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## NEW ADDITIONS TO ANT GENUS *CAREBARA* WESTWOOD (HYMENOPTERA: FORMICIDAE: MYRMICINAE) FROM INDIA

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Twenty species of ant genus *Carebara* Westwood are recognized from India including two species described as new and one representing new record to India. The 20 Indian species are: *C. aborensis* (Wheeler, 1913), *C. asina* (Forel, 1902), *C. bengalensis* (Forel, 1902), *C. carinata* Bharti et Kumar (2013), *C. dentata* Bharti et Kumar (2013), *C. hornata* Bharti et Kumar (2013), *C. lamellifrons* (Forel, 1902), *C. leei* (Forel, 1902), *C. lignata* (Westwood, 1840), *C. mukkaliensis* sp. n., *C. nayana* (Sheela et Narendran, 1997), *C. obtusidentata* (Xu, 2003), *C. propomegata* Bharti et Kumar (2013), *C. raja* (Forel, 1902), *C. rectangulata* Bharti et Kumar (2013), *C. rothneyi* (Forel, 1902), *C. similis* (Mayr, 1862), *C. spinata* Bharti et Kumar (2013), *C. terayamai* sp. n., *C. wroughtonii* (Forel, 1902). Key to the major workers of the Indian species is provided.

Key words: ants, Myrmicinae, Eastern Himalaya, Southwestern India, intercaste.

### INTRODUCTION

The ant genus *Carebara* currently contains approximately 250 described taxa, distributed worldwide in the subtropics and tropics (FISCHER *et al.* 2014, BOLTON 2014). Even with this wide distributional range very little taxonomic or biological information is available on the genus (FERNÁNDEZ 2004, 2010). The genus consists of polymorphic, dimorphic and monomorphic cryptic species mostly encountered under decaying wood logs and in leaf-litter samples (BOLTON 1973, LONGINO 2004, ALDAWOOD *et al.* 2011, BHARTI & KUMAR 2013).

FERNÁNDEZ (2004, 2006, 2010) contributed much to the systematics of the genus and established senior synonym of *Carebara* over *Aeromyrma*, *Afroxyidris*, *Aneleus*, *Crateropsis*, *Erebomyrma*, *Hendecatella*, *Lecanomyrma*, *Neoblepharidatta*, *Nimbamyrma*, *Oligomyrmex*, *Paedalgus*, *Parvoimyrmex*, *Solenops*, *Spelaeomyrmex* and *Sporocleptes*. Recently, FISCHER *et al.* (2014) synonymized *Pheidologeton* Mayr, 1862 under *Carebara*. The genus *Carebara* awaits a global taxonomic revision, however, significant taxonomic contributions to the genus include: FOREL (1911, 1913a, b), WHEELER (1928), TERAYAMA (1996, 2009), BOLTON and BELSHAW (1993), BOLTON (1995a, b), WU and WANG (1995), ETTERS HANK (1966), COLLINGWOOD and VAN HARTEN (2001), DLUSKY and PERKOVSKY (2002), XU (2003), ZHOU *et al.* (2006), EGUCHI and BUI (2007), ALDAWOOD *et al.* (2011), TERAYAMA *et al.* (2012), BHARTI and KUMAR (2013), SHARAF and ALDAWOOD (2013).

So far 37 species of genus *Carebara* are known from Oriental region (XU 2003, GUÉNARD & DUNN 2012, BHARTI & KUMAR 2013) and 17 species are

known from India (BHARTI & KUMAR 2013). The present study describes two new species and reports *C. obtusidenta* (XU, 2003) for the first time from India, previously known only from China. All known Indian species of genus *Carebara* (except *C. propomegata*) belong to dimorphic *concinna* group and are characterized by eyes present in major workers, present or absent in minor workers, antennae 9–11 segmented, propodeum armed or unarmed, major and minor worker caste present. A revised key to the major workers of the Indian species is provided. Monotonous minor workers and rare sexual forms are mostly inadequate for species identification.

The rich Indian fauna of *Carebara* is not completed yet and the updating taxonomic information for this group is important. New additions provide more knowledge about the limits of intra- and interspecific variations and eventually will help in diagnose the genus in much better way. The future associations of sexes and castes might also change the number and limits of the species proposed here.

## MATERIAL AND METHODS

The specimens were collected by Winkler extraction of leaf-litter. Taxonomic analysis was conducted using Nikon SMZ 1500 stereo zoom microscope. For digital images, MP evolution digital camera was used on same microscope with Auto-Montage software. Later, images were cleaned as per requirement with Adobe Photoshop CS6. Holotype and paratypes of the species have been deposited in PUAC. One paratype of each species will be deposited at BMNH. Description pattern, morphological terminology for measurements and indices follow (FERNÁNDEZ 2004, 2010) and include: ED Eye diameter; maximum length of compound eye. HL Head length; the length of the head, 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. CI Cephalic index;  $HW / HL \times 100$ . EI Eye index;  $ED / HW \times 100$ . SI Scape index;  $SL / HW \times 100$ .

Acronyms of depositories – BMNH: Natural History Museum, London, U.K.; Insect Collection, Faculty of Conservation Biology, Southwest Forestry, Kunming, Yunnan Prov-

ince, China; PUAC: Punjabi University Patiala, Ant Collection at Department of Zoology and Environmental Sciences, Punjabi University, Patiala, Punjab, India; CASC: California Academy of Sciences, San Francisco, United States of America.

## RESULTS

### **Carebara mukkaliensis** sp. n. (Figs 1–3)

Type material. Holotype (major worker) and 4 paratypes (major worker): INDIA: Kerala, Silent Valley National park, 11°5'N, 76°26'E, 897m, 26.ix.2011, Winkler method (coll. Shahid A. Akbar). Holotype and paratype in PUAC; one paratype will be deposited in BMNH and one in CASC.

Description – Major workers. Measurements (holotype in brackets): HL (0.61)-0.63, HW (0.48)-0.49, SL (0.23)-0.25, ED (0.04)-0.05, ML (0.14)-0.15, MSL (0.41)-0.44, PW (0.22)-0.25, PTL (0.14)-0.16, PPTL (0.11)-0.14, PTW (0.12)-0.15, PPTW (0.11)-0.13, PTH (0.11)-0.14, PPTH (0.08)-0.10, HHL (0.01), CI 77-(78), SI (47)-51, EI (8)-10 (n = 5).

Head longer than broad, rectangular in full face view. Occipital margin transverse to slightly concave in the middle with occipital corners gently roundly, lateral sides slightly convex. Mandible with 4-teeth. Median portion of clypeus longitudinally depressed, bicarinate and divergent forward, anterior margin strongly concave. Antennae 9-segments with a 2-segmented club, scapes short and clavate; reaching up to 1/2 of posterior margin of head. Eyes with 2–3 ommatidia. In profile view, vertex with a pair of small well developed acute horns. Dorsum of head straight.

Promesonotum high and roundly convex. Promesonotal suture obsolete on the dorsum. Metanotum obsolete. Metanotal groove deeply impressed. Propodeum with a pair of protruding dents, dorsum straight and truncate, declivity straight without thin lateral laminae. Petiole pedunculate anteriorly. Petiole node cone shaped with thick anterior and posterior faces. Postpetiole node roundly convex and lower than petiolar node. In dorsal view postpetiolar node as broad as petiolar node.

Mandibles and clypeus smooth and shiny. Head finely and longitudinally striate throughout. Transverse striations present on dorsum of occipital lobes and between vertexal horns, with lateral sides having rugose-reticulations. Mesosoma, petiole and postpetiole uniformly punctuate throughout. Gaster smooth and shining.

Head and body with abundant erect to suberect hairs. Scapes and tibiae with dense decumbent pubescence.

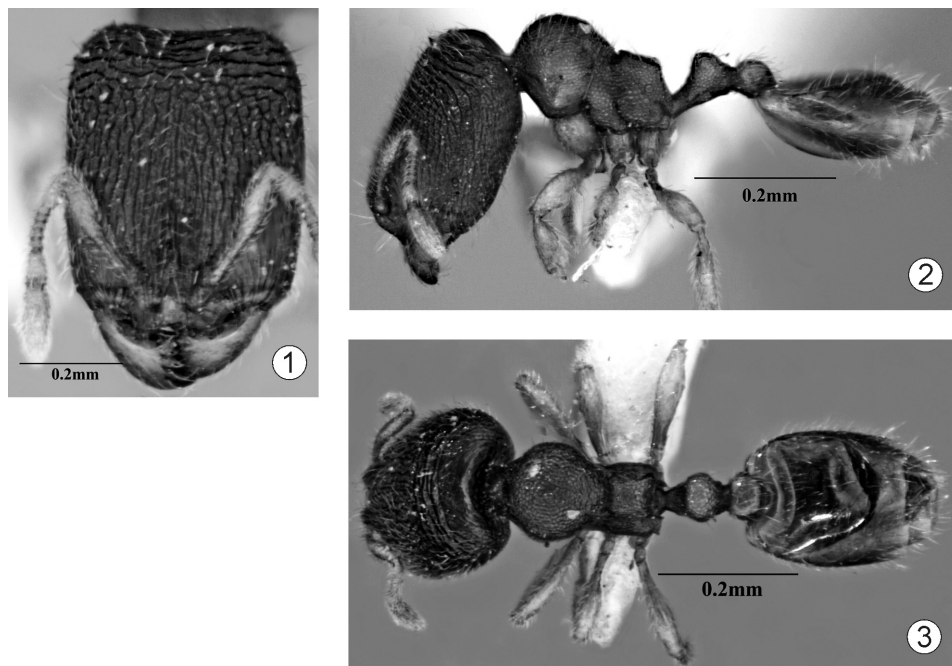
Body dark yellowish in colour.

Etymology. The species is named after its type locality Mukkali, part of Silent Valley National Park.

Differential diagnosis. *C. mukkaliensis* somewhat resembles to the Chinese *C. obtusidenta* (Xu, 2003) but can be easily distinguished from the latter. In case of *C. mukkaliensis* cephalic dorsum is strongly and uniformly sculptured throughout, posterodorsal corner of propodeum bluntly angled, eyes consists

of 2–3 ommatidia, masticatory margin of mandible is having 4-teeth, metanotal groove is deeply impressed and petiole with straight ventral face; anteroventral corner is not dentate whilst in case of *C. obtusidenta* cephalic dorsum is having anterior and posterior portions more sculptured, propodeum with a pair of rightly angled teeth, eyes consisting of single ommatidium, masticatory margin of mandibles with 5-teeth, metanotal groove is less deeply impressed and petiole with concave ventral face; anteroventral corner acutely dentate. *C. mukkaliensis* also shares some affinities with *C. wheeleri* Ettershank, 1966. However, the two species can be easily separated. In case of *C. mukkaliensis* anterior margin of clypeus is deeply concave, posterior cephalic margin with small, acute spines, eyes consists of 2–3 ommatidia and mesosoma uniformly punctuate throughout whilst in case of *C. wheeleri* anterior margin of clypeus is straight, posterior cephalic margin with well prominent upcurved spines, eyes consists of single ommatidium and mesosoma shagreened or reticulate.

Ecology. The specimens were collected from leaf litter approximately of 2 cm thickness. The study area is situated at an altitude of 897 meters. It is a shady place with minimum of sunlight penetration. Mean annual temperature is 20.2 °C. Average annual rainfall is 6,066 mm with 95% relative humidity. It is a primary undisturbed tropical moist evergreen forest.



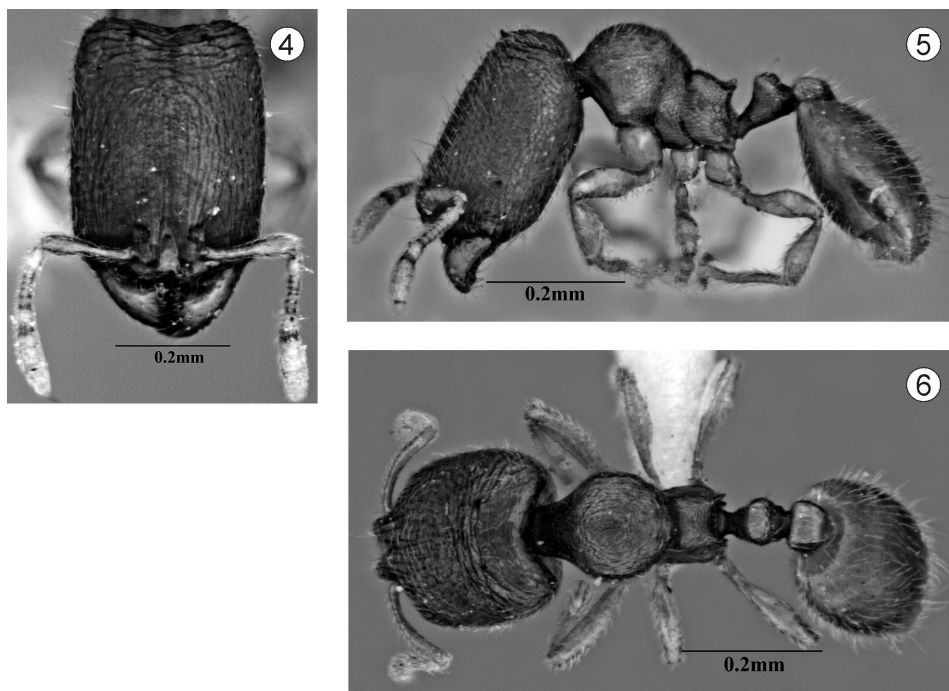
**Figs 1–3.** *Carebara mukkaliensis* sp. n., major worker: 1 = head in full-face view, 2 = body in lateral view, 3 = body in dorsal view.

*Carebara obtusidenta* (Xu, 2003)  
(Figs 4–6)

Material examined – Arunachal Pradesh: Lumla, 2800 m, 27.31°N, 91.43°E, 2 (major workers), 8.x.2013. Sikkim: Rorathang, 587 m, 27.11°N, 88.36°E, 2 (major workers), 12.vi.2012 (coll. Shahid A. Akbar & Joginder Singh). Kerala: Periyar tiger reserve, Thanikkudy, 9° 30'N, 77° 16'E, 1003m a.s.l., 3 (major workers), 15.x.2011 (coll. Shahid A. Akbar).

Differential diagnosis. *C. obtusidenta* (Xu, 2003) is allied to *C. spinata* Bharti et Kumar, 2013, however, the two species can be easily separated. In case of *C. obtusidenta* masticatory margin of mandibles is having 4-teeth, anterior margin of clypeus concave without lateral developed teeth, propodeal spines are acute and up-curved, postpetiole broader than petiole and head predominantly longer than broad whilst in case of *C. spinata* masticatory margin of mandibles is having 5-teeth, anterior margin of clypeus with two prominent lateral teeth, propodeal spines are acute and straight, postpetiole as broad as petiole and head slightly longer than broad.

Interestingly the specimens collected in India are having body relatively smaller, head and propodeal teeth relatively longer. These differences are ob-



**Figs 4–6.** *Carebara obtusidenta* (Xu, 2003), major worker: 4 = head in full-face view, 5 = body in lateral view, 6 = body in dorsal view.

served among type specimens and can be safely placed within limits of intraspecific variations (Xu, pers. comm.).

Ecology. During the intensive surveys this hypogaecic ant was encountered mostly in leaf litter samples.

### **Carebara terayamai** sp. n.

(Figs 7–9)

Type material – Holotype (major worker) and 3 paratypes (major worker): INDIA: Kerala, Periyar tiger reserve, Thanikkudy, 9°30'N, 77°16' E, 1003m a.s.l., 15.x.2011, Winkler method (coll. Shahid A. Akbar). Additional 2 paratypes (major workers): INDIA: Arunachal Pradesh, Lumla, 2800 m, 27.31°N, 91.43°E, 12.vi.2012 (coll. Shahid A. Akbar & Joginder Singh). Holotype and paratype in PUAC; one paratype will be deposited in BMNH.

Description – Major worker. Measurements (holotype in brackets): HL 0.52-(0.55), HW 0.43-(0.46), SL 0.22-(0.26), ED 0.03-(0.04), ML 0.10-(0.15), MSL 0.40-(0.45), PW 0.21-(0.24), PTL 0.13-(0.15), PPTL 0.09-(0.12), PTW 0.06-(0.10), PPTW 0.10-(0.12), PTH 0.11-(0.13), PPTH 0.08-(0.09), HHL (0.04), CI 82-(83), SI 51-(56), EI 7-(8) (n=4).

Head longer than broad, rectangular in full face view. Occipital margin strongly concave in the middle with occipital corners almost straight, acutely rounded, lateral sides convex. Mandible with 4-teeth. Median portion of clypeus broad depressed, slightly divergent forward, anterior margin weakly concave. Antennae 9-segmented with a 2-segmented club, scapes short and clavate; reaching up to 1/3rd of posterior margin of head. Eyes with single well developed ommatidium. In profile view, vertex with a pair of well developed acute and upcurved horns. Dorsum of head convex.

Promesonotum high and roundly convex. Promesonotal suture obsolete on the dorsum. Metanotum less prominent. Metanotal groove deeply impressed. Propodeum with posterodorsal corners rounded to bluntly angled, dorsum straight and sloping down rearwards, declivity truncate to nearly straight. Petiole pedunculate anteriorly, ventral face straight. Petiole node thick with sloping anterior and posterior faces, dorsum straight to cone shaped. Postpetiole node roundly convex and lower than petiolar node. In dorsal view postpetiolar node broader than the petiolar node.

Mandibles and clypeus smooth and shiny. Head finely and longitudinally striated anteriorly and posteriorly, smooth in the middle with few longitudinal striations. Transverse striations present between vertexal horns. Mesosoma smooth and shining; lateral sides of propodeum punctuate. Petiole and postpetiole finely punctured. Gaster smooth and shining.

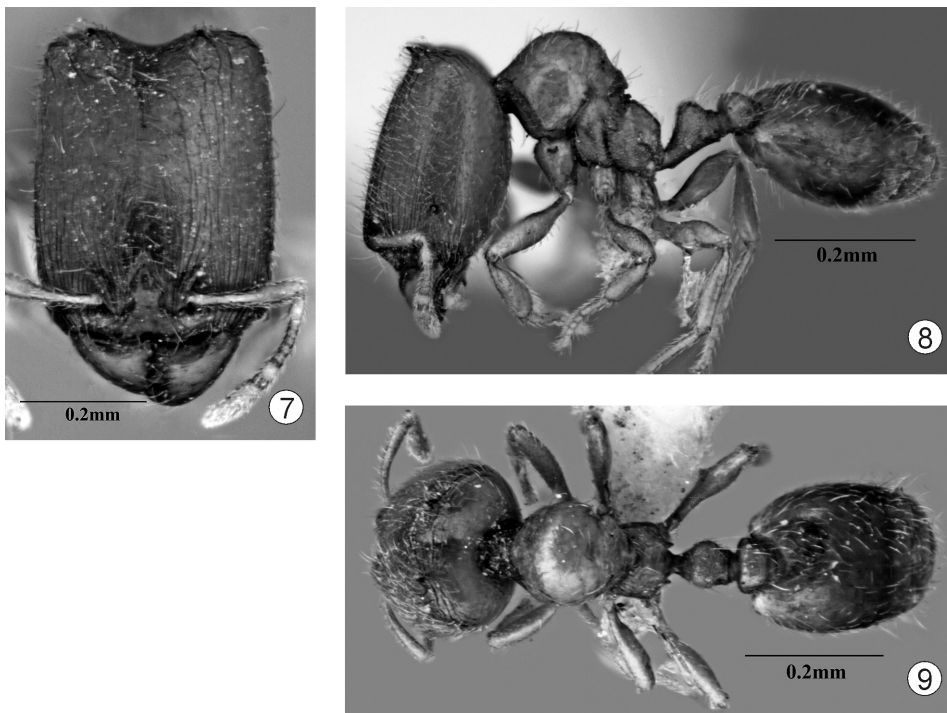
Head and body with abundant erect to suberect hairs. Scapes and tibiae with dense decumbent pubescence.

Body brownish in colour. Head and gaster darker than rest of body.

Etymology. The species is named after Mamoru Terayama for his contributions to ant systematics.

Differential diagnosis. *C. terayamai* sp. n. is close to *C. sauteri* (Forel, 1912), however, the two species can be easily separated. In case of *C. terayamai* pos-

terior margin of head is strongly concave, cephalic dorsum predominantly sculptured with longitudinal and transverse rugae present, posterodorsal corners of propodeum forming an angle not rounded, postpetiole broader than petiole, pro and mesonotal dorsum strongly convex in profile, subpetiolar process without a small blunt tubercle whilst in case of *C. sauteri* posterior margin of head is shallowly concave, cephalic dorsum is mostly smooth with few transverse rugae on vertex, posterodorsal corners of propodeum rounded, not forming an angle, postpetiole as broad as petiole, pro and mesonotal dorsum moderately convex in profile and subpetiolar process bearing a small blunt tubercle. The new species is also similar to *C. dentata* Bharti et Kumar, 2013. However, the two species can be easily separated. In case of *C. terayamai* posterior margin of head is strongly concave, vertexal horns are well developed, cephalic dorsum is mostly sculptured, metanotal groove deeply impressed and body is dull, not shiny whilst in case of *C. dentata* posterior margin of head is weakly concave, vertexal horns are reduced, cephalic dorsum is mostly smooth, metanotal groove is less deeply impressed and body is shining. *C. terayamai* also shares affinities with *C. rectidorsa* (Xu, 2003) but the strong sculp-



**Figs 7–9.** *Carebara terayamai* sp. n., major worker: 7 = head in full-face view, 8 = body in lateral view, 9 = body in dorsal view.

ture over whole dorsum of head, vertex with well-developed horns and posterodorsal corner of propodeum clearly bluntly angled.

Ecology. This species seems to be infrequent in occurrence. Specimens were collected by Winkler extraction method from Thanikkudy region of Periyar Tiger Reserve and Lumla region of Arunachal Pradesh.

## DISCUSSION

*Carebara* is a very complex genus and isolated descriptions of sexes and castes are difficult to integrate. However, the new species described here are distinct and easily separated from other congeneric species. Among the 20 known Indian species (Table 1) of genus *Carebara*, 10 species (*C. bengalensis*, *C.*

**Table 1.** Known Indian species of genus *Carebara*. Abbreviations: s = soldier or major worker, w = minor worker, m = male, q = queen, – = not known. Major workers in this genus usually have more similarities with queens and so this genus is a rare situation where the females might have turned into major workers (BARONI URBANI & PASSERA 1990).

S. no.	Species known from India	Castes known	Antennal count
1.	<i>C. aborensis</i> (Wheeler, 1913)	s, w	9, –
2.	<i>C. asina</i> (Forel, 1902)	s, w, q	9, –, –
3.	<i>C. bengalensis</i> (Forel, 1902)	q, m	9, 13
4.	<i>C. carinata</i> Bharti et Kumar, 2013	w	11
5.	<i>C. dentata</i> Bharti et Kumar, 2013	s, w	9, 9
6.	<i>C. hornata</i> Bharti et Kumar, 2013	s, w	9, 9
7.	<i>C. lamellifrons</i> (Forel, 1902)	q	11
8.	<i>C. leei</i> (Forel, 1902)	q	9
9.	<i>C. lignata</i> Westwood (1840)	q, w, m	10, –, –
10.	<i>C. mukkaliensis</i> sp. n.	s	9
11.	<i>C. nayana</i> (Sheela et Narendran, 1997)	s	11
12.	<i>C. obtusidenta</i> (Xu, 2003)	s, w	9, 9
13.	<i>C. propomegata</i> Bharti et Kumar, 2013	w	9
14.	<i>C. raja</i> (Forel, 1902)	q	9
15.	<i>C. rectangulata</i> Bharti et Kumar, 2013	s, w	9, 9
16.	<i>C. rothneyi</i> (Forel, 1902)	q, m	9, 13
17.	<i>C. similis</i> (Mayr, 1862)	w	10
18.	<i>C. spinata</i> Bharti et Kumar, 2013	s, w	9
19.	<i>C. terayamai</i> sp. n.	s	9
20.	<i>C. wroughtonii</i> (Forel, 1902)	w.	10



*carinate*, *C. lamellifrons*, *C. leei*, *C. lignata*, *C. propomegata*, *C. raja*, *C. rothneyi*, *C. similis*, and *C. wroughtonii*) do not have the description of majors. Out of these 10 species, four species (*C. wroughtonii*, *C. similis*, *C. carinate* and *C. propomegata*) are described on minor workers. Regardless of monotonous nature of these minor workers and no available description of majors, these four species are easily differentiated from other known Indian species. *C. carinate* is distinct with its 11-segmented antennae and a central isolated hair on the anterior clypeal margin. *C. similis* and *C. wroughtonii* have 10-segmented antennae, which easily separate them from other known Indian species of genus. *C. propomegata* is the only known species of its complex (*escherischi* = *Paedalgus* complex) to be reported from India. Out of rest of six species that are without described major caste (*C. bengalensis*, *C. lamellifrons*, *C. leei*, *C. lignata*, *C. raja* and *C. rothneyi*) three species (*C. lamellifrons*, *C. leei* and *C. raja*) are only having description of queens available; two species (*C. bengalensis* and *C. rothneyi*) are having descriptions of male and female castes while one species (*C. lignata*) is having description of queen, worker, and male available. Among these *C. lamellifrons* with its 11-segmented antennae and *C. lignata* with central isolated hair on the anterior clypeal margin and femora and tibiae with brown rings are marked as distinct species. Median portion of clypeus longitudinally depressed, bicarinate with anterior margin strongly concave, propodeum with a pair of protruding dents and distinct cephalic sculpture easily separates *C. mukkaliensis* from *C. bengalensis*, *C. leei*, *C. raja* and *C. rothneyi*. While high convex promesonotum, metanotal groove deeply impressed and propodeum with posterodorsal corners bluntly angled easily separates *C. terayamai* from *C. bengalensis*, *C. leei*, *C. raja* and *C. rothneyi*.

KEY TO INDIAN SPECIES OF CAREBARA  
BASED ON MAJOR WORKER  
(modified after BHARTI & KUMAR 2013)

- 1 Antenna 11-segmented *C. nayana* (Sheela et Narendran)
- Antenna 9-segmented 2
- 2 Eyes distinct with numerous ommatidia (>8); base of first gastral tergite finely reticulate with traces of fine longitudinal rugae *C. aborensis* (Wheeler)
- Eyes rudimentary with few ommatidia (<4); base of first gastral tergite smooth and shining 3
- 3 Vertex without a pair of distinct horns or minute teeth *C. rectangulata* Bharti et Kumar

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- Vertex with a pair of distinct horns or minute teeth 4
  - 4 Vertexal corners protruding into a pair of well-developed acute horns or spines 5
  - Vertex with a pair of small minute horns or teeth in lateral view 6
  - 5 Head rectangular with straight parallel sides, punctured only and finely longitudinally rugulose anteriorly; occiput and vertex smooth and shining  
*C. hornata* Bharti et Kumar
  - Head with convex sides, sparsely punctured and longitudinally obscurely striated anteriorly; occiput and vertex wrinkled *C. asina* (Forel)
  - 6 Propodeum with a pair of protruding dents or spines 8
  - Propodeum unarmed, posterodorsal corner rounded or bluntly angled 7
  - 7 Cephalic dorsum unsculptured, smooth and shining; vertexal horns reduced  
*C. dentata* Bharti et Kumar
  - Cephalic dorsum sculptured, dull; vertexal horns well-developed  
**C. terayamai** sp. n.
  - 8 Head with lateral sides convex, almost as long as broad (CI 84-85)  
*C. spinata* Bharti and Kumar
  - Head with parallel lateral sides, longer than broad (CI 74-78) 9
  - 9 Anterior margin of clypeus concave without lateral developed teeth; Propodeal spines well developed; masticatory margin of mandible with 5-teeth  
*C. obtusidenta* (Xu)
  - Anterior margin of clypeus with two prominent lateral teeth; Propodeal spines reduced; masticatory margin of mandible with 4-teeth  
**C. mukkaliensis** sp. n.

[Note: *C. bengalensis*, *C. carinata*, *C. lamellifrons*, *C. leei*, *C. lignata*, *C. propomegata*, *C. raja*, *C. rothneyi*, *C. similis* and *C. wroughtonii* are excluded from the key as their major workers are not known].

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