5 teeth on masticatory margin including the basal tooth. Basal



Figs. 65–80. Wing of Japanese *Proceratium*. — 65–68, *P. itoi*; 69–72, *P. japonicum*; 73–75, *P. morisitai* sp. nov.; 77–80, *P. watasei*. 65, 66, 69, 70, 73, 74, 77, 78, queen; 67, 68, 71, 72, 75, 76, 79, 80, male; 65, 67, 69, 71, 73, 75, 77, 79, fore wing; 66, 68, 70, 72, 74, 76, 78, 80, hind wing.

margin of mandible forming an angle of about 130 degrees with masticatory margin. Palp formula 3, 3 (1 dissected, 1 observed on SEM). Anterior margin of clypeus in full-face view projecting in the middle, and the projection trapezoidal, anteriorly weakly bicarinate, which may be in some cases obscured by a median carina beginning a little posterior to the anterior margin. Frontal carinae much raised, relatively narrow between, very slightly widened at posterior 1/3, and antennal insertions mostly exposed. Scape long, nearly reaching the posterior margin. Apical segment of antenna with sensilla basiconica situating irregularly on the transitional area between upper and outer surfaces (Fig. 53). Eye very small, with 1 well pigmented facet.

Dorsal surface of mesosoma in dorsal view very long, more than twice as long as wide, moderately narrowing posteriad; dorsal margin in lateral view gently curved, metanotal groove very slightly impressed. Posterior margin of propodeal dorsum distinctly carinate, dark colored, and a little overhanging in dorsal view. Propodeal corner with a lamellate tooth, the lamella extending to the propodeal lobe. Declivity distinctly concave; the lateral margin in lateral view straight or slightly concave excluding propodeal lobe. Propodeal lobe situating at the same plane of the propodeal corner. Each leg with a broadly pectinate tibial spur and a reduced arolium.

Petiole (Fig. 17) low nodiform, in lateral view longer than high, the anterior slope of node nearly straight, and the summit well rounded, the anterior slope forming an obtuse angle with the posterior slope; the node about as long as wide; anterodorsal margin in dorsal view carinate or rarely not carinate. Subpetiolar process small, in lateral view obtusely or rarely right-angled triangular, occupying anterior 1/2 of petiole, the apex situating at anterior 1/3 of petiole, directing ventrally. Gastral segment I of small size, a little wider than long and a little higher than long, lateral margins in dorsal view rapidly converging anteriorly; in lateral view anterior margin of the tergite slightly convex and dorsal margin convex; anteroventral corner of sternite in lateral view produced and acutely to obtusely angled. Gastral segment II 1.5 times as long as high and twice as long as the ventral margin length; in lateral view, dorsal margin of tergite very strongly curved, and at its posterior end forming an angle of 120 degrees with the posterior margin and situating distinctly anterior to the posteriormost point of tergite.

Mandible, sparsely punctate and at basal 3/4 finely and longitudinally striate. Head densely reticulate-

punctate, but gena rugulose-punctate. Mesosoma to gastral segment I rugulose-punctate. Propodeal declivity almost smooth and shining. Gastral segment II smooth and shining except for very small hair pits.

Hair conditions similar to *P. morisitai*.

Body color reddish brown or yellowish brown.

Queen. HL 125, HW 111–113, CI 89–90, HD 82–89, ML 71–74, SL 94–99, SI 83–89, FCW 23–24, EL 14–20, PW 94, WL 180, PtL 67–69, PtW 53, PtH 54–57, G1L 75–77, G1W 96–101, G2L 148–157, G2W 129–132. (3 measured.)

Generally similar to the worker with the usual caste differences (Figs. 28–30). Mandible subtriangular with 6–7 teeth on masticatory margin including the basal tooth: apical 2 large and acute and the remaining 4–5 small and acute or blunt. Palp formula 3, 3 (1 observed on SEM). Eye small relative to head and slightly convex, with numerous hairs of length of 4 times the facet diameter. Antenna with long sensilla basiconica on the apical segment (Fig. 54). Head posteriorly with 3 relatively small, transparent ocelli.

Mesoscutum a little longer than wide. Mesoscutum and mesoscutellum without a median carina. Mesoscutellum not overhanging metanotal dorsum. Metanotum with a median carina, which is slightly lamellate and slightly protruding posterodorsally. Propodeal corner carinate and lamellate. Propodeal declivity lamellate at both sides, the lamellae connecting to propodeal lobes. Each leg with a broadly pectinate tibial spur and a very small arolium.

In fore wing (Fig. 77), Rsf5 reaching the anterior margin of wing membrane so that connecting to R, Rsf3 present, m-cu present, and Mf4 considerably extending apically and failing to reach the apical margin of wing membrane by its 1/4 length. In hind wing (Fig. 78), R present and reaching the anterior margin of wing membrane. Hamuli with 8–9 hooks (2 examined).

Body color brown to reddish brown.

Male (undescribed). HL 75, HW 99, CI 132, HD 67, ML 43, SL 65, SI 66, FCW 15, EL 40, PW 99, WL 178, PtL 58, PtW 43, PtH 41, G1L 60, G1W 74, G2L 108, G2W 95. (1 measured.)

Head to gaster in lateral view is shown in Fig. 43. Head (Fig. 45) a little wider than long, with 3 convex and whitish, transparent ocelli. Median ocellus directing rather dorsally. Mandible (Fig. 46) subtriangular, with 2 teeth masticatory margin, excluding the apical tooth and the basal angle. Basal margin of mandible forming an angle of about 110 degrees with masticatory margin. Palp formula 5, 3 (1 examined on SEM). Anterior margin of clypeus in the middle distinctly

produced and rounded in full-face view, with a weak median carina a little posterior to the anterior margin. Frontal carinae strongly diverging posteriad, relatively narrow between at midlength. Antenna 13-segmented, without sensilla basiconica on the apical segment. Scape long, reaching the anterior margin of lateral ocellus. Eye less than $1/2$ as long as head length; in lateral view its anterior margin situating $1/4$ eye length apart from the anterior clypeal margin, and its posterior margin $3/4$ eye length apart from the posterior margin of head.

Mesoscutum nearly as long as wide. Mesoscutum and mesoscutellum without a median carina. Metanotum with a spiniform, posteriorly much protruding median carina. Propodeal declivity carinate with lamellae at sides. Each leg with a broadly pectinate tibial spur and an arolium. Petiole longer than high, with a median carina from the posterior slope of node to the posterior margin of petiole; the node a little wider than long, the anterior slope of node concave in lateral view, largely truncated before the concavity; the anterodorsal margin in dorsal view carinate. Petiolar sternite slightly lamellate at anterior $1/2$. Gastral segment I a little as higher than long, and in dorsal view a little wider than long. In gastral segment II in lateral view, the outline length of dorsal margin is twice as long as that of the ventral margin.

Subgenital plate as in Fig. 64, the distal margin entire and rounded with long hairs, and the anterior median projection triangular and very long, about twice as long as the paired lateral projections.

Wing venation (Figs. 79, 80) as in the queen. The number of hamuli is 8 (1 examined).

Mandible mostly smooth and shining, with weak striae at basal $2/3$. Head densely reticulate-punctate. Pronotum, mesoscutellum, propodeum, and katapisternum rugulose; mesoscutum reticulate-punctate; anepisternum punctate; propodeal declivity mostly smooth and shining with several rugulae. Petiole rugulose. Gastral segment I reticulate-punctate with weak rugulae. Gastral segment II smooth and shining.

Body densely covered with very short, yellowish, subdecumbent to appressed pubescence, with sparsely scattered, long erect to subdecumbent hairs. Mandible with long, decumbent hairs. Eye with numerous erect, short hairs of length of the facet diameter.

Head to petiole brownish black. Propodeal declivity and gaster dark brown. Mandible, scape, and legs brown. Funiculus dark brown.

Material examined. 1 worker, Kanazawa University, Kanazawa, Ishikawa Pref., 13. vi. 1990, S. Amano leg.; 1 worker, Manazurumisaki, Kanagawa Pref., 60

m alt., 6. x. 1973, K. Onoyama leg.; 1 worker, Nagoya University, Chigusa-ku, Nagoya, Aichi Pref., 4. iv. 1992, K. Onoyama leg.; 3 alate queens, 1 male, Kanmuriyama I., Maizuru Bay, Kyoto Pref., 170 m alt., 18. viii. 1974, M. Hori & H. Hasegawa leg.; 1 worker, Mt. Daimonji, Sakyo-ku, Kyoto, Kyoto Pref., 270m alt., 6. v. 1973, K. Onoyama leg.; 1 queen, Yoshidayama, Sakyo-ku, Kyoto, Kyoto Pref., 100 m alt., 23. v. 1973, K. Onoyama leg.; 1 worker, same locality, 80 m alt., 19. vii. 1974, K. Onoyama leg.; 1 alate queen, 1 male, Karasumashakomae, Sakyo-ku, Kyoto, Kyoto Pref., 23. viii. 1946, M. Morisita leg.; 2 workers, Nushima I. near Awajishima I., Hyogo Pref., 10 m and 80 m alt., 10. vi. 1999, K. Onoyama leg.

Remarks. Ogata (1987: 107) perhaps miscounted the male palp formula as 3, 2, but correctly 5, 3.

We propose to change the Japanese name to correspond to the Japanese name of the generic name from the currently used "Watase-hari-ari" to "Watase-kagibara-ari".

Distribution. JAPAN (Honshu, Shikoku, Kyushu); KOREA. The northernmost locality in Japan is Sendai, Miyagi Prefecture (Sonobe, 1974), and the southernmost is Satamisaki, Kagoshima Prefecture (Azuma, 1951).

Habitat. *P. watasei* workers are found under stones and in litters of rather open, Japanese red pine forests and mixed forests of Japanese red pine trees and deciduous broad-leaved trees. Nests are under stones (Masuko *et al.*, 1979) and probably in the soil of rather open habitats based on the nuptial flight observation below and Kawai (1965).

Colony size. Masuko *et al.* (1985) reported a colony size of 1 queen, 101 workers, and 57 larvae.

Nuptial flight. In Tokyo Kawai (1965) observed 5 males flew from the nest opening at about 8:00 on 4 September. In Kanmuriyama Island of Kyoto Prefecture, according to the above-named collectors, 3 queens and 2 males (1 male of which could not collected) appeared on the ground for their nuptial flight at about 15:00 on 18 August. A copulating pair was found walking on the ground at 17:30 on 23 August in Kyoto, on which day it was rainy during 12:30–15:00, then fair and sometimes cloudy (M. Morisita, pers. comm.). In Kochi alate queens flew to the light at dawn in mid August, and several males flew to the white sweatshirt of a man at about 5:30 early morning in mid August (Okamoto, 1972).

Discussion

1. Sensilla of antenna

The workers and queens of the four species have sensilla basiconica (Figs. 47–54). Since each of the sensilla has a pore on the tip, they are olfactory (see Ozaki & Tominaga, 1999). Various types of sensilla basiconica are reported by Hashimoto (1990) from the antennal segments of ants, but such a particular structure consisting of a number of sensilla and distributed on a particular area of the apical antennal segment was not mentioned. *P. morisitai* is different from other three species in having very short pegs of the sensilla.

2. Mouthparts

Appendages of peculiar form (Fig. 55) on galea are observed in all of four species of *Proceratium*. Such form is not found in the figures of ant mouth parts by Gotwald (1969). It is an open question in what other taxa such structures are observed.

The palp formulae hitherto known for workers of *Proceratium* species are 2, 2 for 3 species (*P. silaceum*, *P. croceum*, and *P. relictum* by Brown, 1958); 3, 2 for two species (*P. lunatum* by Terron, 1981; *P. micrommatum* by Brown, 1980); 3, 3 for one species (probable count for *P. deelemani* by Perrault, 1981); and 4, 3 for 5 species (*P. melinum* and *P. pergandei* by Brown, 1958; *P. goliath* by Kempf & Brown, 1968; *P.*

boltoni by Leston, 1971; *P. avium* by Brown, 1974). We have confirmed the palp formula of 2, 2 for one species (*P. japonicum*), the certain formula of 3, 3 for one species (*P. watasei*), and that of 4, 3 for two species (*P. itoi* and *P. morisitai*). Adding these new observations the formula of 4, 3 is seen for 7 species, most frequent in workers of *Proceratium* species. Queens of all four Japanese species here studied have the same formulae as the workers.

The palp formula for males has been known as 5, 2 from only one species (*P. silaceum* by Brown, 1958 based on the figures of Kennedy & Talbot, 1939), omitting Ogata's (1987) erroneous count of 3, 2. Brown (1958: 331) stated, "we should expect that the formula for other species of *Proceratium* males is ordinarily 5, 3 or 5, 2". This is the case for *P. japonicum* (5, 2) and *P. watasei* (5, 3; a newly observed formula). But *P. itoi* and *P. morisitai* have a new formula of 4, 3; thus Brown's expectation has failed. Male palp formulae are the same as worker's in *P. itoi* and *P. morisitai*, but the numbers of male maxillary palp in *P. japonicum* and *P. watasei* are greater than in the workers.

As Brown (1958) pointed out for the male of *P. silaceum*, the males of all four Japanese species also have the second segment of maxillary palp with the slender basal neck (hammerhead shape), which is a generic character of workers (Brown, 1958; Kempf & Brown, 1968).

Table 1. Worker and female characters of four Japanese species of *Proceratium*. Characters 9 to 13 are for the female only.

	<i>P. itoi</i>	<i>P. japonicum</i>	<i>P. morisitai</i> sp. nov.	<i>P. watasei</i>
1. Body size	medium	small	medium	large
2. Angle formed by basal and masticatory margins of mandible	130 degrees	90–100 degrees	130 degrees	130 degrees
3. Palp formula (maxillary, labial)	4, 3	2, 2	4, 3	3, 3
4. Median anterior margin of clypeus	projecting	not projecting	projecting	projecting
5. Petiole in lateral view	about as long as high	much higher than long	a little higher than long	longer than high
6. Transverse carina on anterior petiolar dorsum	absent	absent	present	present
7. Subpetiolar process	small	large	large	small
8. Dorsal margin of gastral segment II in lateral view	strongly curved	moderately curved	strongly curved	strongly curved
9. Median carina on mesoscutellum	absent	present	absent	absent
10. Median carina on metanotum	absent	present	present	present
11. Rsf3 vein of fore wing	absent	absent	absent	present
12. m-cu cross-vein of fore wing	present	absent	present	present
13. R vein of hind wing	absent	absent	present	present

Table 2. Male characters of four Japanese species of *Proceratium*.

Character	<i>P. itoi</i>	<i>P. japonicum</i>	<i>P. morisitai</i> sp. nov.	<i>P. watasei</i>
1. Masticatory margin of mandible	edentate	edentate	dentate	dentate
2. Angle formed by basal and masticatory margins of mandible	130 degrees	90–100 degrees	130 degrees	130 degrees
3. Palp formula (maxillary, labial)	4, 3	5, 2	4, 3	5, 3
4. Frontal carinae	strongly diverging posteriad	nearly parallel	a little diverging posteriad	strongly diverging posteriad
5. Median carina on mesoscutellum	absent	present	absent	absent
6. Propodeal declivity at sides	not carinate	not carinate	not carinate	carinate
7. Petiole in lateral view	longer than high	higher than long	about as long as high or a little longer than high	longer than high
8. Rsf3 vein of fore wing	absent	absent	absent	present
9. m-cu cross-vein of fore wing	present	absent	present	present
10. R vein of hind wing	absent	absent	present	present
11. Posterior margin of subgenital plate	trilobed, the median lobe with long hairs	entire, with short hairs	entire, with long hairs	entire, with long hairs
12. Anterior median projection of subgenital plate	wide and short	slender and very long	triangular and moderately long	triangular and very long

3. Reproductive castes

The four Japanese species of *Proceratium* are different each other in many characters as shown in Table 1 for the worker and queen and Table 2 for the male. The subgenital plate (Figs. 59, 60, 63, 64) is a useful character in the male for species separation. Wing venations also shows species-level differences among four species. For example, only *P. watasei* has Rsf3 vein on fore wings, and only *P. japonicum* lacks the m-cu cross-vein on fore wings. As seen from the wing-based key, we can identify the four Japanese species of *Proceratium* based on the fore wings only.

Acknowledgments

We would like to acknowledge Mr. Barry Bolton (Natural History Museum, London), Dr. Maria L. de Andrade (Institut NLU-Biogeographie, Basel), Dr. Kazuo Ogata (Kyushu University), and Dr. Mitsuhiro Iwasa (Obihiro University of Agriculture and Veterinary Medicine) for their valuable suggestions. Many thanks are also due to Dr. Cesare Baroni Urbani (Naturhistorisches Museum in Basel, Switzerland) and Dr. Claude Besuchet and Dr. Bernhard Merz (Muséum d'Histoire Naturelle in Geneva, Switzerland) for their kind help for the loan of types; and Mr. Akio Taki (Kyoto), the late Dr. Masaaki Morisita, Mr. Masao Kubota (Odawara), Dr. Kazuo Ogata, Dr. Keiichi Masuko (Senshu University), Dr. Michio Hori (Kyoto University), Mr. Hiroshi Hasegawa (Toho University), Mr. Hidetsune Takamine

(Okinawa Shogaku High School), Mr. Ohki Kohriba (Kyoto), and Dr. Koji Nakamura (Kanazawa University) for offering materials.

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(Received July 5, 2001; Accepted September 25, 2001)