Male-based Keys to the Subfamilies and Genera of Japanese Ants (Hymenoptera: Formicidae)

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Abstract. Keys to the subfamilies and genera of Japanese ants based on the males are presented with scanning electron micrographs and illustrations. The keys cover all 7 subfamilies and 46 out of 56 genera distributed in Japan. Characters of mandibles, antennal sockets, flagellum, pedicel, occipital carina, notauli, scuto-scuteellar suture, metapleural gland orifices, propodeal spiracles, abdominal segments II, III, and IV, and hind tibial spurs are useful to separate among the genera. Hair condition on vertex may be useful to distinguish between Pyramica and Strumigenys.

Key words: character, Japan, identification, illustration, morphology, SEM, taxonomy.

Introduction

Ants are well known for having distinct castes, and within the same colony each caste is morphologically specialized. In ant taxonomy, workers have been usually used for the descriptions and identifications of taxa, because commonly collected ants are workers. Hence the current classification system of ants is very largely based on the worker. The male is morphologically very different from the worker and gyne (queen), and thus male characters may shed new and hopeful lights on ant taxonomy. It might be possible that some genera and species are more clearly defined by male characters than by worker and gyne characters.

In spite of its potential importance, male-based taxonomy has been poorly studied and hence utilized. In the previous studies, several male-based keys to subfamilies, genera, and/or species were presented for central Europe (Stitz, 1914), for Africa (Wheeler, 1922), for the United States (Smith, 1943), for Switzerland (Kutter, 1977), for Fennoscandia and Denmark (Collingwood, 1979), and for Nevada (Wheeler & Wheeler, 1986). But most of these keys are at least partly out of date due to the recent taxonomic changes. Male generic synopses for most Japanese genera of Myrmicinae, Ponerinae, and Cerapachyinae were given by Ogata (1987, 1991). However, there have been no subfamilial or generic keys for Japanese male ants.

The keys are also indispensable for the identification of male ants (for example, those collected after nuptial flights). In addition, ants have been used as bioindicators (Ogata et al., 1998), and male ants, which can be collected with light traps, may be helpful for understanding the local ant fauna.

The present paper provides male-based keys to subfamilies and genera of Japanese ants. Scanning electron micrographs and illustrations are used to show key characters. Comparisons between the previous keys and our keys are also given. Usefulness of characters previously used are discussed: e.g., the morphologies of antennal sockets, mandibles, occipital carina, notauli, propodeal spiracles, orifices of metapleural gland, constriction between abdominal segment III and IV, and tibial spurs. These characters are useful to separate among several genera.

Terminology

Material Examined

A total of 134 species of 46 genera belonging to seven subfamilies were examined. When Japanese specimens were unavailable, foreign materials were used. When the undetermined species were examined, the species code by Japanese Ant Database Group (1998) is used.

The male specimens examined are as follows: when foreign materials were used, the country names are shown in brackets after the species names. When specimens were unavailable, but taxa were included on the basis of published references, the references are given in brackets after the species names.

*Myrmica luteola* Kupynanskaya (1990: 103) (=*Myrmica* sp. 5 of Onoyama & Sonobe, 1992: 11; Japanese

Aenictinae Emery, 1901
*Aenictus* Shuckard, 1840: *Aenictus* sp. [Taiwan], *A. lifiae* Terayama, 1984 [Terayama, 1984]

Cerapachyinae Forel, 1893

Dolichoderinae Forel, 1878
*Dolichoderus* Lund, 1831: *D. sibiricus* (Emery, 1889)
*Ochetellus* Shattuck, 1992: *O. glaber* (Mayr, 1862)
*Tapinoma*Foerster, 1850: *T. melanocephalum* (Fabricius, 1793), *Tapinoma* sp. 3
*Technomyrmex* Mayr, 1872: *T. albipes* (Smith, 1861) [wingless: Yamauchi et al., 1991], *T. gibbosus* Wheeler, 1906

Formicinae Latreille, 1809
*Anoplolepis* Santschi, 1914: *A. gracilipes* (Smith, 1857)


Formica Linnaeus, 1758: F. (Formica) truncorum Fabricius, 1804, F. (Raptiformica) sanguinea Latreille, 1798, F. (Serviformica) candida Smith, 1878 (=*F. transkaucusica* Nasonov, 1889), F. (S.) hayashi Terayama & Hashimoto, 1996, F. (S.) japonica Motschoulsky, 1866


Paratrechina Motschoulsky, 1863: *P. flavipes* (Smith, 1874), *P. yaeyamensis* Terayama, 1999, Paratrechina spp.

Polyergus Latreille, 1804: *P. samurai* Yano, 1911

Polyrhachis Smith, 1857: *P. (Myrna) latona Wheel er, 1909, P. (Myrmhopla) dives Smith, 1857, P. (Mh.) moesta Emery, 1887, P. (Polyrhachis) lamellidens Smith, 1874

Leptanillinae Emery, 1910


Myrmicinae Emery, 1877


*Lordomyrma* Emery, 1897: L. *azumai* (Santschi, 1941)

*Manica* Jurine, 1807: M. *jessensis* Azuma, 1955

*Messor* Forel, 1890: M. *aciculatus* (Smith, 1874)

*Monomorium* Mayr, 1855: M. *destructor* (Jerdon, 1851), M. *intrudens* (Smith, 1874), M. *floricola* (Jerdon, 1851)


*Pheidole* Westwood, 1839: P. *fervida* Smith, 1874, P.
megacephala (Fabricius, 1793), P. noda Smith, 1874, P. pieli Santschi, 1874
Pristomyrmex Mayr, 1866: P. pungens Mayr, 1866
Pyramica Roger, 1862: P. hexamera (Brown, 1958)
(formerly in 'Epipritius Emery, 1869'), P. mutica (Brown, 1949) ('Kyidris Brown, 1949'), P. canina (Brown & Boisvert, 1979) ('Pentastroma Forel, 1912'), P. incerta (Brown, 1949) ('Smithistruma Brown, 1948'), P. japonica (Ito, 1914) ('Smithistruma'), P. rostrateformis (Brown, 1949) ('Smithistruma')
Recurviris Bolton, 1992: R. recurvispinosa (Forel, 1890)
Solenopsis Westwood, 1840: S. japonica Wheeler, 1928, S. tipuna Forel, 1912
Strumigenys Smith, 1860: S. lewisi Cameron, 1886, S. stenorrhina Bolton, 2000, Strumigenys sp. 4, Strumigenys sp. 9, Strumigenys sp.
Ponerinae Lepeletier de Saint-Fargeau, 1835
Amblyopone Erichson, 1842: A. silvestrii (Wheeler, 1928)
Cryptopone Emery, 1893: C. saturei (Wheeler, 1906)
Diacamma Mayr, 1862: Diacamma sp.
Discothyrea Roger, 1863: D. saturei Forel, 1912
Leptogenys Roger, 1861: L. conficii Forel, 1912
Pachycondyla Smith, 1858: P. chinesis (Emery, 1895) (formerly in 'Brachypomera Emery, 1900'), P. luteipes (Mayr, 1862) ('Brachypomera'), P. pilosior (Wheeler, 1928) ('Trachymesopus Emery, 1911'), Pachycondyla sp. [Ogata, 1987, as Ecotomomyrmex javanus Mayr, 1867]
Odontomachus Latreille, 1804: Odontomachus sp.
Probolomyrmex Mayr, 1901: P. longinodus Terayama & Ogata, 1988 [Taiwan]
Pseudomyrmecinae Smith, 1952
Tetraponera Smith, 1852: T. allabrans (Walker, 1859) [Taiwan]

Key to the Subfamilies

1. Mandibles distinctly longer than head (Fig. 8). Head including eyes about twice as wide as long. ..........................................................................................Aenictinae
   - Mandibles shorter than head (Fig. 9). Head including eyes less than twice as wide as long........................................2

2. In full-face view, frontal carinæ very distinct and converging posteriorly (Fig. 9). Posterior margin of subgenital plate with two projections posteriorly.....................Cerapachynae
   - In full-face view, frontal carinæ absent (Fig. 10), or if present then diverging posteriorly (Fig. 11) or horizontally meeting each other between antennal sockets (Fig. 12). Posterior margin of subgenital plate mostly with a single projection, rarely with three or more projections......................3

3. Only abdominal segment II reduced in size and separated from other segments (Figs. 13, 14)........................................4
   - Both abdominal segments II and III reduced in size and separated from each other and from other segments by constrictions (Fig. 15) ....7

4. In lateral view, antennal sockets situated close to mandibles. Clypeus much reduced. Frontal carinæ absent.................................Leptanillinae
   - In lateral view, antennal sockets situated distant from mandibles (Figs. 16, 17). Clypeus not reduced. Frontal carinæ usually present.........5

5. Mandible triangular, with distinct serrate dentition consisting of many minute teeth on masticatory margin (Fig. 18), if not such dentition, abdominal segment II in dorsal view expanded laterally and concealing anterior margin of abdominal segment III (Fig. 19) ....Dolichoderinae
   - Mandible not triangular or dentition of masticatory margin not minutely serrate (Fig. 20). Abdominal segment II not expanded laterally......6
6. Presclerites of abdominal segment IV concealed by abdominal segment III (Fig. 21). Scuto-scutellar suture not sculptured (Fig. 22).…………
                      ..........................................................Formicidae
− Presclerites of abdominal segment IV exposed (Fig. 14); if seen as concealed, then the scuto-scutellar suture longitudinally sculptured (Fig. 23).……………………………………..Ponerinae
7. Abdominal segment III widely attached to abdominal segment IV; abdominal segment IV anteriorly nearly as wide as posterior width of abdominal segment III in dorsal view (Fig. 24). Peduncle of abdominal segment II very long and the node obscure (Fig. 25).……………………………………..Pseudomyrmecinae
− Abdominal segment III narrowly attached to abdominal segment IV; abdominal segment IV anteriorly distinctly wider than posterior width of abdominal segment III in dorsal view (Fig. 26). Peduncle of abdominal segment II relatively short; if long then petiolar node distinct (Fig. 15).……………………………………..Myrmicinae

Key to the Genera

Subfamily Aenictinae
A single genus is represented in Japan, answering the characters given in the key to the subfamilies....
                      ..........................................................Aenictus

Subfamily Cerapachynae
A single genus is represented in Japan, answering the characters given in the key to the subfamilies....
                      ..........................................................Cerapachys

Subfamily Dolichoderinae
1. Wingless (apterous).........Technomyrmex (part)
   − Winged…………………………………………………………2
2. Abdominal segment II expanded laterally and concealing anterior margin of abdominal segment III (Fig. 19)..........................Ochetellus
   − Abdominal segment II not expanded laterally..........................3
3. Scuto-scutellar suture distinctly sculptured longitudinally (as in Fig. 23)..................Dolichoderus
   − Scuto-scutellar suture not sculptured (as in Fig. 22)..................................................4
4. Scape short, less than twice as long as first flagellar segment (Fig. 27)........Technomyrmex (part)
   − Scape relatively long, distinctly more than twice as long as first flagellar segment (Fig. 18)...........
                      ..........................................................Tupinoma

Subfamily Formicinae
1. Mandible in full-face view sickle-shaped (Fig. 28). Antennae, legs, mandibles, and genitalia distinctly light-colored (white to light yellow) compared to other parts..............Polyrergus
   − Mandible in full-face view not sickle-shaped (Fig. 20). Body not bicolored as above............2
2. Antenna with 13 segments..........................3
   − Antenna with 12 or fewer segments....................9
3. Mesopleuron smooth, without rugulae (Fig. 29). Scape long, exceeding 1/2 length of flagellum....
                      ..........................................................Paratrechina
   − Mesopleuron with imbricate rugulae (Fig. 30). Scape long or short.................................4
4. Propodeal spiracles slit-shaped to elliptical (Fig. 31)..........................5
   − Propodeal spiracles subcircular (as in Fig. 29)..........................................................7
5. Antennal socket in full-face view situated close to or at posterior margin of clypeus (Fig. 20). Metapleural gland orifice distinct and densely hairy (Fig. 31)..........................Formica
   − Antennal socket in full-face view situated distant from posterior margin of clypeus (Fig. 32). Metapleural gland orifice absent (as in Fig. 33).............6
6. Head in full-face view not narrowing anteriorly: head width at level of posterior margins of eyes as wide as that at level of anterior margins of eyes (Fig. 34). Dorsal surface of abdominal segment III without setae (Fig. 35)..............Polyrhachis
   − Head in full-face view narrowing anteriorly: head width at level of posterior margins of eyes wider than that at level of anterior margins of eyes (Fig. 32). Dorsal surface of abdominal segment III with setae (Fig. 36)............Camponotus (part)
7. Metapleural gland orifice distinct and densely hairy (as in Fig. 31).................................Lasius (part; subgenera other than Dendrolasius)
   − Metapleural gland orifice absent (Fig. 33)..........8
8. Posterior margin of head in full-face view nearly straight (Fig. 37). Propodeal spiracle relatively large and situated above mid height (Fig. 33)..................................................Lasius (part; subgenus Dendrolasius)
   − Posterior margin of head in full-face view broadly convex (Fig. 32). Propodeal spiracle relatively small and situated at mid height (Fig. 38)..........................Camponotus (part)
9. Scape long, more than three times the length between antennal sockets and posterior margin of head (Fig. 39)..........................Anoplolepis
   − Scape short, less than twice the length between antennal sockets and posterior margin of head.
Figs. 8-13. Male ants of Aenictinae (8), Cerapachyinae (9), Myrmicinae (10), and Ponerinae (11-13). Arrows indicate key characters. 8, *Aenictus* sp.; 9, *Cerapachys biroi*; 10, *Pheidole* sp.; 11, *Proceratium itoi*; 12, *Discothyrea sauteri*; 13, *Pachycondyla luteipes*. 8-12, head in full-face view; 13, propodeum and abdominal segments II to IV in lateral view.
Figs. 14–19. Male ants of Dolichoderinae (18, 19), Myrmicinae (15), and Ponerinae (14, 16, 17). 14, Amblyopone silvestrii; 15, Oligomyrmex sp.; 16, Cryptopone sauteri; 17, Probolomyrmex longinodus; 18, Tapinoma melanocephalum; 19, Ochetellus glaber. 14, abdominal segments II and III in lateral view; 15, abdominal segments II to IV in lateral view; 16, 17, head in lateral view; 18, head in full-face view; 19, abdominal segments II to IV in oblique dorsal view.
Figs. 20–25. Male ants of Formicinae (20–22), Ponerinae (23), and Pseudomyrmecinae (24, 25). 20, 21, *Formica sanguinea*; 22, *Camponotus obscuripes*; 23, *Pachycondyla luteipes*; 24, 25, *Tetraponera allaborans*. 20, head in full-face view; 21, head to abdomen in lateral view; 22, 23, alitrunk in dorsal view; 24 abdominal segments II to IV in dorsal view; 25, abdominal segments II and III in lateral view.
Figs. 26–31. Male ants of Myrmicinae (26), Dolichoderinae (27), and Formicinae (28–31). 26, Oligomyrmex sp.; 27, Technomyrmex albipes; 28, Polyporus samurai; 29, Paratrechina sp.; 30, 31, Formica sanguinea. 26, abdominal segments II to IV in dorsal view; 27, 28, head in full-face view; 29, alitrunk in lateral view; 30, mesopleuron in lateral view; 31, propodeum in lateral view.
Figs. 32–37. Male ants of Formicinae. 32, 36, Camponotus obscuripes; 33, 37, Lasius (Dendrolasius) sp.; 34, 35, Polyrhachis lamellidens. 32, 34, 37, head in full-face view; 33, alitrunk and abdominal segment II in lateral view; 35, 36, abdominal segment III in dorsal view.
Subfamily Leptanillinae

Leptanilline males are known only from *Leptanilla*, but unknown for *Anomalomyrma* and *Protanilla*, hence a key to genera can not be constructed. The male characters of Japanese *Leptanilla* were given in the key to the subfamilies.

Subfamily Myrmicicinae

Bolton (1999) synonymized *Epitriteus, Kyidris, Pentastruma*, and *Smithistruma* with *Pyramica*, but in the present key these four genera are shown in single quotation marks.

1. Wingless (apterous)............ *Cardiocondyla* (part)
   - Winged........................................2

2. Body distinctly bicolored, head black and other parts light yellow.................. *Recurviridis*
   - Body not bicolored, or if bicolored then head is nearly the same color as alitrunk..................3

3. Antenna with 10 segments. First flagellar segment distinctly elongate (Fig. 40)........4
   - Antenna with more than 10 segments. First flagellar segment not elongate (Fig. 41)...........5

4. Mandible in full-face view sickle shaped, without teeth on masticatory margin (as in Fig. 42).................... *Strongylognathus*
   - Mandible in full-face view triangular, with teeth on masticatory margin (Fig. 40).............. *Tetramorium*

5. Abdominal segment II without spongiform appendages (Fig. 15)....................6
   - Abdominal segment II ventrally with spongiform appendages (Fig. 43)......................24

6. Eye densely hairy (Fig. 41).................................................................7
   - Eye without hairs or sparsely hairy (Fig. 44)................................................9

7. Notauli present on mesoscutum (as in Fig. 23). ........................................... *Lordomyrma*
   - Notauli vestigial or absent on mesoscutum (as in Fig. 22)........................................8

8. Anterior margin of abdominal segment IV in lateral view concealing the posterior margin of abdominal segment III (Fig. 15). Ventral margin of abdominal tergite III in lateral view forming an obtuse angle with posterior margin of the tergite (Fig. 15). Peduncle of abdominal segment II relatively long (Fig. 15)........ *Oligomyrmyrex*
   - Anterior margin of abdominal segment IV in lateral view not concealing posterior margin of abdominal segment III (Fig. 45). Ventral margin of abdominal tergite III in lateral view forming an angle of nearly 90° with posterior margin of the tergite (Fig. 45). Dorsal margin of abdominal segment II in lateral view gently rounded so that the peduncle becomes obscure (Fig. 45).......................... *Vollenhovia*

9. Mandibles absent (Fig. 46). Abdominal segment II nearly cylindrical and without a distinct peduncle (Fig. 47).................. *Myrmecina*
   - Mandibles present (Fig. 44). Abdominal segment II not cylindrical and usually with a distinct peduncle (as in Fig. 43)..............10

10. Antenna with 11 or 12 segments........11
   - Antenna with 13 segments..............14

11. Each of second to fourth flagellar segments nearly as long as wide (Fig. 48). Abdominal segment III attached to abdominal segment IV dorsally (Fig. 49).......................... *Cremautogaster*
   - Each of second to fourth flagellar segments distinctly longer than wide (as in Fig. 50). Abdominal segment III attached to abdominal segment IV anteriorly (as in Fig. 45)............12

12. Notauli vestigial or absent on mesoscutum (as Fig. 22)........................................ *Solenopsis*
   - Notauli present on mesoscutum (as in Fig. 23)..............................................13

13. Alitrunk nearly as long as high (as in Fig. 51)........................................... *Pristomyrmyrex*
   - Alitrunk distinctly longer than high (as in Fig. 52)............. *Leptothorax* (part: *L. acervorum*)

14. Alitrunk and pronotum nearly as long as high (Fig. 51)............... *Pyramica* (part: *Kyidris*)
   - Alitrunk or pronotum or both distinctly longer than high (Fig. 52)..............................15

15. Pedicel distended and globose (Fig. 10)...........16
   - Pedicel not distended, or if distended then distinctly longer than wide (Fig. 53).............17

16. Occipital carina distinct (Fig. 54). Head with large and very convex lateral ocelli in full-face view (Fig. 10). Body color yellow to brown.............. *Pheidole*
   - Occipital carina vestigial or absent (Fig. 55). Head with relatively small lateral ocelli in full-face view (as in Fig. 46). Body color brown to black....................................... *Monomorium* (part)

17. Apical four flagellar segments forming a club (Fig. 53).......................... *Leptothorax* (part)
   - Apical four flagellar segments not forming a club (Fig. 56)...................................18

18. Mandible sickle-shaped, without distinct teeth on masticatory margin (Fig. 42). Propodeum with distinct spines.................. *Cardiocondyla* (part)
   - Mandible triangular, with distinct teeth on masticatory margin (Fig. 44). Propodeum with or
Figs. 38–42. Male ants of Formicinae (38, 39) and Myrmicinae (40–42). 38, Camponotus obscuripes; 39, Anoplolepis gracilipes; 40, Tetramorium bicarinatum; 41, Oligomyrmex sp.; 42, Cardiocondyla yamauchii. 38, head to abdomen in lateral view; 39–42, head in full-face view.
Figs. 43-48. Male ants of Myrmicinae. 43, Strumigenys stenorrhina; 44, Myrmica katokui; 45, Vollenhovia emeryi; 46, 47, Myrmecina nipponica; 48, Crematogaster teranishi. 43, 45, 47, abdominal segments II and III in lateral view; 44, 46, 48, head in full-face view.
Figs. 49–54. Male ants of Myrmicinae. 49, Crematogaster sp.; 50, Stenamma nipponense; 51, Pyramica ['Kydris'] mutica; 52, Monomorium intrudens; 53, Leptothorax spinosior; 54, Pheidole sp. 49, abdomen in lateral view; 50, 53, head in full-face view; 51, alitrunk in lateral view; 52, head to abdomen in lateral view; 54, head in oblique posterodorsal view.
Figs. 55–60. Male ants of Myrmicinae. 55, Monomorium intrudens; 56, 57, Myrmica kotokui; 58, 60, Messor aciculatus; 59, Aphaenogaster japonica. 55, head in oblique posterodorsal view; 56, head to abdomen in lateral view; 57, 58, hind tibia and tibial spur; 59, 60, propodeum in dorsal view.
without spines or carinae...........................................19
19. Hind tibial spur distinctly pectinated (Fig. 57). Scapae usually long, exceeding posterior margin of head (Fig. 44) (except *M. luteola*)......................................*Myrmica*
   - Hind tibial spur not pectinated (Fig. 58). Scapae short, not reaching posterior border of head (Fig. 50)..................................................20
20. Most part of dorsal surface of propodeum smooth, not covered with rugulae or punctures (Fig. 59)............................................................21
   - Dorsal surface of propodeum covered with rugulae or punctures (Fig. 60).................................................................22
21. Occipital carina distinct (Fig. 61). Propodeum always extended posteriorly and often with projections (spines, carinae, or appendages). Head in lateral view small and thin (Fig. 62).................................*Aphaenogaster*
   - Occipital carina vestigial or absent (Fig. 55). Propodeum not extended posteriorly and without projections. Head in lateral view large and thick (Fig. 52)..........................................................*Monomorium* (part)
22. Notauli vestigial or absent on mesoscutum (as in Fig. 22).................................................................*Messor*
   - Notauli present on mesoscutum (as in Fig. 23).................................................................*Stenamma*
23. Propodeum with spines or carinae (Fig. 63).........................................................................................*Manica*
   - Propodeum without spines or carinae (as in Fig. 52).................................................................*Pyramica* (part: ‘*Pentastroma’*)
24. Abdominal sternite III with distinct process ventrally; abdominal segment III distinctly thicker than abdominal segment II in lateral view (Fig. 64)..............................................................*Pyramica* (part: ‘*Pentastroma’*)
   - Abdominal sternite III without process or with vague process ventrally; abdominal segment III nearly as thick as abdominal segment II in lateral view (Fig. 65).........................................................25
25. Vertex with only several erect hairs (Fig. 66)..................................................................................*Strumigenys*
   - Vertex with numerous decumbent hairs (Fig. 67). ..............................................................................*Pyramica* (part: ‘*Epipristus’* and ‘*Smithistruma’*), 26
26. Mesopleuron wholly covered with punctures.....................................................................................‘*Epipristus’*
   - Mesopleuron partly covered with punctures, the rest smooth or costate..................................‘*Smithistruma’

Subfamily Ponerinae

1. Wingless (apterous)..............................................................................................................*Hypoponera* (part)
   - Winged....................................................................................2
2. Notauli present on mesoscutum (Fig. 23)........................................................................3
   - Notauli vestigial or absent on mesoscutum (as in Fig. 22).................................................................5
3. Abdominal segment II broadly attached to the dorsal half of abdominal segment III in lateral view (Fig. 14).................................................................*Amblyopone*
   - Abdominal segment II narrowly attached to the ventral half of abdominal segment III in lateral view (Fig. 13).................................................................4
4. Propodeum in lateral view long and gently curved (Fig. 68). Abdominal segment II in lateral view subtriangular (Fig. 68).................................................................*Leptogenys*
   - Propodeum in lateral view short and strongly curved (Fig. 13). Abdominal segment II in lateral view scale-like or node-like (Fig. 13).................................*Pachycondyla*
5. Abdominal tergite IV strongly arched dorsally; abdominal apex directed ventrally (Fig. 69)......6
   - Abdominal tergite IV not strongly arched; abdominal apex directed posteriorly (Fig. 70)......7
6. Frontal carinae not meeting (Fig. 11)............................................................................................*Proceratium*
   - Frontal carinae meeting each other and forming a single longitudinal carina on the midline of head in full face view (Fig. 12).............................................*Discothyrea*
7. Subpetiolar process in lateral view with a small fenestra (Fig. 71)...................................................*Ponera*
   - Subpetiolar process in lateral view without a fenestra (as in Fig. 14)...........................................8
8. Antennal socket in lateral view protruding anteriorly (Fig. 17)......................................................*Probolomyrmex*
   - Antennal socket in lateral view not protruding anteriorly (Fig. 16).............................................9
9. Abdominal tergite VIII with a distinct spine-like projection (Fig. 72)..........................................10
   - Abdominal tergite VIII without a spine-like projection..............................................................11
10. Abdominal sternite II with two projections ventrally (Fig. 73)....................................................*Diacamma*
   - Abdominal sternite II with a single projection ventrally (Fig. 74)...........................................*Odontomachus*
11. Hind tibia with a single pectinated spur (Fig. 75). ......................................................................*Hypoponera* (part)
   - Hind tibia with two spurs, one is simple and the other is pectinated (Fig. 76)..................*Cryptopone*

Subfamily Pseudomyrmecinae

A single genus is represented in Japan, answering the characters given in the key to the subfamilies....

.................................................................*Tetraponera*

Remarks and Discussion

This study includes the keys to 46 genera belonging
Figs. 66–71. Male ants of Myrmicinae (66, 67) and Ponerinae (68–71). 66, Strumigenys stenorrhina; 67, Pyramica ['Smithistroma'] japonica; 68, Leptogenys conficii; 69, Proceratium itoi; 70, Cryptocone saui; 71, Ponera scabra. 66, 67, vertex in oblique dorsolateral view; 68, propodeum and abdominal segment II in lateral view; 69, 70, head to abdomen in lateral view; 71, abdominal segment II in lateral view.
Figs. 72–76. Male ants of Ponerinae. 72, 73, *Diacamma* sp.; 74, *Odontomachus* sp.; 75, *Hypoponera sauteri*; 76, *Cryptopone sauteri*. 72, abdomen in dorsal view; 73, 74, abdominal segment II in lateral view; 75, 76, hind tibia and tibial spurs.
to seven subfamilies. The keys can be applied to the species occurring in Japan. Although several genera were excluded from the keys in this study, it is not likely to compromise the usability of these keys because all of the species belonging to these genera are very rare and few records of males have been reported in Japan. Usefulness of morphological characters used in previous studies and male characters of dacetine ants are discussed below. The characters of wings were not used in this study mainly because of specimen's condition, however, it does not negate the possibility of using these characters to separate among genera or species.

The subfamilies

At present, a total of seven subfamilies have been recorded from Japan and our key includes all subfamilies.

Specimens belonging to the Leptanillinae were not available in this study, but they were also included in this key on the basis of the references (Petersen, 1968; Baroni Urbani, 1977; Bolton, 1990; Ogata et al., 1995). Some characters from these references, such as the location of the antennal insertion, the morphologies of the clypeus and the frontal carinae have been adopted.

As in Brown (1975), both conditions, abdominal segment III reduced and not reduced, are confirmed also in Japanese Cerapachyinae. This subfamily therefore could not be clearly separated if the abdominal segment III is reduced and divided from abdominal segment IV such as in the key to subfamilies by Smith (1943). In Smith (1943) and Wheeler & Wheeler (1986), the Cerapachyinae was separated by a character of subgenital plate that is two-forked at the posterior margin. Brown (1975), on the other hand, showed on figures that several Cerapachys species have the subgenital plates not two-forked on posterior margin. In addition, although all Japanese Cerapachys have a two-forked subgenital plate, the projections on the posterior margin of subgenital plate of C. humicina may be too weak to judge the character state without dissection (Ogata, 1983, fig. 13). Therefore we separate this subfamily by the character of the frontal carinae converging posteriorly.

The Ponerinae was separated from other subfamilies by the constriction between the abdominal segments III and IV by Collingwood (1979) and Wheeler & Wheeler (1986), but this constriction is too weak to recognize in several ponerine genera in Japan. Examples are the genus Cryptopone and two species of Pachycondyla, P. chinensis and P. luteipes (these two species were formerly in 'Brachyponera'). Therefore we adopt the combination of the following two characters to separate the Ponerinae from other subfamilies: 1) presclerites of abdominal segment IV are not concealed by abdominal segment III; 2) scuto-scutellar suture is sculptured longitudinally. In Japanese species it was observed that when one character is unclear the other character is clear.

The Formicinae and Dolichoderinae have been hitherto separated by the number of visible segments of posterior to abdominal III. According to Collingwood (1979), in dorsal view, five segments are visible behind the abdominal segment II in the Dolichoderinae while six segments are visible in the Formicinae. However, only five segments are visible in the formicine genus Polyrachis in Japan.

Baroni Urbani et al. (1992: 311), on their character 47 "the antennal sockets are situated at the anterior margin of head vs. at some distance behind the anterior margin of head", provided as polymorphic in the Ponerinae (e.g. Probolomyrmex) and tribe Leptanillini of Leptanillinae. However, it is possible for males of Japanese species to distinguish Leptanillinae (Leptanilla only) from other subfamilies by the location of antennal sockets as follows: 1) the antennal sockets of Probolomyrmex in lateral view are situated distant from the mandibles as shown in Fig. 17, 2) the antennal sockets of Leptanilla in lateral view are situated close to the mandibles.

The genera of Dolichoderinae

At present, five dolichoderine genera have been reported from Japan. We key four genera; not included is the recently reported Lineipithema Mayr, 1866 (Sugiyama, 2000). Distinguishable characters of Lineipithema humile Mayr, 1868 from the other Japanese subfamilies and genera provided by Shattuck (1992) could not be applied to Japan. Wheeler (1922) used the relative scape length to separate several dolichoderine genera. This character is useful also among males of Japanese species to distinguish between Taphonomia and Technomyrmex.

The genera of Formicinae

We have distinguished seven formicine genera out of ten in Japan. Acropyga and Plagiolepis could not be separated by males, and Prenolepis Mayr, 1861 was excluded due to the shortage of morphological information.

From previous studies, we could adopt the following male characters to separate among formicine genera: 1) the antennal sockets situating distant from the posterior margin of clypeus in Camponotus (Colling-
wood, 1979); 2) the orifices of metapleural gland absent in Camponotus (Collingwood, 1979; Holldobler & Engel-Siegel, 1984), and we have also confirmed this character in the males of the Japanese species of Camponotus, Polyrhachis, and subgenus Dendrolasius of genus Lasius; 3) propodeal spiracles of Formica are elliptical in shape (Collingwood, 1979). Baroni Urbani et al. (1992: 312) has presented evidence that the propodeal spiracles in Formicinae are “round to elliptical”. However, we confirmed that males of Japanese species of Formica, Polyrhachis, and three subgenera of Camponotus (Camponotus, Paramyrmelobus, Tanaeomyrmex) have slit-shaped to elliptical propodeal spiracles.

Collingwood (1979) used eye location to separate Paraatrechina from Polyrugus, Formica and Lasius. However, this character is often unclear because the male’s eyes are always larger than the worker’s. Instead, we have observed that the presence (as in Fig. 30) or absence (as in Fig. 29) of imbricate rugulae on the mesopleuron is useful for the separation of Paraatrechina from the other three genera.

Bolton (1994) reported that workers of Camponotus and Polyrhachis were separated from each other by the relative length of abdominal tergite III. But this character was often unclear in the males of Camponotus and Polyrhachis mainly due to the condition of specimens, their status is possibly difficult to determine when drying up. We distinguished these genera by the presence or absence of setae on the dorsal surface of abdominal segment III.

The genera of Myrmicinae

From Japan, 23 myrmicine genera have been reported. We have keyed 21 genera. Pheidolegeton Mayr, 1862 and Rhopalomastix Forel, 1900 are excluded due to insufficient morphological information.

Based on references, we have examined and used the following male characters to separate among the genera: 1) antennae consist of 10 segments with an elongate first flagellar segment in Tetramorium and Strongylognathus; Tetramorium has subtriangular mandibles, while Strongylognathus has sickle-shaped mandibles (Kutter, 1977; Collingwood, 1979); 2) the mandibles are extremely reduced and the abdominal segment II is quadrangular without peduncle in lateral view in Myrmecina (Collingwood, 1979); 3) the pedicel is short and bulbous in Pheidole (Collingwood, 1979); 4) the hind tibiae have distinct pectinate spurs in Myrmica (Collingwood, 1979).

Presence or absence of notauli on the mesoscutum is also useful to separate among several genera in Japan, as observed by Smith (1943) in the United States. This character may be applicable in other regions.

Kutter (1977) and Collingwood (1979) separated Crematogaster by abdominal segment III dorsally attached to abdominal segment IV. Since this is often unclear in the males of Japanese species, we add the character of wide and short flagellar segments.

Ogata (1991) examined the presence of occipital carina in the genera of Japanese Myrmicinae, and its absence is useful to distinguish Monomormium from the other genera.

In the Dacetini revision, Bolton (1999) synonymized the genera Epitritus, Kyridis, Pentastruma, Smithistroma, and Trichoscon with Pyramica, and Quadristroma with Strumigenys. As we have shown in couplet 25, only several erect hairs are present on the vertex in Strumigenys vs. numerous decumbent hairs are present on the vertex in ‘Epitritus’ and ‘Smithistroma’. Further, we observed ‘Kyridis’ and ‘Pentastruma’ also have numerous decumbent hairs on the vertex. Although we could not examine males of the species in ‘Trichoscapa’ and ‘Quadristroma’, the hair condition on the vertex may be useful to distinguish between Pyramica and Strumigenys. We can separate among the four genera synonymized with Pyramica by male characters for Japanese species (couplets 14 and 24 to 26), but it is not enough to discuss here their taxonomic status.

The genera of Ponerinae

In Japan, 12 ponerine genera are represented. We have keyed 11 genera. Although genus Anochetus was excluded due to the shortage of information, the species belonging to this genus may be keyed to couplet 9, Diacamma and Odontomachus group. Taylor (1967) referred to ergatoid males in Hypoponera, and ergatoid males have been also found in Japanese species (Yamauchi et al., 1996). In most cases, morphological characters of wingless males are similar to those of workers, excluding their genitalia, and keys for workers may be usable to identify such wingless males.

Based on literature, we have used the following male characters for the generic key: 1) presence or absence of notauli (Mayrian furrows) was used in the key to myrmicine genera (Smith, 1943), we confirmed that the character is also useful to separate several ponerine genera in Japan; 2) posterior margin of pygidium with a spine in Odontomachus (Wheeler, 1922), this character was also observed in Diacamma; 3) the middle and hind tibiae each with two spurs in Cryptopone (Kutter, 1977), this was also observed in the species belonging to Japanese species of Crypto-
pone.

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