

Six New Species of *Carebara* Westwood (Hymenoptera: Formicidae) with Restructuring of World Species Groups and a Key to Indian Species

Himender BHARTI^{1*}

Rakesh KUMAR²

Department of Zoology and Environmental Sciences, Punjabi University, Patiala, Punjab- 147002, INDIA. *Corresponding author. e-mails: ¹himenderbharti@gmail.com, ²rakeshsharmassm@gmail.com

ABSTRACT

Six new species of the myrmicine ants *Carebara* Westwood are described: The monomorphic *C. carinata* sp. nov. and *C. propomegata* sp. nov. and the dimorphic *C. dentata* sp. nov., *C. hornata* sp. nov., *C. rectangulata* sp. nov. and *C. spinata* sp. nov. *Carebara carinata* sp. nov. has a central long clypeal hair as an unusual trait, also present in other foreign *Carebara*. Some of these new species support the previous synonymy of *Oligomyrmex* and *Parvomyrma* under *Carebara* and show mixed attributes that recall the restructuring of existing World species groups. Separate keys for major worker, worker and gyne are provided for Indian species.

Key words: Ants, *Carebara*, India, alpha taxonomy, Myrmicinae, Old World, species groups.

INTRODUCTION

Ant genus *Carebara* Westwood, 1840 (Subfamily Myrmicinae, tribe Solenopsidini) is known by 179 species from the World (Bolton, 2012) and 11 species from India (Bharti, 2011). Ettershank (1966) treated *Carebara* as member of the *Pheidologeton* genus group, along with *Oligomyrmex* Mayr, *Paedalgus* Forel, *Anisopheidole* Forel and *Lophomyrmex* Emery. Currently *Carebara* is considered senior synonym of the genera *Aeromyrma*, *Afroxyidris*, *Aneleus*, *Crateropsis*, *Erebomyrma*, *Hendecatella*, *Lecanomyrma*, *Neoblepharidatta*, *Nimbamyрма*, *Oligomyrmex*, *Paedalgus*, *Parvomyrma*, *Solenops*, *Spelaeomyrmex* and *Sporocleptes* as proposed by Fernández (2004, 2010).

Carebara includes subterranean, dimorphic and secondarily monomorphic species, some displaying an acute dimorphism of size between the female and the worker (Hölldobler and Wilson 1990). These ants are also inhabitants of rotten wood (Bolton, 1973).

Diagnostic characters of the worker of genus *Carebara*: Dimorphic to secondarily monomorphic myrmicine ants; masticatory margin of mandibles with four to six teeth, which decrease in size from the apical (two teeth in *Afroxyidris*); anterior clypeal margin

with or without central isolated and paracarinal setae; anterior border of clypeus usually with four distinct setae; palp formula 2, 2; antennae with eight-eleven segmented; antennal club two-segmented, the apical segment larger; eyes present and reduced or absent; frontal carinae and antennal scrobes absent; propodeal lobes small; sting functional; major with lateral sides of head right, posterior side strongly bilobed; mesosomal segmentation variously developed, sometimes very similar to queens, with metanotum narrow, clearly produced in lateral view (Fernández, 2004; 2010).

The biology of *Carebara* ants has not been studied. Further investigations are needed for study the intercastes, the disappearance of the intermediate caste, and the major workers of exaggerated size occurring with very small blind minor workers (some less than 1mm in total length) and big queens as pointed by Fernández (2010).

Carebara awaits a global taxonomic revision, however, recently significant contributions to this genus include Collingwood and van Harten (2001), Dlussky and Perkovsky (2002), Xu (2003), Fernández (2004, 2006, 2010), Eguchi and Bui (2007), Aldawood *et al.* (2011).

From India, 11 species are known (Bharti, 2011). Out of these five species i.e. *C. bengalensis* (Forel, 1902), *C. lamellifrons* (Forel, 1902), *C. leei* (Forel, 1902), *C. raja* (Forel, 1902), and *C. rothneyi* (Forel, 1902) were described on the basis of queen caste. Rest of the six species distributed are *C. aborensis* (Wheeler, 1913), *C. asina* (Forel, 1902), *C. lignata* Westwood (1840), *C. nayana* (Sheela and Narendran, 1997), *C. similis* (Mayr, 1862), and *C. wroughtonii* (Forel, 1902). In this study six new species for the Indian fauna, including monomorphic and dimorphic species have been described. These new species are quite distinguished from already known species of this genus. Keys to all sexes and castes are provided. The *Carebara* species groups proposed in Fernandez (2004, 2010) have been redefined based on some distinct features of these new species.

MATERIAL AND METHODS

The ants were collected by soil core and Winkler's extractor. The digital images were prepared on Nikon SMZ-1500 stereo zoom microscope using Auto-Montage software. Later, images were cleaned as with Adobe Photoshop CS5.

Abbreviations used are as follows: Ψ , major worker; ♀ , worker;

Abbreviations of Museums

NHM The Natural History Museum, London, U.K.

PUPAC Punjabi University Patiala Ant Collection, Patiala, India.

Type depositories

Two paratype of each *C. dentata* sp. nov., *C. hornata* sp. nov., *C. propomegata* sp. nov., *C. rectangulata* sp. nov. and *C. spinata* sp. nov. will be deposited in NHM.

Measurements and indices

ED Eye diameter; maximum length of compound eye.

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GL Gaster length; maximum length of gaster in lateral view from the anterior most point of first gastral segment to the posterior most point (excluding sting).

HL Head length; the length of the head proper, excluding the mandibles, measured in a straight line from the mid-point of the anterior clypeal margin to the mid-point of the posterior margin of head, in full face view.

HHL Head horn length; the straight dorsal distance from the base of the horn to its apex in full lateral view. The base of the horn was arbitrarily considered as the midpoint of the concavity where posterior margin of head and spine meet.

HW Head width; the maximum width of the head in full face view behind eyes.

ML Mandible length; in full face view, the maximum length between anterior clypeal margin and mandible apex, with mandibles closed.

MSL Mesosomal length; the diagonal length of the mesosoma in lateral view, from frontal most point of declivous area of pronotum to posteriormost point of apex of metapleural lobes.

PTH Petiole height; maximum height of petiole in lateral view.

PTL Petiole length; maximum length of petiole in dorsal view.

PTW Petiole width; maximum width of petiole in dorsal view.

PPTH Postpetiole height; maximum height of postpetiole in lateral view.

PPTL Postpetiole length; maximum length of postpetiole in dorsal view.

PPTW Postpetiole width; maximum width of postpetiole in dorsal view.

PW Pronotal width; maximum width of the pronotum in dorsal view.

SL Scape length; maximum straight line length of the antennal scape excluding the basal constriction or neck close to the condylar bulb.

TL Total length; Length of outstretched ant measured from apex of closed mandibles to apex of gaster, that is, $ML+HL+MSL+PTL+PPTL+GL$.

CI Cephalic index; $HW / HL \times 100$

EI Eye index; $ED / HW \times 100$

SI Scape index; $SL / HW \times 100$

RESULTS

Carebara carinata Bharti and Kumar, sp. nov. (Figs. 1-3)

Type Material. Holotype ♀, India: Himachal Pradesh, Ghati, 31.935957°N 75.934603°E, 450m, 27.ix.2009, soil core; R. Kumar Leg.; PUPAC.

Paratypes. 2♀ same data as of holotype (in 1 specimen gaster broken).

Description

Worker

Measurements. Holotype ♀. HL 0.45, HW 0.32, SL 0.3, ML 0.10, MSL 0.44, PW

0.21, PTL 0.14, PPTL 0.09, PTW 0.06, PPTW 0.08, PTH 0.1, PPTH 0.07, GL 0.36, TL 1.58, CI 71.11, SI 93.75.

Paratype ♀. HL 0.44, HW 0.32, SL 0.3, ML 0.11, MSL 0.44, PW 0.21, PTL 0.15, PPTL 0.08, PTW 0.07, PPTW 0.08, PTH 0.1, PPTH 0.06, GL 0.39, TL 1.61, CI 72.73, SI 93.75 (1 measured).

Monomorphic. Head longer than broad, sides weakly convex, nearly rectangular; posterior margin of head straight; clypeus steep somewhat convex, without lateral teeth, its anterior margin with a single median long seta and a pair of 1st paracarinar setae; mandibles triangular, masticatory margin with five teeth gradually reduced in size from the apical tooth to basal tooth; frontal lobes small; eyes absent; antennae slender, 11 segmented; scape falls short from posterior margin of head by almost 1/3rd of its length and 0.67x times of head length; promesonotum suture absent, weakly convex; metanotal groove narrow and deep; dorsal face of propodeum weakly sloping backwardly and weakly concave; propodeal spines short, triangular (0.02mm longer); declivitous face of propodeum concave with thin lateral laminae; propodeal lobes narrow and rounded; petiole with longer peduncle, ventral face with very feeble or indistinct anteroventral process and almost straight; petiole and postpetiole node rounded in dorsal view and former not much higher; gaster elongate and oval.

Head shagreenate or rugoreticulate except smooth anteromedian part behind posterior clypeal margin up to almost half of scape length and genae longitudinally rugulose; posterior margin of head with a transverse carina; clypeus without carinae; clypeus and mandibles smooth and shiny; mesosoma, petiole, postpetiole, gaster and legs smooth and shiny except lower part of mesopleuron and petiolar peduncle with shagreenate sculpture.

Whole body yellowish brown, covered with abundant short erect to suberect hairs; scape, middle and hind tibiae with short suberect hairs.

Etymology. The specific epithet refers to presence of carina on posterior margin of head.

Remarks. This new species is somewhat allied to *C. sangi* (Eguchi and Bui, 2007) and can be differentiated from it by the combination of the following characters: propodeum with short triangular spine, metanotal groove deep, dorsal face of propodeum weakly sloping backwards and peduncle of petiole without anteroventral process. In *C. sangi* the propodeum is unarmed, the metanotal groove is shallow, the dorsal face of propodeum steep, and the peduncle of petiole has a small anteroventral process. As in *C. sangi*, *C. lignata* and some *C. peruviana*, *C. carinata* possesses a central isolated hair on the anterior clypeal margin. Probably this is a derived, convergent trait in each species, and adds support to the previous synonymy of *Parvimyrma* under *Carebara*.

Carebara dentata Bharti and Kumar, sp. nov. (Figs. 4-9)

Type Material. Holotype ♀, India: Himachal Pradesh, Mandi, 31.704716° N 76.937497° E, 800m, 27.06.2010, soil core; R. Kumar Leg.: PUPAC.

Paratypes. India. Punjab: Raja Ranjit Sagar Dam, 600m, 1♀, 20.06.2009, soil core. Jammu and Kashmir: Suriensar, 700m, 3♀, 14.07.2009, soil core; Kathua, 350m, 3♀, 25.07.2010, soil core.

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Uttarakhand: Rajaji Forest Area, 660m, 4♂, 11.08.2009, winkler; Dehradun, Forest Research Institute, 640m, 4♂, 31.07.2009, soil core, 7 ♀, 04.08.2009, winkler. Himachal Pradesh: Andretta, 940m, 3 ♀, 12.06.2010, soil core; Mandi, 800m, 5 ♀, 27.06.2010, soil core, 3 ♀, 27.06.2010, soil core; Kotla, 560m, 1 ♀, 13.07.2010, soil core; Terrace, 420m, 2 ♀, 17.07.2010, winkler. R. Kumar Leg.; PUPAC.

Description

Major worker (Figs. 4-6)

Measurements. Holotype ♀. HL 0.73, HW 0.56, SL 0.30, ML 0.19, ED 0.02, MSL 0.57, PW 0.32, PTL 0.21, PPTL 0.15, PTW 0.13, PPTW 0.18, PTH 0.14, PPTH 0.12, GL 0.57, TL 2.42, CI 76.71, EI 3.57, SI 53.57.

Paratypes ♀. HL 0.73-0.75, HW 0.54-0.57, SL 0.30-0.32, ML 0.19-0.20, ED 0.02, MSL 0.55-0.60, PW 0.25-0.35, PTL 0.19-0.22, PPTL 0.14-0.18, PTW 0.11-0.13, PPTW 0.15-0.18, PTH 0.14-0.15, PPTH 0.11-0.13, GL 0.54-0.62, TL 2.35-2.56, CI 73.97-76.71, EI 3.51-3.70, SI 53.57-57.41 (7 measured).

Head large, massive, longer than broad, sides weakly convex, nearly rectangular in full-face view with anterior and posterior margins equal; posterior margin of head concave; posterolateral corners of head equipped with minute horns in profile; clypeus longitudinally weakly concave, anterior margin prominently concave with two blunt lateral teeth; mandibles triangular, masticatory margin with five teeth; frontal lobes developed, raised laterally and cover the condylar bulb; eyes with single ommatidium, situated below mid-length of head at a distance of 0.19mm from mandibular insertions into head; antennae slender, nine segmented; scape short, almost reach to half of the distance from antennal insertion to posterior margin of head and 0.41x of head length; promesonotum high, rounded and strongly convex, suture indistinct; metanotal groove broad and deep; dorsal face of propodeum short, weakly concave, sloping backwardly and with posterodorsal corners bluntly angled; declivitous face weakly concave, with narrow lateral laminae; petiole with a long peduncle, ventral face sinuate, node thick at base, dorsum convex in lateral view, broader than long; postpetiole weakly convex, as broad as long and its node broader than petiolar node; gaster broadly oval.

Head longitudinally rugulose up to level of almost half of scape length; posterior margin of head transversely rugose; frontal lobes finely longitudinally rugulose; clypeus with lateral divergent carinae; clypeus and mandibles smooth and shiny; mesosoma smooth and shiny except katepisternum, lower half of metapleuron and upper half of declivitous face of propodeum finely punctured with fine longitudinal rugulae; petiolar and postpetiolar nodes, gaster and legs smooth and shiny.

Head and gaster brownish; antennae, mesosoma and legs yellowish brown; head and legs with short suberect hairs, three-four pairs of long hairs directed outward and forward behind eyes near occipital lobes; scape with short subdecumbent hairs; rest of the body with short and long, suberect hairs.

Minor worker (Figs. 7-9)

Measurements. Paratypes ♀. HL 0.31-0.38, HW 0.27-0.32, SL 0.21-0.24, ML 0.07-0.11, ED 0.02, MSL 0.29-0.39, PW 0.16-0.22, PTL 0.11-0.14, PPTL 0.06-0.10,

PTW 0.06-0.07, PPTW 0.07-0.08, PTH 0.06-0.10, PPTH 0.05-0.06, GL 0.22-0.32, TL 1.06-1.44, CI 84.21-87.1, EI 6.25-7.41, SI 75-77.78 (10 measured)

Head slightly longer than broad, not massive, sides convex; posterior margin of head weakly concave; mandibles with five acute teeth; clypeus steep flat, anterior margin straight without two blunt lateral teeth; eyes situated below mid-length of head at a distance of 0.08mm from mandible insertion into head; scape reach to 2/3rd of the distance from antennal insertion to posterior margin of head and 0.63-0.68x of head length; promesonotum weakly convex; promesonotal suture absent; dorsal face of propodeum weakly convex, with posterodorsal corners rounded; ventral face of petiole straight, petiolar node rounded in dorsum; gaster elongate oval.

Head smooth and shining except genae which are faintly longitudinally rugulose; frontal lobes smooth; katapisternum faintly punctured, metapleuron and declivitous face of propodeum smooth and shiny.

Body yellowish brown; head without long hairs. Rest like major worker.

Etymology. The specific epithet refers to the minute horns on the posterolateral corners of head.

Remarks. *Carebara dentata* sp. nov. is a dimorphic species and is widespread in Shivalik range of North-western Himalaya. In some of the major workers the frons anterior to occiput is longitudinally rugulose. However, *C. dentata* sp. nov. resembles *C. rectidorsa* (Xu, 2003), but can be easily distinguished by the combination of following features: head anteriorly and posteriorly equally broader, eyes with a single ommatidium, anterior clypeal margin prominently concave, propodeum with posterodorsal corners bluntly angled, postpetiole broader than petiole in dorsal view (PTW 0.13mm, PPTW 0.18mm), body large in size (TL 2.42mm), while in *C. rectidorsa* head narrowed forward, eyes with two facet, anterior clypeal margin weakly concave, propodeal posterodorsal corners prominently rounded, postpetiolar and petiolar node equally broader (PTW 0.10mm), body smaller in size (TL 1.7mm).

***Carebara hornata* Bharti and Kumar, sp. nov. (Figs. 10-15)**

Type Material. Holotype ♀, India: Himachal Pradesh, Andretta, 32.036638°N 76.566532°E, 940m, 11.vi.2010, soil core; R. Kumar Leg.; PUPAC.

Paratypes. 22 ♀, with same data as of holotype; 1 ♂, with same data as of holotype.

Description

Major worker (Figs. 10-12)

Measurements: Holotype ♀. HL 0.91, HW 0.56, SL 0.32, HHL 0.07, ML 0.21, MSL 0.78, PW 0.41, PTL 0.30, PPTL 0.20, PTW 0.20, PPTW 0.21, PTH 0.21, PPTH 0.16, GL 0.82, TL 3.22, CI 61.54, SI 57.14.

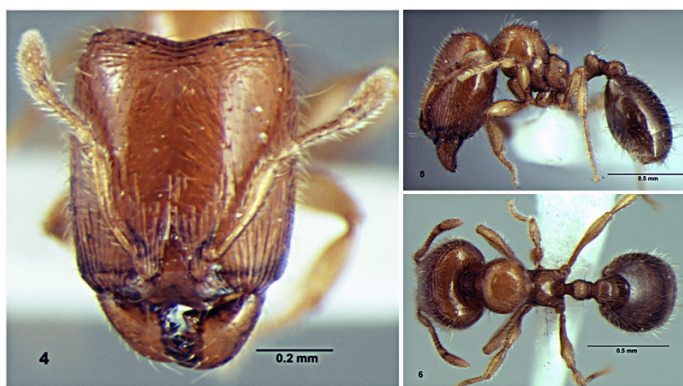
Paratypes ♀. HL 0.82-1.00, HW 0.45-0.63, SL 0.30-0.37, HHL 0.06-0.13, ML 0.17-0.23, MSL 0.66-0.88, PW 0.37-0.48, PTL 0.19-0.28, PPTL 0.16-0.21, PTW 0.16-0.20, PPTW 0.17-0.24, PTH 0.13-0.23, PPTH 0.13-0.19, GL 0.69-0.91, TL 2.69-3.51, CI 54.88-63.00, SI 57.69-66.67 (10 measured).

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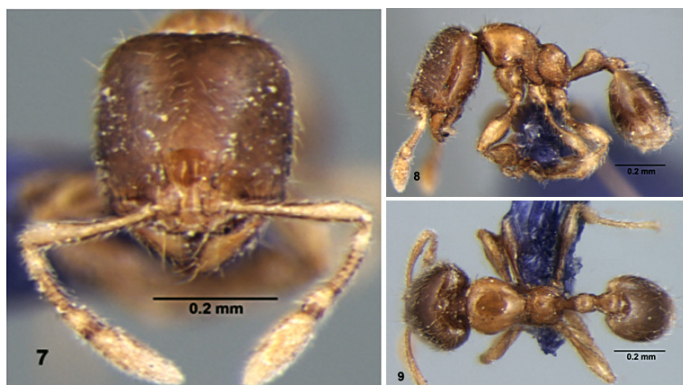
Figs. 1-3. *Carebara carinata* sp.nov., worker: 1. Head, full-face view; 2. Body, lateral view; 3. Body, dorsal view.



Figs. 4-6. *Carebara dentata* sp.nov., major worker: 4. Head, full-face view; 5. Body, lateral view; 6. Body, dorsal view.



Figs. 7-9. *Carebara dentata* sp.nov., minor worker: 7. Head, full-face view; 8. Body, lateral view; 9. Body, dorsal view.



Head large, about twice longer than broad, nearly rectangular in full-face view, sides straight and parallel; posterior margin of head deeply and evenly concave, corners protruding into a pair of well developed acute horns and with a transverse carina between horns; horns directed upward and forward; clypeus longitudinally weakly depressed with anterior margin slightly concave; mandibles triangular, masticatory margin with five teeth; frontal lobes developed and cover the condylar bulb; eyes with single ommatidium, situated below mid-length of head at a distance of 0.24mm from mandibular insertions into head; antennae slender, nine segmented; scape short, not reach to half of the distance from antennal insertion to posterior margin of head and 0.35x of head length; promesonotum strongly convex; promesonotum suture present; metanotal groove broad and deep; propodeum flat slightly depressed medially, sloping backwards with posterodorsal corners bluntly angled; declivitous face of propodeum vertical, depressed medially, with raised lateral margins; petiole with a long peduncle, ventral face straight, node broader than long and compressed antero-posteriorly in dorsal view; postpetiole convex, as broad as long; gaster narrow anteriorly and broader posteriorly in dorsal view.

Head finely longitudinally rugulose anteriorly up to half of scape length, rest of the head smooth and shiny, punctures at the base of hairs; frontal lobes finely longitudinally rugulose; clypeus with divergent lateral carinae; clypeus and mandibles smooth and shining; mesosoma smooth and shiny except meso-metapleuron which are finely punctured with fine longitudinal rugulae and scattered smooth patches; petiole, postpetiole and propodeal declivity punctured; gaster and legs smooth and shining.

Whole body yellowish brown with masticatory margins of mandibles black; body covered with abundant, short and long subdecumbent pilosity, while scape, middle and hind tibiae with short subdecumbent hairs.

Minor worker (Figs. 13-15)

Measurements. Paratype ♀, HL 0.39, HW 0.32, SL 0.23, ML 0.10, ED 0.01, MSL 0.44, PW 0.20, PTL 0.14, PPTL 0.10, PTW 0.09, PPTW 0.10, PTH 0.10, PPTH 0.07, GL 0.38, TL 1.55, CI 82.05, EI 3.12, SI 71.88 (1 measured).

Head longer than broad, sides convex; posterior margin of head almost straight, posterior margin of head without horns; masticatory margin of mandibles with five acute teeth; eyes with a single elongate ommatidium, situated below mid-length of head at a distance of 0.11mm from mandibular insertions into head; scape falls short from posterior margin of head by almost half of its length and 0.59x times of head length; promesonotum weakly convex and suture absent; metanotal groove narrow and shallow; petiolar node subovale.

Whole head smooth and shining with punctures at the base of hairs except genae which have faint fine longitudinal rugulae and; frontal lobes with fine punctures; meso-metapleuron faintly sculptured; propodeal declivity, petiolar and postpetiolar node smooth and shiny.

Whole body light yellowish brown. Rest like major worker.

Etymology. The specific epithet refers to the presence of horns on head.

Remarks. This species seems uncommon. Few major workers of this species have single large ocellus at vertex of head and occipital carina effaced in middle. *Carebara hornata* sp. nov. is allied to *C. bihornata* (Xu, 2003) and *C. asina* (Forel, 1902), but can be differentiated from *C. bihornata* by the following characters: head nearly rectangular with straight parallel sides and finely longitudinally rugulose anteriorly and eyes with single ommatidium. In *C. bihornata* the head is roughly rectangular, smooth, shiny and with convex sides eyes with four ommatidia. From *C. asina* this new species can be separated due to the following combination of characters: in case of major worker, posterior margin of head and vertex smooth and shiny, head rectangular with straight parallel sides and finely longitudinally rugulose anteriorly and in case of worker (minor) eyes elongated, but in major worker of *C. asina* occiput and vertex wrinkled, head with convex sides and anteriorly obscurely longitudinally striate, while its workers are without eyes.

***Carebara propomegata* Bharti and Kumar, sp. nov. (Figs. 16-18)**

Type Material. Holotype ♀, India: Jammu and Kashmir, Ramnagar Wildlife Sanctuary, Manda, 32.750232°N 74.866183°E, 400m, 04.08.2010, soil core; R. Kumar Leg.; PUPAC.

Paratypes. India. Jammu and Kashmir: Ramnagar Wildlife Sanctuary, Manda, 400m, 5♀, 15.07.2009, soil core, 10♀, 04.08.2010, soil core. Himachal Pradesh: Paonta Sahib, 350m, 4♀, 19.08.2009, soil core; Saketi, 300m, 1♀, 25.08.2009, soil core. Punjab: Patiala, 250m, 1♀, 05.10.2010, soil core. R. Kumar Leg.; PUPAC.

Description

Worker

Measurements. Holotype ♀. HL 0.38, HW 0.31, SL 0.20, ML 0.08, ED 0.02, MSL 0.36, PW 0.23, PTL 0.14, PPTL 0.08, PTW 0.10, PPTW 0.13, PTH 0.14, PPTH 0.10, GL 0.39, TL 1.43, CI 81.58, EI 6.45, SI 64.52.

Paratypes ♀. HL 0.37-0.38, HW 0.30-0.31, SL 0.20, ML 0.06-0.08, ED 0.02, MSL 0.35-0.36, PW 0.22-0.23, PTL 0.13-0.14, PPTL 0.08-0.11, PTW 0.10-0.11, PPTW 0.13, PTH 0.13-0.14, PPTH 0.08-0.10, GL 0.37-0.39, TL 1.39-1.43, CI 81.08-81.58, EI 6.45-6.66, SI 64.52-66.67 (7 measured).

Monomorphic. Head longer than broad, broader posteriorly, sides weakly convex; posterior margin of head straight with rounded corners; mandibles triangular, masticatory margin oblique with four acute teeth and poorly defined basal tooth; anterior clypeal margin straight; frontal triangle narrow; frontal lobes developed and cover the condylar bulb; eyes with a single ommatidium, situated below mid-length of head at a distance of 0.10mm from mandibular insertions into head; antennae slender, nine segmented; scape short, reach to half of the distance from antennal insertion to posterior margin of head and 0.54x of head length; promesonotum weakly convex; promesonotal suture absent, pronotal humeri somewhat angulate in dorsal view; metanotal groove feeble; propodeal dorsum with a long slope down to the declivitous face, distinctly peaked and angular anteriorly and with somewhat raised margins;

declivitous face concave; propodeal lobes large with posterior margin round; petiole with a short peduncle and high narrow node in profile; postpetiole convex, broader than long; 1st gastral tergite almost rectangular with convex sides.

Head and mesosoma densely foveolate punctured, while punctures on the former larger (0.02mm) than latter; clypeus with lateral divergent carinae; rest smooth and shining.

Whole body yellowish with brownish yellow gaster; whole body covered with pubescence, short and long erect to suberect pilosity; head with abundant pubescence and long erect hairs, two pairs of long hairs directed outwards and upwards close to the occipital corners; scape with subdecumbent pubescence directed apically and leading edge with single long stiff hair projected upward and forward; mesosoma with seven-eight pairs of erect straight hairs and with pubescence; propodeal lobes with a pair of short subdecumbent hairs dorsally; petiole and postpetiole with long erect hairs and few pubescence on postpetiole; whole gaster with sparse pubescence and long erect hairs; longer hairs on head, mesosoma and gaster equal in length; dorsal surface of middle and hind tibiae with short subdecumbent pubescence and with a number of erect, long hairs projected at right angles to the tibial shaft.

Etymology. The specific epithet refers to large propodeal lobes.

Remarks. This species is spread throughout Shivalik range of north-western Himalaya. *Carebara propomegata* sp. nov. resembles to *C. rara* (Bolton and Belshaw, 1993) but can be differentiated from latter by the combination of following characteristics: leading edge of scape with single long stiff hair projected upward and forward, head with two pairs of long hairs directed outwards and upwards close to the occipital corners, CI 81.08-81.58, PW 0.22-0.23mm, while in *C. rara* leading edge of scape with two long stiff hair projected upward and forward, head with three-four pairs of long hairs directed outwards and upwards close to the occipital corners, CI 83-85, PW 0.25-0.26mm. *Carebara propomegata* sp. nov. can also be distinguished from *C. escherichi* (Forel, 1911) by the following attributes: in *C. propomegata* leading edge of scape with single long stiff hair projected upward and forward, tibiae with number of erect, long hairs projected at right angles to the tibial shaft, however, in *C. escherichi* leading edge of scape without single long stiff hair projected upward and forward, tibiae without number of erect, long hairs projected at right angles to the tibial shaft.

***Carebara rectangulata* Bharti and Kumar, sp. nov. (Figs. 19-24)**

Type Material. Holotype ♀, India: Jammu and Kashmir, Bilawar, 32.611653°N 75.608361°E, 650m, 6.viii.2010, soil core; R. Kumar Leg.; PUPAC.

Paratypes. India. Jammu and Kashmir: Suriensar, 700m, 1♀, 01.08.2010, soil core, 1♂, 01.08.2010, soil core; Bilawar, 650m, 9♀, 6.08.2010, soil core, 1♂, 6.08.2010, soil core. R. Kumar Leg.; PUPAC.

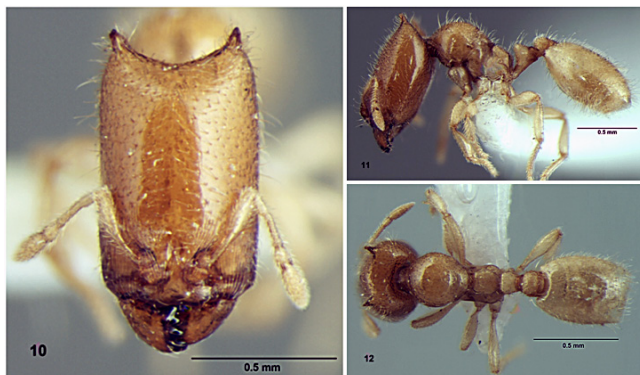
Description

Major worker (Figs. 19-21)

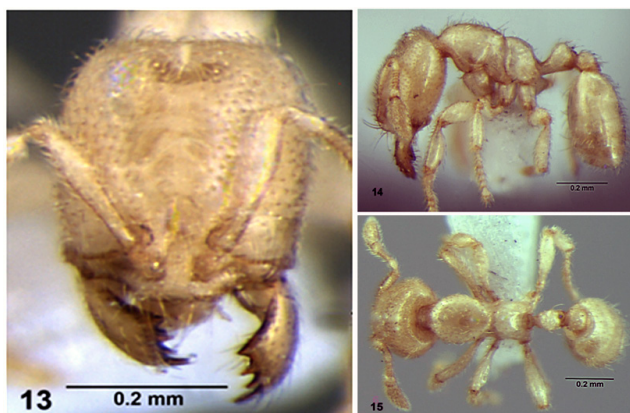
Measurements. Holotype ♀. HL 0.70, HW 0.47, SL 0.28, ML 0.16, MSL 0.60, PW 0.32, PTL 0.19, PPTL 0.14, PTW 0.15, PPTW 0.16, PTH 0.16, PPTH 0.12, GL 0.62, TL 2.41, CI 67.14, SI 59.57.

Six New Species of Carebara Westwood (Hymenoptera: Formicidae)

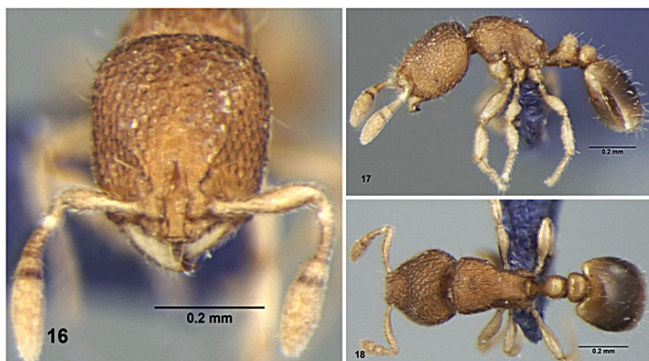
Figs. 10-12. *Carebara hornata* sp.nov., major worker: 10. Head, full-face view; 11. Body, lateral view; 12. Body, dorsal view.



Figs. 13-15. *Carebara hornata* sp.nov., minor worker: 13. Head, full-face view; 14. Body, lateral view; 15. Body, dorsal view.



Figs. 16-18. *Carebara propomegata* sp.nov., worker: 16. Head, full-face view; 17. Body, lateral view; 18. Body, dorsal view.



Description

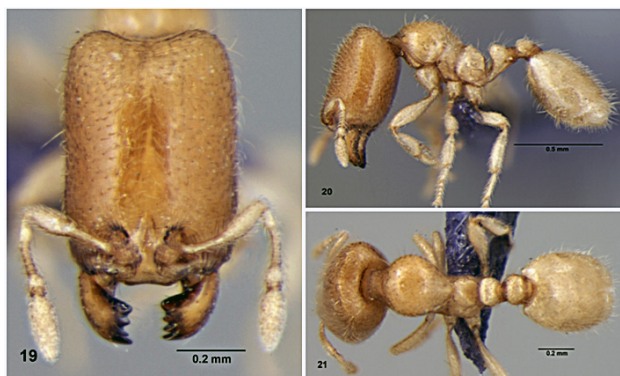
Major worker (Figs. 19-21)

Measurements. Holotype ♀. HL 0.70, HW 0.47, SL 0.28, ML 0.16, MSL 0.60, PW 0.32, PTL 0.19, PPTL 0.14, PTW 0.15, PPTW 0.16, PTH 0.16, PPTH 0.12, GL 0.62, TL 2.41, CI 67.14, SI 59.57.

Paratypes ♀. HL 0.53-0.70, HW 0.37-0.47, SL 0.23-0.28, ML 0.14-0.16, MSL 0.46-0.60, PW 0.23-0.32, PTL 0.15-0.19, PPTL 0.12-0.14, PTW 0.11-0.15, PPTW 0.12-0.16, PTH 0.13-0.16, PPTH 0.10-0.12, GL 0.41-0.62, TL 1.81-2.41, CI 67.14-69.81, SI 58.14-62.16 (10 measured).

Head large, longer than broad, nearly rectangular in full face view, sides straight and parallel; posterior margin of head emarginated, concave, occipital corners without horns; clypeus steep, almost flat with anterior margin straight; mandibles triangular, masticatory margin with 5 teeth; frontal lobes developed and cover the condylar bulb; eyes minute with a single ommatidium, situated below mid-length of head at a distance of 0.15mm from mandibular insertions into head; antennae slender, nine segmented; scape short, just fail to reach half of the distance from antennal insertions to posterior margin of head and 0.4x of head length; promesonotum convex; promesonotum suture indistinct, mesonotum sloping backwards; metanotal groove broad and shallow; propodeum weakly concave, sloping backwards and with posterodorsal corners bluntly angled; declivitous face of propodeum vertical, weakly concave, with lateral raised margins; petiole with a long peduncle, ventral face straight, node broader than long and compressed antero-posteriorly in dorsal view; postpetiole convex, broader than long; gaster broadly oval.

Figs. 19-21. *Carebara rectangularata* sp.nov., major worker: 19. Head, full-face view; 20. Body, lateral view; 21. Body, dorsal view.



Head, clypeus and mandibles smooth and shiny while genae longitudinally rugulose; head with punctures at the base of hairs; posterior margin of head with a transverse carina; frontal lobes finely longitudinally rugulose; clypeus with divergent lateral carinae; mesosoma, dorsum of petiolar and postpetiolar node, gaster, legs smooth and shiny except katapisternum and sides of petiole and postpetiole punctured.

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Body yellowish brown with masticatory margin of mandibles blackish; whole body covered with abundant, short and long erect to suberect hairs, while scape, middle and hind tibiae with short suberect hairs only.

Minor worker (Figs. 22-24)

Measurements ♀, HL 0.37, HW 0.30-0.32, SL 0.21-0.22, ML 0.11-0.12, ED 0.01, MSL 0.38-0.39, PW 0.19-0.20, PTL 0.13, PPTL 0.08-0.10, PTW 0.08, PPTW 0.08-0.1, PTH 0.10, PPTH 0.07, GL 0.30-0.33, TL 1.38-1.43, CI 81.08-86.49, EI 3.13-3.33, SI 68.75-70.00 (2 measured).

Head slightly longer than broad, sides convex, posterior margin of head straight; masticatory margin with five acute teeth; eyes situated below mid-length of head at a distance of 0.11-0.12mm from mandibular insertions into head; scape falls short from posterior margin of head by 1/3 of its own length and 0.57x of head length; promesonotum weakly convex; metanotal groove deep and narrow; petiolar node rounded in dorsal view; postpetiole as broad as long.

Genae faintly longitudinally rugulose; posterior margin of head without a transverse carina. Whole body light yellowish brown in colour. Rest like major worker.

Etymology. The specific epithet refers to nearly rectangular head shape.

Remarks. *Carebara rectangularata* sp. nov. is allied to *C. lusciosa* (Wheeler, 1928) and can be distinguished by following combination of characteristics: in major worker the head longer with straight and parallel sides, posterior margin of head with a transverse carina, katapisternum sculptured, body longer (TL 2.41mm), while its worker with occipital margin straight, eyes present; however, in major worker of *C. lusciosa* head sub oblong with sub parallel sides which are somewhat sinuous in the middle, posterior margin of head without transverse carina, katapisternum smooth, body comparatively smaller (TL 2mm) and worker with posterior margin of head concave, and without eyes.

***Carebara spinata* Bharti and Kumar, sp. nov. (Figs. 25-30)**

Type Material. Holotype ♀, India: Uttarakhand, Dakpathar, 30.516428°N 77.784877°E, 750m, 20.viii.2009, soil core; R. Kumar Leg.; PUPAC.

Paratypes. India. Uttarakhand: Rajaji Forest Area, 660m, 1♀, 11.08.2009, winkler, 2♂, 11.08.2009, winkler, 3♀, 11.08.2009, winkler; Dakpathar, 750m, 26♀, 20.08.2009, soil core, 4♀, 20.08.2009, soil core. Himachal Pradesh: Lwasa, 1200m, 1♀, 27.08.2009, soil core; 9♀, 27.08.2009, soil core; Ghati, 450m, 1♀, 28.09.2009, soil core. Jammu and Kashmir: Shukrala 1040m, 1♀, 07.08.2010, soil core. R. Kumar Leg.; PUPAC.

Description

Major worker (Figs. 25-27)

Measurements. Holotype ♀. HL 0.52, HW 0.44, SL 0.23, ML 0.12, ED 0.02, MSL 0.40, PW 0.24, PTL 0.14, PPTL 0.10, PTW 0.10, PPTW 0.10, PTH 0.11, PPTH 0.07, GL 0.37, TL 1.65, CI 84.62, EI 4.55, SI 52.27.

Paratype ♀. HL 0.52-0.53, HW 0.44-0.45, SL 0.23, ML 0.11-0.12, ED 0.02, MSL 0.38-0.40, PW 0.24, PTL 0.13-0.14, PPTL 0.10, PTW 0.10, PPTW 0.10, PTH 0.11,

PPTH 0.07-0.08, GL 0.37-0.38, TL 1.63-1.65, CI 84.62-84.91, EI 4.44-4.55, SI 51.11-52.27 (7 measured).

Head large, massive, slightly longer than broad, sides convex; posterior margin of head emarginated with rounded corners, and minute horns in profile; clypeus longitudinally depressed, anterior margin concave with two lateral teeth; mandibles triangular, masticatory margin with five teeth; frontal lobes developed, flat and cover the condylar bulb; eyes with a single ommatidium, situated below mid-length of head at a distance of 0.13mm from mandibular insertions into head; antennae slender, nine segmented; scape short, almost reach to half of the distance from antennal insertions to posterior margin of head and 0.44x of head length; promesonotum weakly convex; promesonotal suture absent; metanotal groove narrow and deep; dorsal face of propodeum short, flat, sloping backwards; propodeal spines short, triangular and slightly down curved; declivitous face of propodeum concave with thin lateral laminae; petiole with a short peduncle, ventral face straight, node convex, thick at base; postpetiole dorsum almost flat, as broad as long; gaster broadly oval.

Head longitudinally rugose up to vertex, posterior margin of head transversally rugose, interrugal space punctured and subopaque; frontal lobes and sides of head longitudinally rugose; clypeus with divergent lateral carinae; clypeus and mandibles smooth and shiny; whole mesosoma and petiole densely foveolate punctured; propodeal declivity, postpetiole, gaster and legs smooth and shiny.

Whole body yellowish brown with masticatory margin of mandibles blackish; body covered with subdecumbent pubescence and long erect to suberect hairs; scape, middle and hind tibiae with short subdecumbent hairs only.

Minor worker (Figs. 28-30)

Measurements. Paratypes ♀. HL 0.33-0.36, HW 0.28-0.31, SL 0.19-0.21, ML 0.05-0.08, ED 0.02, MSL 0.28-0.32, PW 0.18-0.20, PTL 0.08-0.11, PPTL 0.07, PTW 0.06-0.07, PPTW 0.06-0.08, PTH 0.07-0.08, PPTH 0.06, GL 0.27-0.30, TL 1.08-1.24, CI 84.85-86.11, EI 6.45-7.14, SI 67.74-67.86 (10 measured).

Head slightly longer than broad, not much massive, posterior margin of head without minute horns in profile; eyes situated below mid-length of head at a distance of 0.07-0.08mm from mandibular insertions into head; scape short, slightly cross half of the distance from antennal insertion to posterior margin of head and almost 0.58x of head length.

Genae longitudinally rugulose; head densely foveolate punctured except anteromedian part behind posterior clypeal margin with prominent longitudinal rugae upto half length of scape behind which fade out; foveolate punctures on the head larger (0.02mm) than mesosoma. Rest like major worker.

Etymology. The specific epithet refers to presence of propodeal spines.

Remarks. An interesting variation has been noticed in this species with one major worker has three ommatidia in right eye and a single ommatidium in left eye while another major worker with two ommatidia in right eye and a single ommatidium in left

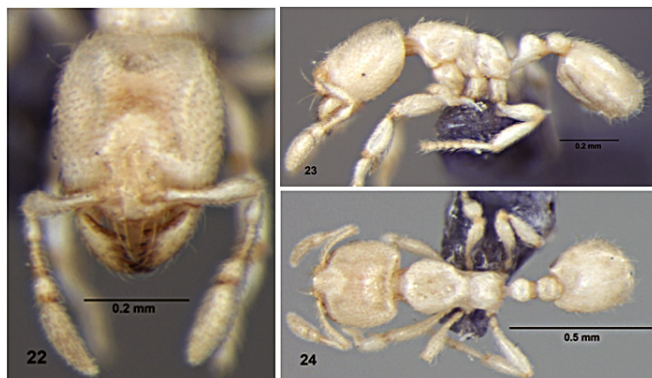
Six New Species of Carebara Westwood (Hymenoptera: Formicidae)

eye. Although, *C. spinata* sp. nov. is close to *C. obtusidenta* (Xu, 2003) and can be separated from latter by the combination of following characteristics: major worker with head slightly longer with convex sides, CI 84.62-84.91, ventral face of peduncle straight, dorsum and sides of head longitudinally rugose up to vertex and posterior margin of head transversally rugose and worker (minor) with occipital horns, but in *C. obtusidenta*, major worker with head much longer, with straight and parallel sides, CI 76-81, ventral face of peduncle concave, anterior 2/3rd of head densely, finely striate and posterior 1/3rd of head dorsum and lateral sides reticulate, while workers are without occipital horns.

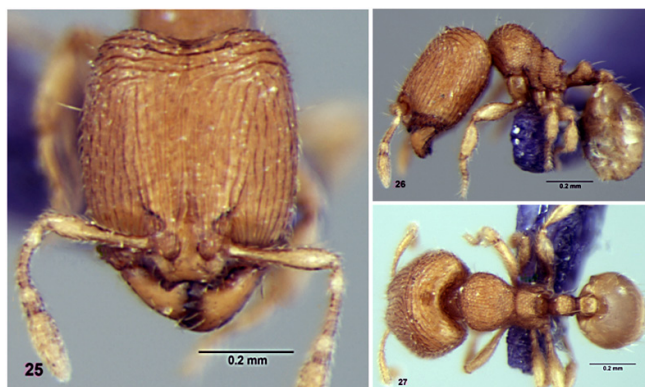
Key to Indian species of *Carebara* based on major worker

1. Antenna 11- segmented*C. nayana* (Sheela and Narendran)
- Antenna 9- segmented.....2
2. Eyes with numerous ommatidia; base of first gastral tergite finely reticulate with traces of fine longitudinal rugae.....*C. aborensis* (Wheeler)
- Eyes minute and with a single ommatidium; first gastral tergite smooth and shining.....3
3. Occiput without a pair of distinct horns or minute teeth.....*C. rectangulata* sp. nov.
- Occiput with a pair of distinct horns or minute teeth.....4
4. Occipital corners protruding into a pair of well developed acute horns or spines.....5
- Occiput with a pair of small minute horns or teeth in lateral view.....6
5. Head rectangular with straight parallel sides, punctured only at the base of hairs and finely longitudinally rugulose anteriorly; occiput and vertex smooth and shining*C. hornata* sp. nov.
- Head with convex sides, sparsely punctured and anteriorly obscurely longitudinally striate; occiput and vertex wrinkled*C. asina* (Forel)
6. Propodeum with posterodorsal corners bluntly angled; dorsal mesosoma smooth and shiningbg*C. dentata* sp. nov.
- Propodeum with short, triangular spines; mesosoma densely foveolate -punctured*C. spinata* sp. nov.

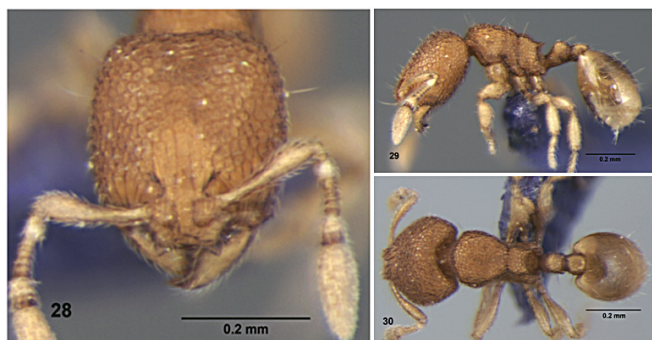
Figs. 22-24. *Carebara rectangularata* sp.nov., minor worker: 22. Head, full-face view; 23. Body, lateral view; 24. Body, dorsal view.



Figs. 25-27. *Carebara spinata* sp.nov., major worker: 25. Head, full-face view; 26. Body, lateral view; 27. Body, dorsal view.



Figs. 28-30. *Carebara spinata* sp.nov., minor worker: 28. Head, full-face view; 29. Body, lateral view; 30. Body, dorsal view.



Key to Indian species of *Carebara* based on minor worker(Note: *C. similis* (MAYR) is poorly described, so this species is excluded from the key)

1. Antenna 11-segmented.....*C. carinata* sp. nov.
- Antenna 9-10 segmented.....2
2. Eyes absent3
- Eyes present.....4
3. TL 2.5 mm; articulation of the femora and tibiae of the legs with a brown ring
.....*C. lignata* Westwood
- TL 1mm; articulation of the femora and tibiae of the legs without brown ring
.....*C. asina* (Forel)
4. Eyes with 2 ommatidia, clypeus without lateral carinae.....*C. aborensis* (Wheeler)
- Eyes absent or with single ommatidium; clypeus with lateral carinae.....5
5. Propodeal spines present.....*C. spinata* sp. nov.
- Propodeum rounded or obtusely angled, not dentate.....6
6. Head reticulate or densely foveolate punctured; propodeal lobes large and broad with rounded posterior margin; mandibles with 4 teeth.....
.....*C. propomegata* sp. nov.
- Head smooth or rugulose; propodeal lobes small, narrow or absent; mandibles with 5 acute teeth.....7
7. Head opaque with front and sides of striate, antenna 10 segmented.....
.....*C. wrightonii* (Forel)
- Head smooth and shiny, antenna 9 segmented.....8
8. Eyes situated at a distance of 0.08 mm from mandibular insertions into head; EI 6.25-7.41, SI 75-77.78*C. dentata* sp. nov.
- Eyes situated at more than distance of 0.08 mm from mandible insertion into head; EI ≤ 4 , SI ≤ 72 9
9. Eyes elongate, not rounded, sides of head comparatively weakly convex; EI 3.12, SI 71.88*C. hornata* sp. nov.
- Eyes rounded, sides of head comparatively strongly convex; EI 3.13-3.33, SI 68.75-70*C. rectangularata* sp. nov.

Key to Indian species of *Carebara* based on females

1. Antenna 10-11 segmented.....2
- Antenna 9 segmented.....3
2. Antenna 10 segmented, more than 10 mm.....*C. lignata* Westwood
- Antenna 11 segmented, less than 4.5-4.6 mm.....*C. lamellifrons* (Forel)
3. Length >5mm, colour more or less brown.....4

- Length < 5mm, colour more or less yellow.....6
- 4. Clypeus feebly but distinctly bicarinate.....*C. bengalensis* (Forel)
- Clypeus not carinate.....5
- 5. Anterior border of clypeus emarginated in the middle; body 5-5.5 mm longer
.....*C. raja* (Forel)
- Anterior border of clypeus not emarginated, body 7-8 mm longer
.....*C. leei* (Forel)
- 6. Postpetiole transverse, much broader than long.....*C. asina* (Forel)
- Postpetiole not broader than long.....*C. rothneyi* (Forel)

DISCUSSION

Carebara ants are subterranean to rotten wood inhabitants, dimorphic and monomorphic. Wilson (1971, 1985) and Hölldobler and Wilson (1990) reviewed the evolution of ant castes and suggested that in *Oligomyrmex* (now *Carebara concinna* group), as well as in *Acanthomyrmex* and some *Pheidole* and other groups, the 'intermediate' worker caste disappeared at some point during their evolution. These ants are known by the loss of the intermediate caste. This implies that the ancestral forms of these groups were probably polymorphic. The disappearance of the intermediate workers is an evolutionary trait in these ants (Fernandez, 2004). The ants of *Carebara* has a tendency towards reduction of number of ommatidia in the compound eyes to completely absent. This reduction could be observed in *C. spinata* sp. nov. In the present study, the *C. spinata* sp. nov. soldier have 1 ommatidium except one soldier with 3 ommatidia on right side eye and 1 ommatidium on left side eye, while other soldier have 2 ommatidia on right side eye and 1 ommatidium on left side.

Similarly, 12 segmented antennae is plesiomorphic in Formicidae (Bolton 2003: 288) and reduction in antennal segments and antennal club has occurred several times in the Myrmicinae (Fernandez, 2010). From India, ants of this genus with 9-11 segmented and two-segmented club antennae have been known (for example: *C. asina*, *C. lignata* and *C. propomegata* sp. nov. have 9 segmented antennae while, *C. carinata* sp. nov. has 11 segmented antennae; see Table 1).

Carebara usually has bicarinate clypeus, although this is absent in *C. carinata* sp. nov. as probable apomorphic, although can be a plesiomorphic feature. This species also shows presence of median clypeal hair, as in a few other not Indian *Carebara*.

Thus the currently described new species show mixed attributes that recall the species groups proposed by Fernandez (2010) for the New World fauna; so it is necessary to evaluate such proposal for the rich and poorly studied Old World fauna. The following species groups have been proposed by Fernandez (2010):

***Carebara alperti* group:** eyes present, 11 segmented, propodeum unarmed and propodeal lobes small, major worker caste absent.

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Carebara concinna group: eyes present, 9-11 segmented antennae, propodeum armed, major and minor worker caste present.

Carebara crigensis group: mandibles with 2 teeth, 10 segmented antennae, major worker caste absent.

Carebara escherichi group: 8-9 segmented antennae, narrow head, short propodeum, major worker caste absent.

Carebara lignata group: eyeless minor workers, 9 segmented antennae, propodeum normal, major worker caste absent.

Table 1. Species of *C. concinna* group

Species	Antennal segments (9-11)	Eyes	Propodeal spines/tubercles	Dimorphic/monomorphic species
<i>C. aborensis</i>	9	present	present	dimorphic
<i>C. bengalensis</i>	9	present	absent	unknown
<i>C. dentata</i> sp. nov.	9	present	absent	dimorphic
<i>C. hornata</i> sp. nov.	9	present	absent	dimorphic
<i>C. lamellifrons</i>	11	present	present	unknown
<i>C. nayana</i>	11	present	present	unknown
<i>C. leei</i>	9	present	present	unknown
<i>C. raja</i>	9	present	absent	unknown
<i>C. rectangulata</i> sp. nov.	9	present	absent	dimorphic
<i>C. rothneyi</i>	9	present	present	unknown
<i>C. similis</i>	10	present	absent	unknown
<i>C. spinata</i> sp. nov.	9	present	present	dimorphic
<i>C. wroughtonii</i>	10	present	either present or absent	unknown

From India eleven species of this genus are known (Bharti, 2011). The study of these species is greatly limited by tiny minor workers, poor descriptions and most of the species known by queens only. The placement of Indian species described till to date in the species group is as follows:

1. Carebara concinna group: (Table 1) Based on characters outlined by Fernandez (2004, 2010) seven Indian species of *Carebara* viz., *C. aborensis* (based on major worker caste), *C. lamellifrons* (based on female), *C. leei* (only female known), *C. nayana* (based on worker), *C. rothneyi*, *C. spinata* sp. nov. and *C. wroughtonii* belong to this group. However, the six species *C. bengalensis*, *C. dentata* sp. nov., *C. hornata* sp. nov., *C. raja*, *C. rectangulata* sp. nov. and *C. similis* (table 1) show affinity with this group except for the unarmed propodeum.

So we propose that *concinna* species group should be redefined, including “propodeum armed and unarmed” for the inclusion of above listed species.

2. *Carebara escherichi* group:

Carebara propomegata sp. nov. is the only Indian species belonging to this group.

3. *Carebara lignata* group:

This include *C. lignata* (eyeless minor worker), *C. asina*. In *C. asina* major worker possesses eyes, propodeum with denticles and occipital horns but minor worker lacks all these traits. This provides a strong proof that that "*Oligomyrmex*" is junior synonym of *Carebara*, because the minor eyeless worker match with the traditional definition of *Carebara*, BUT the major worker match with the traditional definition of *Oligomyrmex* (Bolton, 2003 and Fernández, 2004). Based on this we propose that the *concinna* group need to be fused with *lignata* group. This also open other intriguing possibilities, that other species in *lignata* group have major caste that are not collected nor described along with the abundant and readily collected minor, eyeless caste. Furthermore, this view is also supplemented by attributes of *C. carinata* sp. nov. (absence of eyes relate this to *lignata* group but 11 segmented antennae, armed propodeum relate this to *concinna* group). Presence of median clypeal hair in *C. carinata* sp. nov. (the same trait in *C. sangi*) which is an convergent trait has been observed in several workers of *C. lignata* (Fernández, 2010).

Thus to summarize *C. concinna* group is redefined (with the fusion of *C. lignata* group) with the following attributes: eyes present in major workers, present or absent in minor workers, antennae 9- 11 segmented, propodeum armed and unarmed, major and minor worker caste present.

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