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THE MALES OF *CARDIOCONDYLA* EMERY (HYMENOPTERA: FORMICIDAE) WITH THE DESCRIPTION OF THE WINGED MALE OF *CARDIOCONDYLA WROUGHTONI* (FOREL)*

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ABSTRACT

A review of the males of *Cardiocondyla* Emery is given. The winged male of *C. wroughtoni* (Forel) is described. Short redescriptions are given for the winged and wingless males of *C. emeryi* Forel, *C. batesi* var. *nigra* Forel, and for the wingless males of *C. wroughtoni*, *C. stambuloffi* Forel, *C. nuda* Mayr var. *mauritanica* Forel, *C. elegans* Emery and *C. papuana* (Reiskind). *C. bicolor* Donisthorpe is synonymized with *C. wroughtoni*. It is shown that the wingless male described by Borgmeier as *C. emeryi* is the male of *C. wroughtoni*. A key for the males of *Cardiocondyla* is given.
KEY WORDS: Formicidae, *Cardiocondyla*, winged and wingless male, revision.

INTRODUCTION

The genus *Cardiocondyla* was erected in 1869 by Emery, who described the worker and the female of the type species, *C. elegans*, found in Italy. According to Bolton (1982), about 40 species of the genus are known, mostly from the warmer parts of the Old World. The species occurring in the New World have probably been introduced from the Old World (Creighton, 1950; Bolton, 1982). The workers and females of the genus are easily recognized. The workers (Fig. 1) are small (1.6–2.5 mm long), monomorphic; the eyes are well developed, the ocelli are absent; the usually 12 segmented antennae have a 3 segmented club; the clypeus is projecting; the mandibles are short, wide, with 5 teeth; the alitrunk is without dorsal sutures, the postpetiole is much wider than the petiole; the first gastral segment is very large; the sting is well developed. The wide postpetiole is the most conspicuous character. The females (Fig. 2) are similar to the workers, but usually slightly larger, being 2.25–3 mm long; they have ocelli in addition to the eyes. Their alitrunk has well differentiated dorsal sclerites as typical for winged ants. The venation of the wings is very reduced, having a single small cubital cell and lacking radial and discoidal cells.

Contrary to the uniformity of workers and females, the males of *Cardiocondyla* are diversified (Forel, 1892a, b; Santschi, 1907; Emery, 1909; Smith, 1944; Bernard, 1956; Bolton, 1982). Winged and wingless males are known and the form of mandibles may differ considerably between different species.

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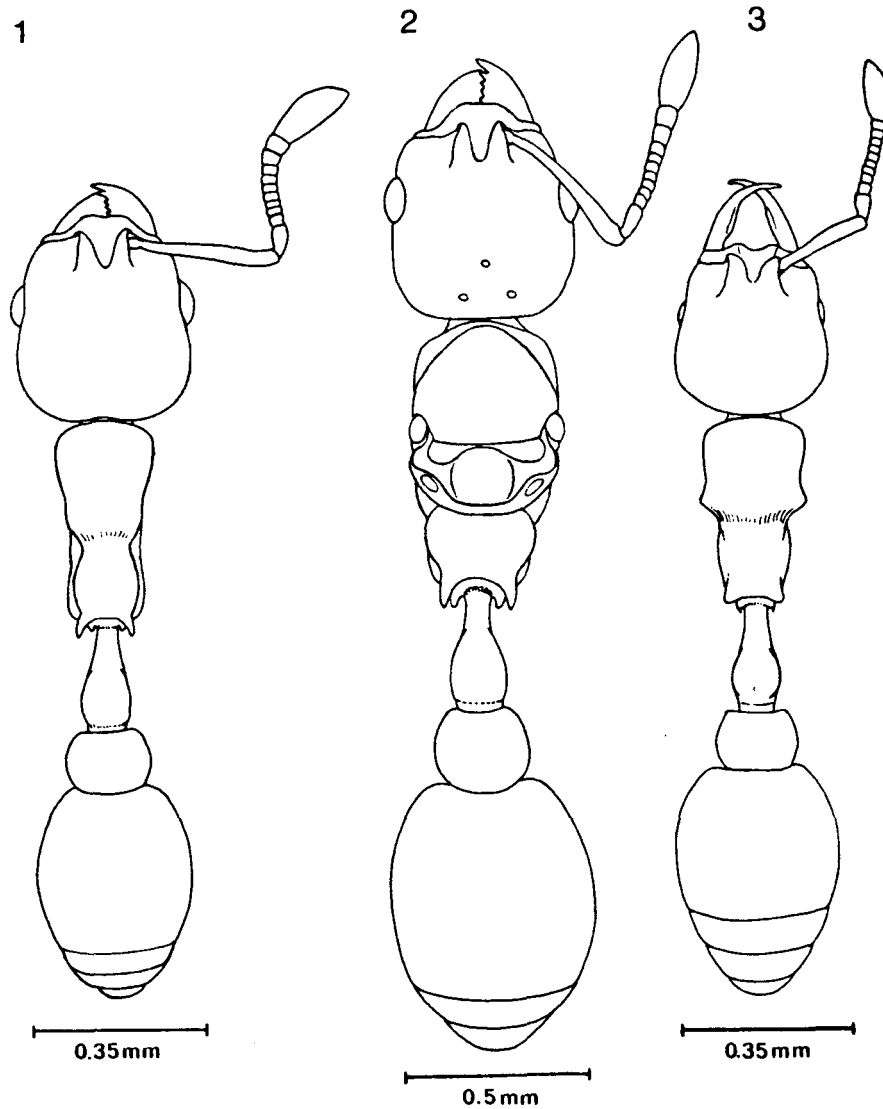


Figs. 1-3. *Cardiocondyla wroughtoni* (Forel). 1. ☿, 2. ♀, 3. Wingless ♂.

A winged male of *Cardiocondyla* was first mentioned by Emery (1869). In a footnote to the description of the worker of *C. elegans* he described a male which he thought might belong to the same species. André (1882) examined the same male and came to the conclusion that it was not a *Cardiocondyla*. The first description of a male of *Cardiocondyla* was the winged male of *C. emeryi* Forel, described by André (1881).

The wingless males are so peculiar (Fig. 3), that they were described twice as different genera, living as social parasites in the nests of *Cardiocondyla*. The first description of a wingless male was that of *C. wroughtoni* (Forel) (1890a), described as a worker of a new genus, *Emeryia*. Two years later (1892a, b) Forel corrected his mistake. Emery (1917) erected the genus *Xenometra* for a specimen of a wingless male of *Cardiocondyla emeryi* Forel, considering it a female. The synonymy of *Xenometra* and *Cardiocondyla* was clarified by Baroni-Urbani only in 1973.

In most *Cardiocondyla* species only workers and females are described. Winged males were described only for *C. emeryi* Forel (1881) and *C. batesi* var. *nigra* Forel (Santschi, 1907). Wingless males were described for *C. wroughtoni* (Forel, 1890a), *C. stambuloffi* (Forel, 1882), *C. nuda* Mayr (Emery, 1897), *C. nuda* var. *mauritanica* Forel (1904); *C. batesi* var. *nigra* Forel (Santschi, 1907), *C. emeryi* Forel (Emery, 1909), *C. elegans* Emery (Menozzi, 1918), *C. (Prosopidris) papuana* Reiskind (1965) and *C. ectopia* Snelling (1974).

In the present paper a review and a key for the males of *Cardiocondyla* are given and the winged male of *C. wroughtoni* is described for the first time. In addition *Cardiocondyla bicolor* Donisthorpe, 1930, described from Israel, is synonymized with *C. wroughtoni*. References to original descriptions of the species, as well as to first descriptions, redescriptions and synonymy of the males are also given. The following abbreviations are used: HL = Head length excluding mandibles. HW = Maximum head width. SL = Scapus length.

The review is based on the material examined in the following institutions:

BMNH British Museum (Natural History), London, U.K.

LACM Natural History Museum of Los Angeles County, Los Angeles, California, U.S.A.

MCZ Museum of Comparative Zoology, Harvard University, Cambridge, Massachusetts, U.S.A.

MHNG Museum d'Histoire Naturelle, Geneva, Switzerland.

MNHP Museum National d'Histoire Naturelle, Paris, France.

MSNG Museo Civico di Storia Naturale "Giacomo Doria", Genoa, Italy.

NHMB Naturhistorisches Museum, Basle, Switzerland.

TAU Department of Zoology, Tel Aviv University, Tel Aviv, Israel.

REVIEW OF THE MALES OF CARDIOCONDYLA
(Figs. 3-22)

Cardiocondyla emeryi Forel, 1881
(Fig. 4-7)

Cardiocondyla emeryi Forel, 1881: 5 (☿); André, 1881: 69 (winged ♂); Emery, 1909: 26 Figs. 7 c, d (winged ♂, wingless ♂ described as ♀); Arnold, 1916:200 (winged ♂); Borgmeier, 1937: 129, Figs. 1-5 (misidentified wingless ♂ of *C. wroughtoni*); Smith, 1944: 34 (wingless ♂ sensu Borgmeier, winged ♂); Creighton, 1950: 198 (wingless ♂ sensu Borgmeier, winged ♂); Baroni-Urbani, 1973: 200 (synonymy, wingless ♂); Snelling, 1974: 81 (wingless ♂ sensu Borgmeier); Smith, 1979: 1375 (Catalog, wingless ♂ sensu Borgmeier); Bolton, 1982: 313 (synonymy).

C. emeryi mahdii Karawaiew. Finzi, 1936: 169 Fig. 4b (winged ♂).

Xenometra monilicornis Emery, 1917: 201 (wingless ♂ and ♀); 1922: 126 (Catalog, wingless ♂ as ♀); Bernard, 1957: 100 (wingless ♂ as ♀).

A species with wide distribution in the Old and New World. Described from workers collected at St. Thomas (Virgin Islands). The winged male was described (in French) by André (1881) based on a single male collected in Jaffa (Israel). The same description was given in English by Arnold (1916). Smith (1944) redescribed the male based on a specimen from Havana (Cuba). The winged male of *C. emeryi* subsp. *mahdii* Karawaiew was described and figured by Finzi (1936), based on specimens collected at Meadi and Atar el Naby (Egypt). Bolton (1982) synonymized the subspecies with the typical form. The wingless male was described as female from one specimen found with workers in St. Thomas, Virgin Islands (Emery, 1909). After Arnold (1916) described a normal winged female of *C. emeryi*, Emery (1917) erected the genus *Xenometra* for this specimen, calling it *Xenometra monilicornis*, supposing that it was a female and a parasite of *C. emeryi*. This specimen continued to be listed as *Xenometra monilicornis* (Emery, 1922; Bernard, 1957). Only Baroni-Urbani (1973) synonymized *Xenometra* with *Cardiocondyla* and established that *X. monilicornis* is the male of *C. emeryi*.

A different wingless male from Rio de Janeiro found together with workers in a gall of *Acacia*, was described by Borgmeier (1937) as a male of *C. emeryi*. This is undoubtedly a misidentification, as it has very long, pointed toothless mandibles. Borgmeier's description fits the male of *C. wroughtoni* (Forel), a species which nests in plant galls or in other plant parts, while *C. emeryi* nests in the soil (Arnold, 1916; Creighton and Snelling, 1974). Borgmeier's concept of the wingless male of *C. emeryi* was accepted by Smith (1944); Creighton (1950); Snelling (1974) and Smith (1979).

WINGED MALE

Length. 1.8 – 2 mm.

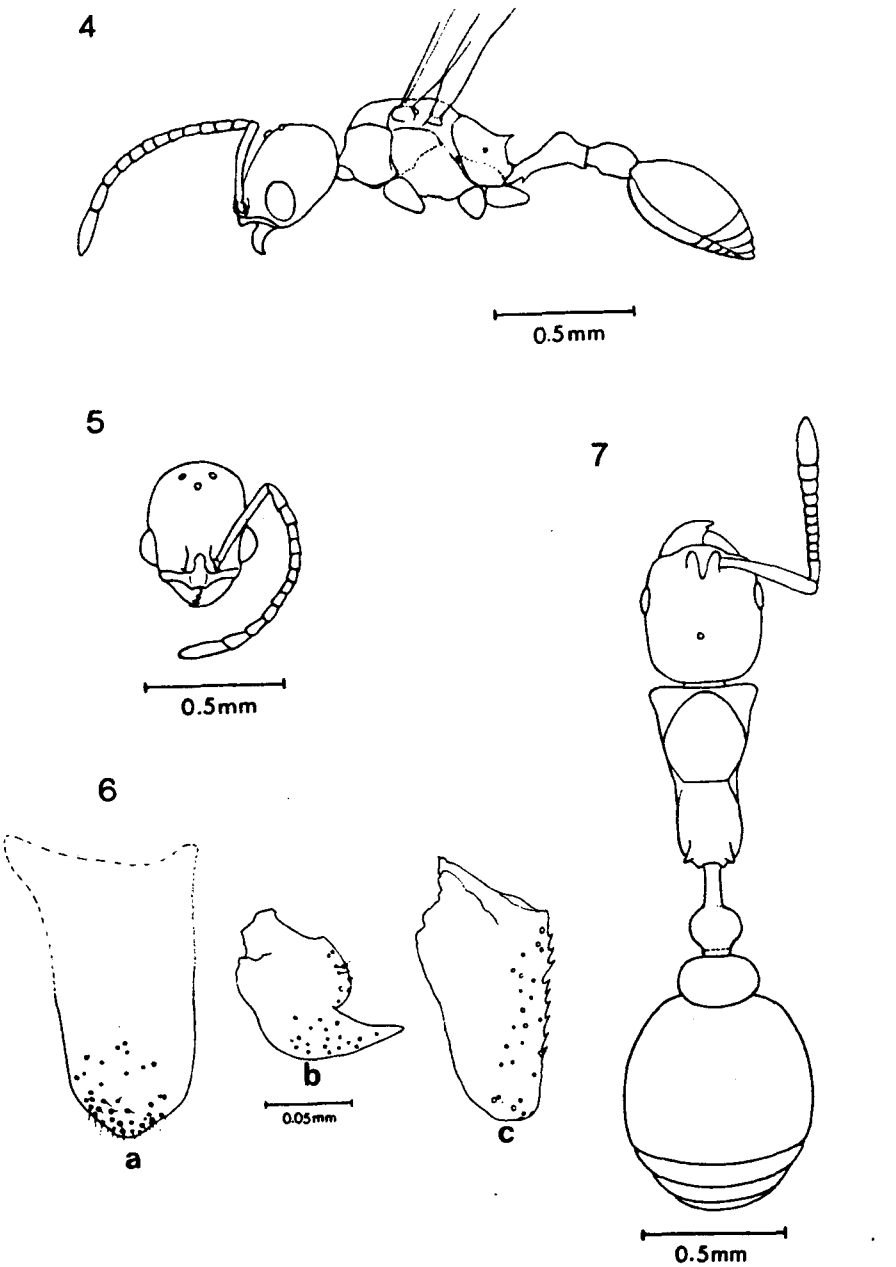
Color. Yellow; head, distal part of antenna, parts of alitrunk, more or less infuscated; gaster dark brown – black, shining.

Head. (Figs. 4, 5) 1/5 longer than wide (HL 0.4 – 0.43 mm., HW 0.34 – 0.36 mm) granulose; posterior margin convex. Eyes oval, large (large diameter 1/3 of head length); ocelli present. Antennae long with 13 segments, all segments longer than wide; scapus as long as the combined 5-7 basal funicular segments; clypeus slightly excavated in the middle with two weak longitudinal carinae; mandibles widening distally with 4 teeth, the apical tooth much larger than the others.

Alitrunk with well differentiated sclerites; pronotum seen from above narrower than mesonotum; mesonotum convex; propodeum with 2 spines; wing venation very reduced, radial and discoidal cells absent, stigma present, posterior margin of the single cubital cell present or more or less reduced.

Pedicel. Postpetiole 1/3 wider than long; petiolar node 1/2 as wide as postpetiole, in profile with a strongly convex dorsal margin (Fig. 4).

Genitalia (Fig. 6). Small, concealed; gonostylus flat with rounded distal margin; volsellar digitus hooklike; gonapophyse blade-like ventrally with a row of fine teeth.



Figs. 4-7 *Cardiocondyla emeryi* Forel. Winged ♂. 4. Lateral view, 5. Head, 6. Genitalia: a – gonostylus, b – volsella, c – gonapophyse, 7. Wingless ♂.

WINGLESS MALE (Fig. 7)

Length. 2.6 mm
Color. Yellow-orange, gaster brown.
Head. Shining and less sculptured than in worker and winged male, larger than in winged male (HL 0.52 mm., HW 0.44 mm.); posterior margin less convex; eyes smaller (large diameter 1/5 of head length) and flat; only the anterior ocellus well developed; antenna 12 segmented, without a well developed club; funicular segments except 1st and last, larger than long; mandibles widening distally with 4-5 teeth.
Alitrunk. Widest at shoulder level, with large angular shoulders. Scutellum not differentiated. Propodeum with a pair of short spines.
Pedicel. Petiolar node robust, 1/4 wider than long; postpetiole 1 1/2 as wide as long.
Genitalia. Concealed.

MATERIAL EXAMINED. Winged ♂: Israel, Jaffa (1, MNHP): Michmoret; 11.VII.1980 (1, TAU), 20.XII.1980 (1, TAU), 6.XI.1980, (1, TAU); Yavne IX.1982, (1, TAU); all by Q. Argaman; Madeira (1, MHNG); Egypt, Ghizeh XII.1901, P. Morey (1, BMNH); Siva 30.VI.1935, J. Omer-Cooper (1, BMNH); Nigeria, Gambari 10.VI. 1969, (1, BMNH); Jamaica, Lignenea Plains, L.T. Brues (1, MCZ) Barbados, Weber (1, MCZ). Wingless ♂: Virgin Islands, St. Thomas, (1, MSNG).

Cardiocondyla wroughtoni (Forel, 1890)
(Figs. 1, 2, 3, 8, 9, 10, 11)

Emeryia wroughtoni Forel, 1890a: 10 (wingless ♂ as ♀);

Cardiocondyla wroughtoni. Forel, 1892a: 161 (wingless ♂); Forel, 1892b: 313 (wingless ♂); Forel, 1902: 689 (☿, ♀, wingless ♂); Emery, 1922: 126 (catalog, wingless ♂); Smith, 1979: 1376 (catalog, wingless ♂); Bolton, 1982: 317 (synonymy).

Cardiocondyla wroughtoni var. *hawaiiensis* Forel. Smith, 1944: 30 (wingless ♂)

Cardiocondyla bicolor Donisthorpe, 1930: 366 (♀). **n. syn.**

Cardiocondyla emeryi. Borgmeier, 1937: 129, Figs. 1-5 (wingless ♂ misidentification).

A species with wide distribution in the Old and New World. The wingless male was described by Forel (1890) as a new genus and species, *Emeryia wroughtoni*. According to Forel one specimen was found in Poona (India) together with workers and females of a new *Cardiocondyla* species, nesting in the space between the two layers of the leaves of *Eugenia jambolana*, probably bored by a caterpillar. Forel erroneously identified it as a worker and expressed the opinion that *Emeryia wroughtoni* may be a symbiotic species of *Cardiocondyla*.

During a visit to Bulgaria in 1891, Forel found workers, females and wingless males of a new species, *Cardiocondyla stambuloffi*. Because of the similarities between the male of the new species and his *Emeryia*, Forel examined the genitalia of the supposed worker of *Emeryia wroughtoni* and found that it was a male. He decided correctly that it is the male of the *Cardiocondyla* from Poona (Forel, 1892a, b). A nearly identical description was given by Borgmeier (1937) for a wingless male found in Rio de Janeiro, in a gall of *Acacia*. Borgmeier erroneously identified this male as *C. emeryi*,

and the only difference from *C. wroughtoni* that he gave, was a straight instead of concave anterior border of the postpetiole. This character is variable, and as already mentioned this specimen fits *C. wroughtoni.*

Smith (1944) mentioned that he saw the same type of male among specimens of *C. wroughtoni* var. *hawaiiensis* Forel from Hawaii. Wilson and Taylor (1967) synonymized this variety with the typical form.

In 1981 Prof. J. Galil and Dr. A. Lupo from the Dept. of Botany, Tel Aviv University, submitted to the author for identification, a small, pale yellow ant with very long, toothless mandibles. It was found in a colony reared in a plaster nest in the laboratory and supposed to be of *Cardiocondyla bicolor* Donisthorpe (1930: 366, a species described from workers from Israel). The colony was taken from a nest found in an empty gall of *Amblypalpis olivierella* (Gelechiidae) on a *Tamarix* tree on the campus of the Tel Aviv University. The author found that this male fits very well with the description of the male of *C. wroughtoni*. By comparing the ants (additional males, workers and females) collected or reared by Lupo and Galil with the type series of *C. wroughtoni* (in MHNG) and *C. bicolor* (in BMNH) it was decided that they are conspecific and that *C. bicolor* Donisthorpe is a junior synonym of *C. wroughtoni* (Forel). The same opinion was expressed by Mr. B. Bolton, the curator of the ant collection in the British Museum (personal communication). Winged males were also found by Lupo and Galil in their colonies and are described below for the first time.

WINGLESS MALE (Fig. 3)

Length. 1.7 mm.
Color. Yellow, gaster light to dark brown.
Head. Smooth and shining contrary to winged male and worker. Slightly longer than wide (HL 0.35 mm., HW 0.32 mm.) narrowing anteriorly; posterior margin nearly straight with rounded corners. Eyes smaller than in worker, nearly circular, large diameter 1/7 of head length; ocelli absent. Antenna 11 segmented, funicular segment except first and last, wider than long, last segment club-like thick and long. Clypeus excavated in the middle with 2 carinae; mandibles long, distally curved, narrowing, pointed and toothless.
Alitrunk. Dorsally without clear sutures. Pronotum with developed shoulders; mesonotum with a lateral, triangular protuberance on each side; propodeum with a pair of short blunt teeth.
Pedicel. Petiolar node longer than wide; postpetiole 1 1/2 as wide as long.
Genitalia. (Fig. 11)

WINGED MALE.
(Not described before, Figs. 8, 9, 10).

Length. 1.8 – 2 mm.
Color. Yellow; head partly infuscated, opaque and granulose, gaster shining dark brown.
Head. A little longer than wide (HL 0.38 – 0.44 mm., HW 0.35 – 0.37 mm.); occiput convex, eyes in the anterior half of the head, large, convex, nearly circular, large

diameter 1/3 head length; ocelli present; antenna 13 segmented, without club, (the male from Sanchi has only 12 antennal segments); scapus (SL 0.20 – 0.23 mm.) a little shorter than the combined 4 basal segments of funiculus; all funicular segments longer than wide, last segment nearly twice as long as penultimate segment. Clypeus large, slightly compressed anteriomedially; frontal carinae short; mandibles short, narrow, tapering, pointed distally and toothless.

Alitrunk. Pronotum visible from above, with rounded, not protruding, shoulders. Alitrunk narrower at shoulders than at base of anterior wings. Mesonotum without lateral bulges. Propodeum with 2 well developed spines.

Wings. (Fig. 10). Venation very reduced, no radial cell; the single cubital cell not clearly closed posteriorly.

Pedicel. Petiole with a peduncle longer than node, width of node in dorsal view equal to its length, in profile dorsal margin of the node nearly flat.

Genitalia. Very small, almost entirely concealed. In profile only the tip of the gonostylus is seen.

MATERIAL EXAMINED. Wingless ♂: India, Poona (1, MHNG). Malaya, Alor Star V.1947, G.H. Lowe (1, BMNH). Israel, Tel Aviv, I-VII.1982 collected or reared from colonies found in empty galls on *Amblypalpis olivierella* (Gelechiidae) *Tamarix*, A. Lupo and J. Galil (15, TAU). Winged ♂: Israel, Tel Aviv, 18.VI.1982 (1, TAU); 15.VIII.1982, A. Lupo and J. Galil (1, TAU), Sanchi, Bhutan 7-11.V.1972, Nat. Hist. Mus. Basle – Bhutan Expedition (1, NHMB).

Cardiocondyla stambuloffi Forel, 1892

(Fig. 12, 13)

Cardiocondyla stambuloffi Forel, 1892b: 310, Taf. 5 Figs. 1-3 (☿, ♀, wingless ♂); Emery, 1909: 23, Fig. 5 (☿, ♀, wingless ♂); Emery, 1922: 126 (catalog, ☿, ♀, wingless ♂).

Distributed in the Balkans and the USSR (as east as Lake Aral).

Workers, females and wingless males were found by Forel in small nests in sand, (Bulgaria: Burgas, Anchialo and Sozopolis, August, 1891).

WINGLESS MALES

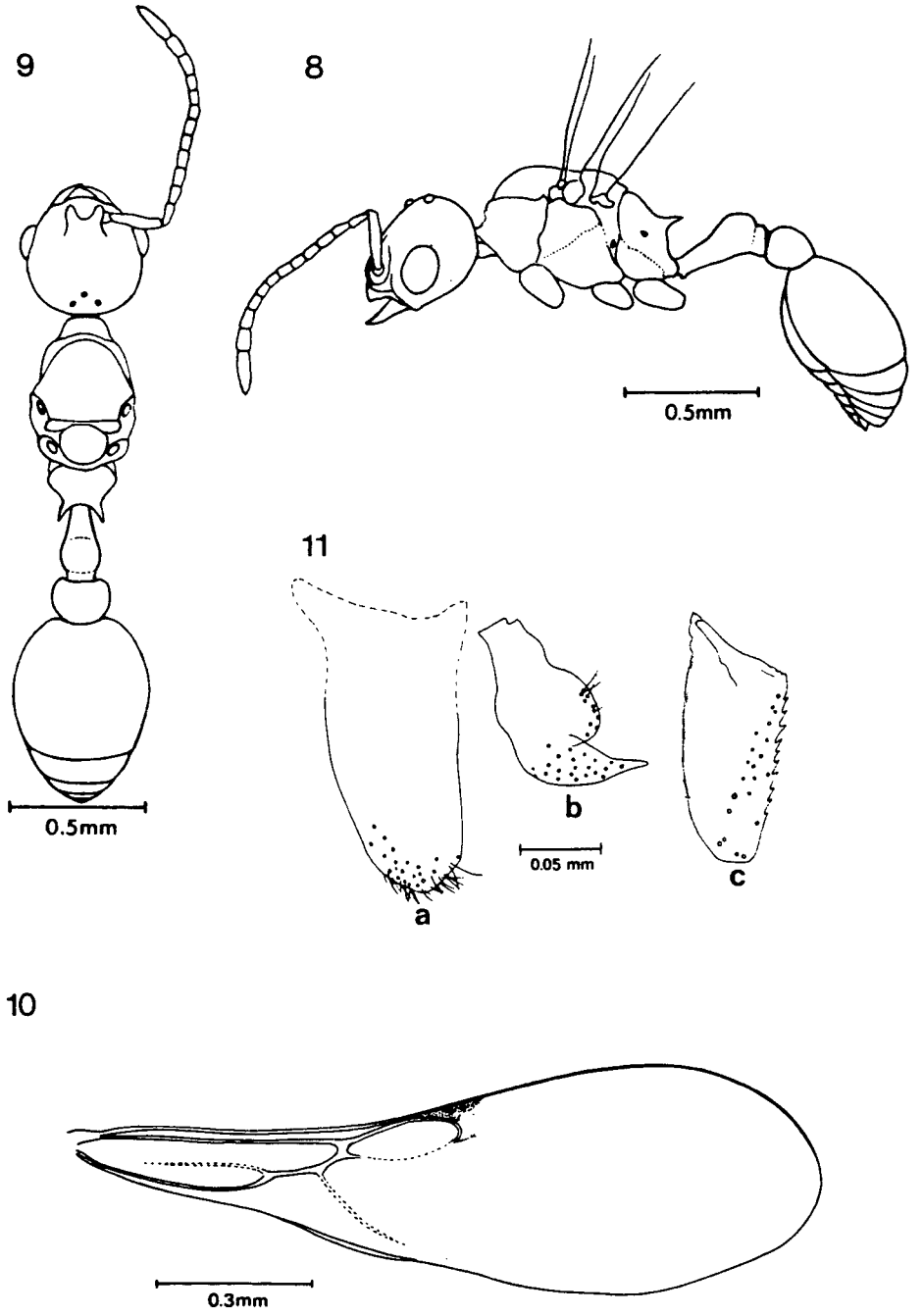
Length. 2.3 mm.

Color. Yellow, gaster light brown.

Head. Smooth and shining. Only slightly longer than wide (HL 0.5 mm., HW 0.45 mm.); eyes slightly oval, smaller than in worker, large diameter 0.08 mm. No ocelli. Mandibles short with 4 teeth. Antenna 12 segmented, segments 3-5 nearly entirely united.

Alitrunk. Widest at shoulders; anterior margin convex; dorsally only the suture between notum and propodeum developed. Propodeum with two short, blunt teeth.

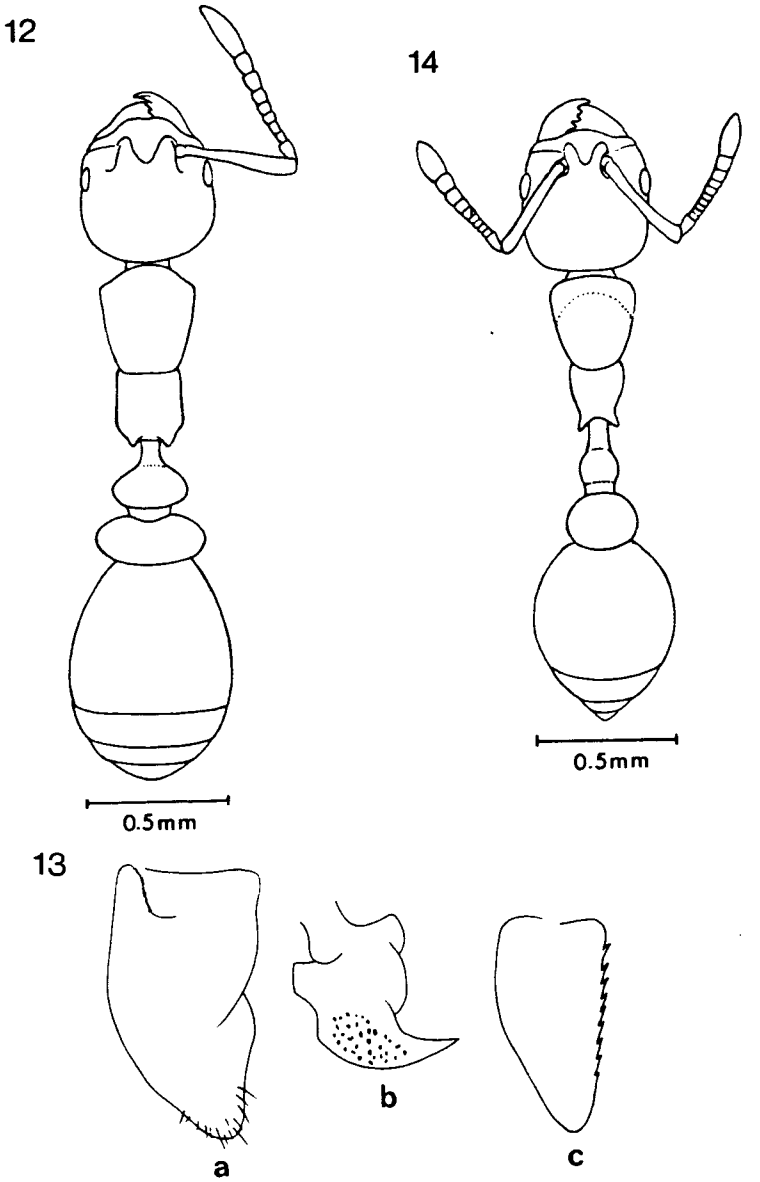
Pedicel. Petiolar node wide, 3/4 as wide as postpetiole, in profile with an oblique anterior margin; postpetiole nearly 3 times as wide as long, with concave anterior margin.



Figs. 8-11. Cardiocondyla wroughtoni (Forel). Winged ♂. 8. Lateral view, 9. Dorsal view, 10. Wing, 11. Genitalia: a – gonostylus, b – volsella, c – gonapophyse.

Genitalia. (Fig. 13). Gonostylus with nearly parallel sides, broadly rounded at the end. Volsella short, with a thick hook-formed digitus, only the base of a volsellar cuspide; gonapophyses simple, elongated, as usually with fine teeth.

MATERIAL EXAMINED. 2 ♂ from the type series, Bulgaria, Burgas (MNHG).



Figs. 12-14. Cardiocondyla spp. 12, 13. *Cardiocondyla stambuloffi* Forel. Wingless ♂. 12. Dorsal view, 13. Genitalia: a – gonostylus, b – volsella, c – gonapophyse (after Forel 1892b, Table 5, Figs. 1b-1d). 14. *Cardiocondyla nuda* (Mayr) var. *mauritanica* Forel. Wingless ♂.

Cardiocondyla nuda (Mayr, 1866)

Leptothorax nudus Mayr, 1866: 508 (☿)
Cardiocondyla nuda Emery, 1897: 588 (♀, wingless ♂); Emery, 1922: 126 (catalog, ☿, ♀, wingless ♂).

This species was described from workers as *Leptothorax nudus* from Fiji Islands. The typical form is distributed in the Pacific Islands, India, Ceylon and Thailand. It was also found in the southern United States, where it is probably introduced (Smith, 1979). Only the wingless male is known. It was described by Emery (1897) from 3 specimens collected on small islands in New Guinea. According to this very short description the male is very similar to the worker in form and sculpture, and has very small genitalia. It differs from the typical brown workers in having a yellow alitrunk. One specimen from New-Guinea (in MSNG) labelled as a male by Emery, was studied by the author and found to fit the description very well. However, since the genitalia were missing (they have been extracted), it was impossible to decide if Emery was right in labelling it as a male. If Emery was right, then the male of *C. nuda* is "ergatomorph" indeed, indistinguishable from the worker except for its genitalia.

Cardiocondyla nuda var. *mauritanica* Forel, 1890
(Fig. 14)

Cardiocondyla nuda var. *mauritanica* Forel, 1890b: 75 (☿); Forel, 1904:7 (wingless ♂, ♀); Emery, 1909: 25 (☿, ♀, wingless ♂); Emery, 1922: 126 (catalog ☿, ♀, ♂).

This form is very similar to the typical form and may even be a synonym. It was described by Forel (1890b) from workers from Tunisia and is known also from Algeria, Lybia, Egypt, Sinai, Palestine and Cyprus (Finzi, 1936). The wingless male was also described by Forel (1904).

WINGLESS MALE (Fig. 14).

Length. 1.9 mm.
Color. Yellow, gaster and last antennal segments brown, entirely smooth and shining.
Head. Slightly longer than wide (HL 0.48, HW 0.43 mm.), smooth and shining, posterior margin straight with rounded corners. Eyes smaller than in worker, large diameter 0.09 mm; ocelli absent. Antenna 12 segmented, only the 1st and last funicular segments longer than wide. Middle of clypeus convex without developed carinae; mandibles short, widening distally with 4 teeth.
Alitrunk. Widest at shoulders; anterior margin of pronotum at shoulder level not a sharp line, shoulders slightly rounded, a faint indication of a promesonotal suture; metanotum slightly depressed; propodeal spines short and blunt.
Pedicel. Petiolar node seen from above, a little wider than long, in profile with oblique anterior and posterior margins; postpetiole 1/4 wider than long.
Genitalia. Concealed.

MATERIAL EXAMINED. Tunisia, Kairouan, 18.IX.1903 Santschi (1 ♂, MHNG), Tunisia, Kairouan, 8.IX.1904 Santschi (1 ♂, MHMB); Israel, Bet Shean 3.III.1983 Argaman (1 ♂, TAU).

Cardiocondyla ectopia Snelling, 1974

Cardiocondyla ectopia Snelling, 1974: 76, Figs. 1-5 (☿, ♀, wingless ♂); Smith, 1979: 1375 (catalog, ☿, ♀, ♂).

Snelling described and figured the worker, female, and wingless male of this species from California. The worker and the female are very similar to the worker and the female of *C. nuda* var. *mauritanica* from Israel. The description of the male is also similar to the original description of the type male from North Africa. The main difference between the males is the form of the funicular antennal segments. In *C. mauritanica*, the segments, except the first and the last, are wider than long, while in *C. ectopia*, according to Snelling's figure (1974: 77, Fig. 3) all segments are slightly longer than wide. Further study is needed to establish whether *C. ectopia* is a synonym of *C. nuda* var. *mauritanica*.

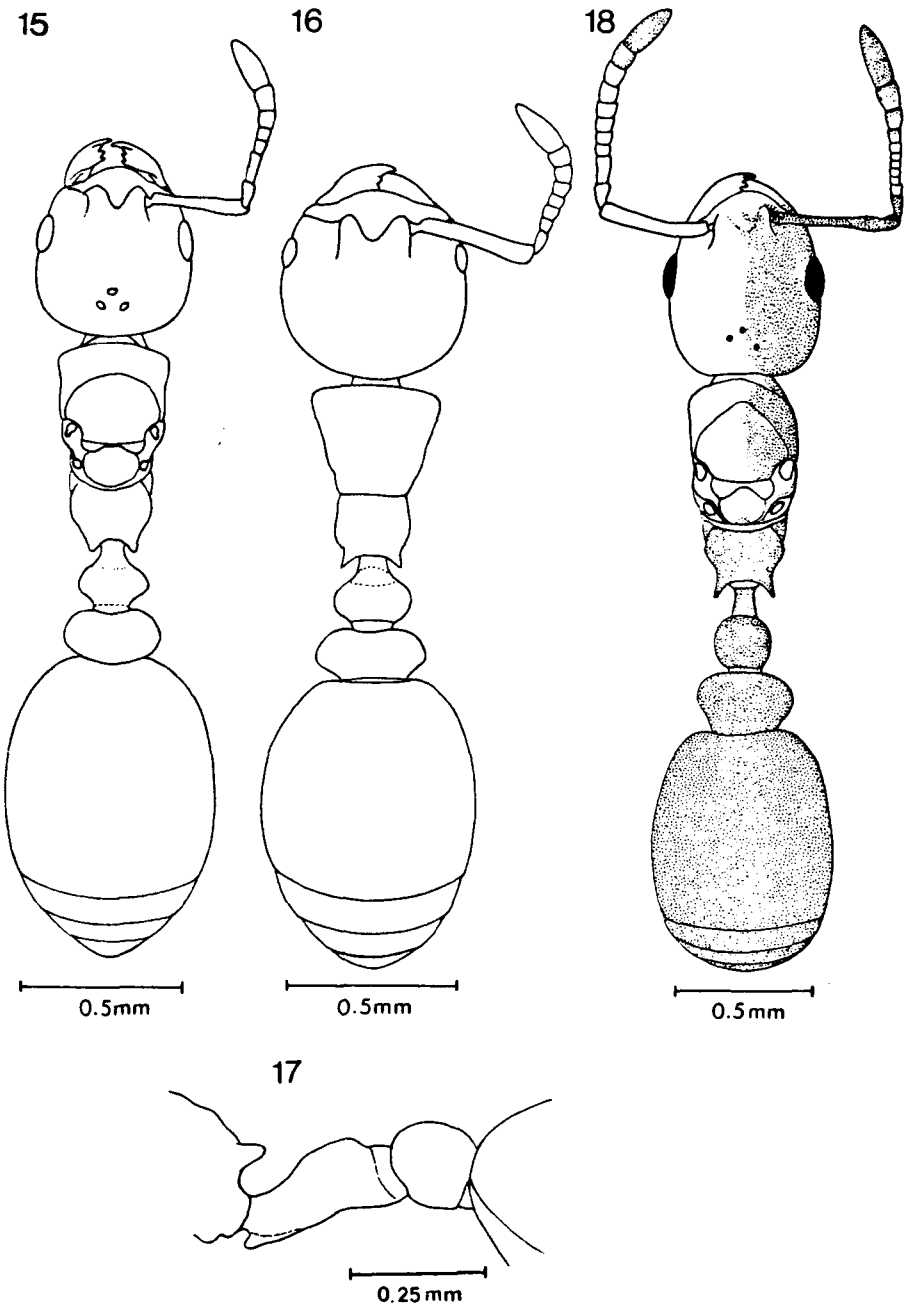
Cardiocondyla batesi Forel var. *nigra* Forel, 1905
(Figs. 15-18)

Cardiocondyla batesi Forel var. *nigra* Forel, 1905: 174 (☿, ♀); Santschi, 1907: 318 Figs. 5a-i (☿, ♀, winged ♂, wingless ♂, gynandromorph); Emery, 1909: 23 (☿, ♀, winged ♂, wingless ♂, gynandromorph); Emery, 1922: 125 (catalog, ☿, ♀, ♂).

The females and workers of the typical form of *Cardiocondyla batesi*, have a black head and gaster and a red alitrunk. No male was described from this form. It is distributed in North Africa and Spain. The workers and females of the var. *nigra* are entirely brown-black. They were described by Forel from Kairouan (Tunisia). The winged male, wingless male and a specimen with male and female characters, were described by Santschi (1907) from the same locality.

WINGED MALE (Fig. 15)

Length. 2.6 mm.
Color. Yellow, gaster brown, last antennal segment infuscated.
Head. Large, smooth and shining, a little longer than wide (HL 0.58 mm. HW 0.52 mm.) slightly narrowing anterior to eyes. Eyes slightly convex, oval, large diameter more than 1/4 of head length; ocelli present. Clypeus convex in the middle, with rounded anterior margin. Mandibles short, widening distally with 4 small teeth. Antenna short, with 8 well differentiated segments, the basal segments except the first and second are united into one long segment.
Alitrunk. Narrower than head with well differentiated sclerites; widest at shoulders,



Figs. 15-18. Cardiocondyla batesi Forel var. *nigra* Forel. 15. Winged ♂, 16. Wingless ♂, 17. Petiole and postpetiole of wingless ♂ (lateral view). 18. Gynandromorph.

1.75 as long as wide at shoulders; anterior margin slightly convex, shoulders angular. In the examined specimen only stumps of wings. Propodeum with a pair of spines.
Pedicel. Petiolar node wide, only 1/4 narrower than postpetiole, in profile with oblique anterior and posterior margin. Postpetiole more than twice as wide as long with concave anterior margin.
Genitalia. Concealed, except the exposed tips of gonostyli.

WINGLESS MALE (Fig. 16)

Length. 2.3-2.7 mm.
Color. Yellow.
Head. Large, nearly as wide as long (HL 0.53 mm., HW 0.51 mm.); ocelli absent, eyes smaller than in winged males (large diameter 0.11 mm.); antenna similar to winged male with a reduced number of well differentiated segments; clypeus and mandibles similar to winged male.
Alitrunk. Shorter than in winged male, only 1.36 longer than wide at shoulders, with very wide angular shoulders. Dorsally only the mesopropodeal suture developed. No signs of wings.
Pedicel. Petiole and postpetiole similar to winged male (Fig. 17).

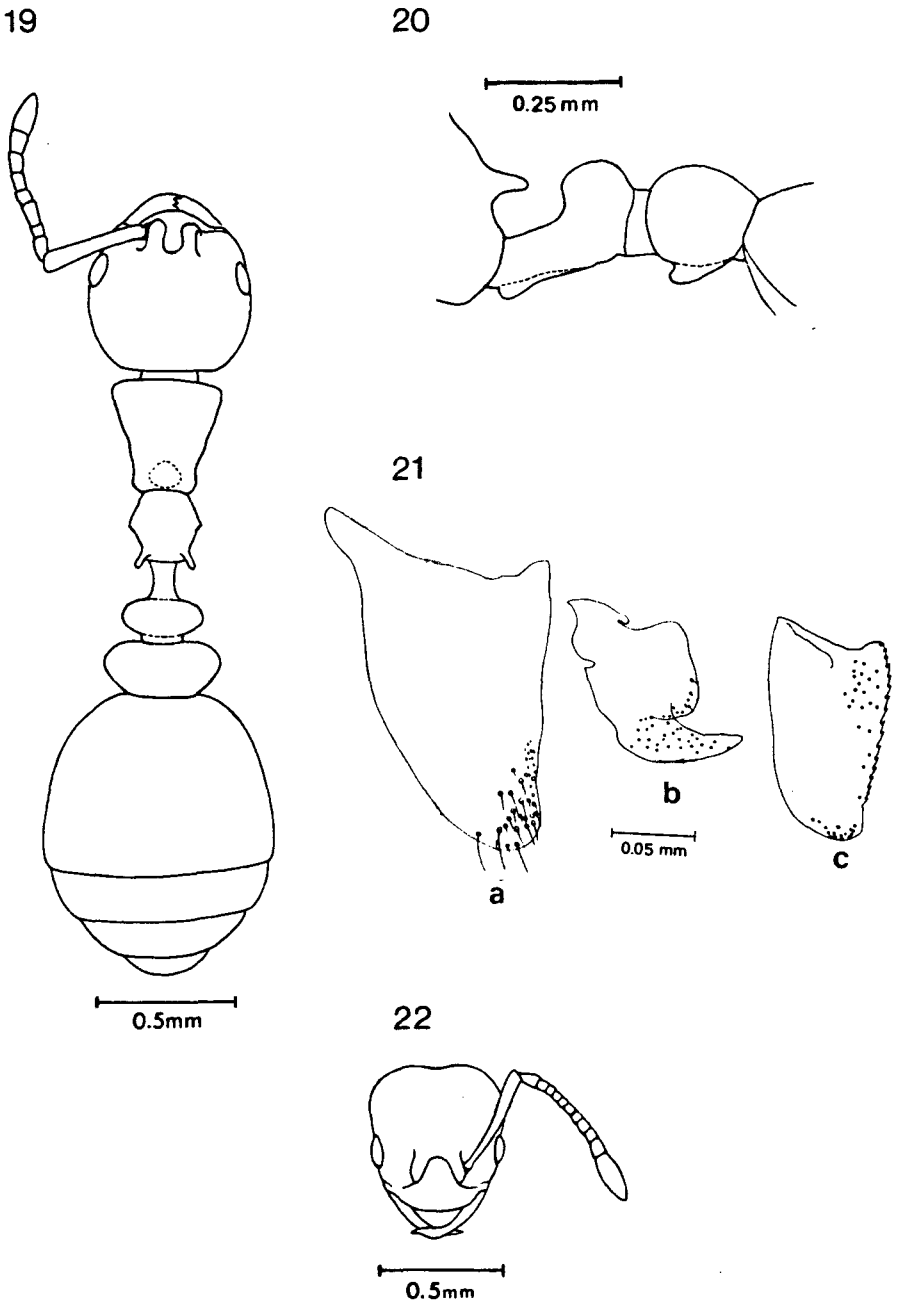
GYNANDROMORPH (Fig. 18)

Santschi found a specimen with male characters on the left side of the body, and female characters on the right side. This specimen was found in a nest with females but without males. The left 1/2 of the head, left antenna, left 1/2 of pro- and mesonotum are yellow as in the male, the rest of the body is dark brown as in the female. The left antenna is 11 segmented, but segment 2 of the funiculus is long, as a result of the fusion of segments 2 and 3. The right antenna has 12 well differentiated segments, with a well differentiated 3 segmented club. The scapus of the right antenna is longer and thinner than in the left antenna. Ocelli present.
Alitrunk. With well differentiated sclerites and wing stump on both sides. Left shoulder angular and bulging, right shoulder less bulging and more rounded.

MATERIAL EXAMINED. Tunisia, Kairouan 8.X.1906 Santschi, (1 winged ♂, 2 wingless ♂, 1 gynandromorph, NHMB); Kairouan, Santschi (1 wingless ♂, MHNG).

Cardicondyla elegans Mayr, 1869
(Figs. 19-21)

Cardiocondyla elegans Mayr, 1869: 21 (☿, ♀); Menozzi, 1918: 83 (wingless ♂); Bernard, 1968: 157 (wingless ♂); Baroni-Urbani, 1973: 200 (synonymy, wingless ♂).
Xenometra gallica Bernard, 1957: 100 (wingless ♂ described as ♀); Bernard, 1968:158 (wingless ♂ described as ♀).



Figs. 19-22. Cardiocondyla spp. 19-21. *Cardiocondyla elegans* Emery. Wingless ♂. 19. Dorsal view, 20. Petiole and postpetiole (lateral view). 21. Genitalia: a – gonostylus, b – volsella, c – gonapophyse. 22. *Cardiocondyla papuana* (Reiskind). Wingless ♂. Head.

Distributed in the countries around the Mediterranean Sea, in Southern European USSR as far east as Turkestan. The wingless male was described by Menozzi (1918) from Spilemberto (Italy).

The same form of wingless males from nests of *C. elegans* found in Pinsac, France was described and redescribed by Bernard (1957, 1968) as a new species of *Xenometra, X. gallica,* and regarded as a parasitic female of *C. elegans.* Brown (1957) and Baroni-Urbani (1971) also mentioned the wingless male of *C. elegans* as *Xenometra.* Only in 1973 Baroni-Urbani established the synonymy of *Xenometra* with *Cardiocondyla*, and that *Xenometra gallica* is the male of *C. elegans* Mayr.

WINGLESS MALE

Length. 2.7-3 mm.
Color. Yellow.
Head. Smooth and shining; as wide as long (HL and HW 0.52- 0.53 mm.); posterior margin straight with rounded corners. Eyes nearly flat oval, smaller than eyes of worker and female; large diameter 1/5 of head length. Ocelli usually absent according to Bernard (1957, 1968), in the specimens from Pinsac the anterior ocellus present. Antenna with a reduced number of well differentiated segments (6-9); part of the basal segments fused into one large segment. Middle of clypeus convex with rounded anterior margin. Mandibles small with 4 teeth.
Alitrunk. Widest at shoulders, anterior margin nearly straight, shoulders angular; dorsally only the mesopropodeal suture well developed, in some specimens, remnants of promesonotal suture and scutellum present; propodeum with two long spines with blunt tips.
Pedicel. Petiolar node more than twice as wide as long, in profile anterior and posterior margin nearly perpendicular; postpetiole more than twice as wide as long, with concave anterior margin and ventrally with a large tooth-like bulge (Fig. 20).
Genitalia. (Fig. 21).

MATERIAL EXAMINED. Italy, Spilamberto, VII.1917, Menozzi (1♂, MSNG); Spilamberto, 18.VII.1920, Menozzi (9♂, MHNG); Mantova, 16.IV.1957, Poldi (2♂, TAU); Vesuvio, 14.X. (1♂, MCZ), Spain, Bellaterra IX.1983, Espadaler (1♂).

Cardiocondyla (Prosopidris) papuana (Reiskind, 1965)
(Fig. 22)

Prosopidris papuana Reiskind, 1965: 79 (☿, ♀, wingless ♂).

The worker, female and male of this New Guinean species, were described as *Prosopidris papuana.* In 1935 Wheeler erected the subgenus *Prosopidris* for *Cardiocondyla sima*, a new species from the Philippines. Reiskind (1965) raised the subgenus to genus status. According to Wheeler and Reiskind the main differences between *Prosopidris* and *Cardiocondyla* are antennae with 11 segments in workers instead of 12, a much larger bulging clypeus, and higher alitrunk. According to Mr. B. Bolton

(British Museum, personal communication) and the author's opinion, the differences are not sufficient to warrant a separate genus, and *Prosopidris* is regarded here a subgenus of *Cardiocondyla.*

WINGLESS MALE

Length. 2.55 mm.
Color. Entirely yellow, shining.
Head. (Fig. 22). Longer than wide (HL 0.59, HW 0.47 mm.); posterior margin concave, antennae 12 segmented, last 3 segments not forming a clear club, last segment longer than the two previous segments taken together. Maximum diameter of eye as in worker 0.13 mm. ocelli absent. Mandibles curved, long, narrow, pointed toothless.
Alitrunk. Pronotum with distinct shoulders; propodeal spines short and blunt.
Pedicel. Postpetiole nearly twice as wide as long.
Genitalia. Gonostylus externally with a subapical extension, internally with a large curved tooth directed ventrally. Volsellar digitus hook-shaped. Gonapophyse rounded apically with a row of fine ventral teeth (Reiskind 1965:84, Figs. 6, 7, 8).

MATERIAL EXAMINED. Papua – New-Guinea, Bisianumu 15-20.III.1955, E.O. Wilson (1♂, MCZ).

KEY FOR THE IDENTIFICATION OF THE KNOWN MALES OF *CARDIOCONDYLA*

1. Winged 2
– Wingless 4
2. Postpetiole less than 1 1/2 times as wide as long; eyes strongly convex; antennae with 13 segments (exceptionally with 12 segments); propodeum with a pair of well developed spines (Figs. 4, 8, 9) 3
– Postpetiole very wide, twice as wide as long, petiole 2/3 as wide as postpetiole; eyes only slightly convex; antennae with a reduced number of well differentiated segments, part of the basal segments of funiculus fused, forming a long compound segment; propodeum with a pair of short blunt teeth (Fig. 15) . . . . . *C. batesi* var. *nigra*
3. Head nearly globular; scapus shorter than the combined length of the 4 basal funicular segments; mandibles toothless, short, narrow and pointed (Fig. 9); in profile dorsal margin of petiolar node wide, only slightly convex (Fig. 8) . . . . . *C. wroughtoni*
– Head 1/5 longer than wide (Fig. 5); scapus as long as the combined 5-7 basal funicular segments; mandibles widening distally with 4-5 teeth; in profile dorsal margin of petiole narrow and strongly convex (Fig. 4) . . . . . *C. emeryi*
4. Mandibles long, narrow and pointed, toothless (Figs. 3, 22) 5
– Mandibles short, widening distally with 4-5 teeth 6

5. Posterior margin of head convex; clypeus excavated medially with two carinae lateral to the excavation; antennae with 11 segments; mesonotum with two lateral bulges (Fig. 3) . . . . . *C. wroughtoni*
– Posterior margin of head strongly concave in the middle; clypeus bulging with a convex anterior margin; antennae with 12 segments (Fig. 22); mesonotum without lateral bulges . . . . . *C. papuana*
6. Petiole as wide as 2/3 of postpetiole (Figs. 12, 16, 19) 7
– Petiole narrower than 2/3 of postpetiole (Figs. 7, 14) 9
7. Propodeum with a pair of spines; alitrunk at anterior margin of shoulders straight, more than twice as wide as at base of propodeal spines; shoulders strongly angulated (Figs. 16, 19) 8
– Propodeum with short blunt teeth; alitrunk at anterior margin of shoulders narrower than at base of propodeal teeth; shoulders less angulated (Fig. 12) . . . . . *C. stambuloffi*
8. Propodeal spines fingerlike, twice or more as long as wide; anterior margin of petiolar node in profile nearly vertical; postpetiole ventrally with a large toothlike, protuberance directed forward (Fig. 20) . . . . . *C. elegans*
– Propodeal spines less than twice as long as wide; anterior margin of petiolar node in profile very oblique; postpetiole without a tooth-like ventral protuberance (Fig. 17) . . . . . *C. batesi* var. *nigra*
9. Pronotal shoulders angular; margin of pronotum at anterior margin of shoulders forming a straight sharp line, as wide as head; postpetiole nearly twice as wide as long (Fig. 7) . . . . . *C. emeryi*
– Pronotal shoulders slightly rounded; margin of pronotum at shoulder level not a sharp line, narrower than head; postpetiole 1 1/4 as wide as long (Fig. 14) . . . . . *C. nuda* var. *mauritanica*

DISCUSSION

The occurrence of winged males in ants is the rule, while wingless males are the exception. In *Cardiocondyla* the reverse situation seems to be true. The genus comprises about 40 described species (Bolton, 1982). Winged males are known from three species only (*C. emeryi, C. wroughtoni* and *C. batesi* var. *nigra*), while wingless males are known from these three species, as well as from five additional ones (*C. stambuloffi, C. nuda, C. elegans, C. papuana* and *C. ectopia*).

Le Masne (1956) summarized the characters of the winged and wingless males of ants in comparison to females and workers. According to him the winged male is characterized by: a realtively small globulose head; small mandibles; large convex eyes; 3 ocelli; the number of antennal segments is nearly always higher than that of the worker and female. The scapus is shorter and the mobility between the funiculus and the scapus is less developed than in workers and females. The thorax is swollen dorsally with well differentiated sclerites. The color is often black, even if the workers are light colored.

The wingless males contrary to the winged males, have a large head; developed mandibles; small eyes; no ocelli; antennae with the same number of segments as the

workers, or even less, an elongated scapus with a very mobile funiculus; a less voluminous thorax, with an extreme simplification of its structures; an incomplete pigmentation; they are even less pigmented than the workers.

Of the three *Cardiocondyla* species from which winged males are known, only those of *C. emeryi* and *C. wroughtoni* are typical winged males. The winged male of *C. batesi* var. *nigra* is intermediate between a winged and wingless male. It has ocelli and the thoracic sclerites are well differentiated as in typical males. The eyes are larger than in the wingless male but nearly flat. The antennae have a reduced number of segments with only the first, second and the last five segments well differentiated, the intermediate segments are fused without clear margins between them. The pronotum has large shoulders as typical for wingless males of *Cardiocondyla*. The color is yellow while the workers and females are blackish brown.

The known wingless males of *Cardiocondyla* are all mainly yellow, even if the color of the workers and females, is black or brown as in *C. elegans, C. stambuloffi, C. nuda, C. ectopia, C. batesi* var. *nigra*. The head is large, smooth and shining, the eyes are smaller than in the worker; ocelli are usually absent (the male of *C. emeryi* and some specimens of *C. elegans* have 1 developed ocellus). The antennae have usually a reduced number of segments. The antennae of workers and females of *Cardiocondyla* are usually 12 segmented with a 3 segmented club. The exceptions are *C. papuana* and *C. sima* with 11 antennal segments. Only in the wingless male of *C. papuana* the antenna has more segments than in females and workers (12 instead of 11). The wingless males of *C. emeryi* and *C. nuda* have 12 antennal segments as do the females and workers (in 1 specimen of *C. nuda* var. *mauritanica* the left antenna is 12 segmented but the 7th segment is rudimentary). The male of *C. wroughtoni* has 11 antennal segments, that of *C. stambuloffi* has 10, *C. batesi* var. *nigra* and *C. elegans* have 9 well differentiated segments or less. In the latter species the small intermediate segments are more or less fused into one long segment.

The mandibles are toothless, long and narrow in *C. wroughtoni* and *C. papuana*. The mandibles of the other species are short, wide, with 4-5 teeth. The thorax is flat, much wider anteriorly than posteriorly; the pronotum usually with very pronounced angular shoulders.

Genitalia: Forel (1892) described and figured the genitalia of the wingless male of *C. stambuloffi* (Fig. 13). The author examined the genitalia of the wingless males of *C. wroughtoni* and *C. elegans* and the winged male of *C. emeryi* (Figs. 6, 11, 21). The genitalia of these 4 species are nearly identical. Reiskind described and figured the genitalia of the wingless male of *C. papuana* (Reiskind, 1965: 83, 84, Figs. 6-8). These genitalia are more differentiated, the gonostylus has a lobe and a tooth which are absent in the other species. This is an additional character which justifies its separation into a different subgenus *(Prosopidris)*.

Behavior: Little is known about the behavior of the wingless males. They occur in nests with many females, and their number usually varies between 1 and 4, but sometimes as many as 10 occur in a single nest (Santschi, 1907). They probably never leave the nest. Their lack of pigmentation and the reduction of eyes, ocelli and antennae, may be an adaptation to a permanently concealed way of life.

Menozzi (1918) observed in Janet nests, workers and even females of *C. elegans*, feeding the wingless males with drops of secretion.

Santschi (1907) observed in an artificial nest, a wingless male of *C. nuda* var. *mauritanica* carrying larvae in a way similar to the worker's activity. This behavior was never observed by Lupo and Galil in nests of *C. wroughtoni* despite more than a year of observations (personal communication).

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