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RESEARCH ARTICLE

A new species of *Paraphaenodiscus* Girault (Hymenoptera: Encyrtidae) from India parasitizing *Coccus* sp. (Hemiptera: Coccidae)

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Abstract: A new species, *Paraphaenodiscus udayveeri* Singh **sp. nov.**, has been described and illustrated with automontaged photographs of both male and female. Species parasitized scale insects on the leaves of *Pterygota alata* which were weaved into nest of red weaver ant, *Oecophylla smaragdina* (Hymenoptera: Formicidae). Species is compared with *P. chrysocomae* Prinsloo and *P. pedanus* Prinsloo & Mynhardt. Key to world species of *Paraphaenodiscus* except European species is also given. Types are deposited with National Forest Insect Collection, Entomology Division, Forest Research Institute, Dehra Dun, India (NFIC-FRI).

Key words: Chalcidoidea, *Paraphaenodiscus udayveeri* Singh sp. nov., key to species, *Pterygota alata*, Coccidae, *Oecophylla smaragdina*.

Introduction

Pterygota alata (Sterculiaceae) commonly called Buddha Coconut is an indigenous soft wooded tree species. At New Forest, Dehradun it was planted along Clutterbuck Road but due to undisturbed conditions has regenerated into a thick patch of forest. There is hardly any insect pest of the tree except occasional scale insects belonging to genus *Coccus* (Hemiptera: Coccidae) present on underside of the leaf. Red weaver ant, *Oecophylla smaragdina* (Hymenoptera: Formicidae) usually weave the scale infested leaves into their nest 25-30 m up into the canopy. From these scales two species of encyrtids emerged - *Encyrtus noyesi* Singh and a new species of *Paraphaenodiscus* which is described in this

paper. This is an interesting species and has light fuscous body color not seen in any other species described under the genus.

The genus *Paraphaenodiscus* was described by Girault (1915) and has worldwide distribution, except Neotropics. The genus can be recognized by characters given in Prinsloo (1976), Prinsloo & Mynhardt (1982) and Singh & Agarwal (1993). They are parasitoids of Coccidae (Hemiptera) (Noyes & Hayat 1984). It belongs to the tribe Microterysiini and subtribe Microterysiina and closely resembles *Microterys* Thomson from which it can be separated mainly on the basis of presence of apical scutellar flange, and on the infuscation of the fore wing of the female.

Prinsloo (1976) and Prinsloo & Mynhardt (1982) have dealt with the Ethiopian species of the genus, former has given detailed generic diagnosis for females based on the type species i.e., *P. verus* Girault and other species *P. wundti* (Girault). Prinsloo (1976) also remarked that Australian and Ethiopian species, which are closely related are not congeneric with Palaearctic ones. Trjapitzin (1989) has dealt with Palaearctic species.

Singh & Agarwal (1993) reported the genus for the first time from Assam, India and described a new species, later Bhuiya (1998), Hayat & Badruddin in Hayat *et al.* (2008) and Hayat (2015) added one species each from the subcontinent. At present 19 species are described from the following regions of the world: Australian (3 species) - *parus* (Girault, 1915), *verus* Girault (1915) and *wundti* (Girault, 1915). Ethiopian: (9) species) - *africanus* Prinsloo (1976), *ceroplastodesi* (Risbec, 1951), *chrysocomae* Prinsloo (1976), *munroi* Prinsloo (1976), *niger* Prinsloo (1976), *paralis* Prinsloo & Mynhardt (1982), *pedanus* Prinsloo & Mynhardt (1982), *pavoniae* Risbec (1951), and *rizicola* (Risbec, 1951). Oriental: (5 species) - *indicus* Singh & Agarwal (1993), *monawari* Bhuiya (1998), *nesiotes* Hayat (2015), *ramamurthyi* Hayat & Badruddin in Hayat *et al.* (2008) and *udayveeri* Singh, sp. nov. Palaearctic: (2 species) - *murgabicus* Myartseva (1980), and *sugonjaevi* Myartseva (1980).

Material and methods

Collection of scale insect infested leaves of *Pterygota alata* from a height of 25-30 m was great problem. During late March to May, trees shed their leaves and some ant nests were also shed. These fallen nests were collected and searched for scales. Recently abandoned and live nests were found to have small to moderate size of scale insect colonies. Nests were carefully opened and scale infested portions of the leaves were cut with the help of scissors. They were reared in the laboratory for emergence of parasitoids. Specimens which emerged were collected with aspirator, killed in ethyl acetate fumes and stored in 80% ethanol. They were later, cleaned and dried using HMDS (Brown 1993). Dried specimens were photographed by Automontage System with Micropublisher Q-Imaging 5.0 RTV camera mounted on Olympus SZX-16 stereozoom microscope. Automontaged photographs of slide mounted parts were taken with Nikon Digital Sight DS-Fi1 using EDF module of NIS-Br software (Nikon) mounted on Nikon Optiphot compound microscope. Holotype and paratype (male) were macrophotographed prior to dissected and mounted on slides.

Terminology used in the descriptions follows Noyes & Hayat (1984) and Huber & Sharkey (1993). Abbreviations of morphological terms used in the text are: F1, F2, etc. = first, second, etc. funicle segment; OCL = distance between a posterior ocellus and occipital margin; OOL = distance between an eye and posterior ocellus; POL = distance between posterior ocelli; ITD = distance between the toruli, TED = shortest distance between torulus and eye margin, TMD = distance between torulus and mouth margin, TVII = seventh tergum. Measurements provided in the descriptions, except for whole body length, were taken from

single specimens that were used for photography for the plates of illustrations and are labeled as such. All measurements given in the descriptions are in μm , unless stated otherwise. All the type materials are deposited with National Forest Insect Collection, Entomology Division, Forest Research Institute, Dehra Dun, India (NFIC-FRI).

Results

Paraphaenodiscus udayveeri Singh sp. nov. (Figs 1–24)

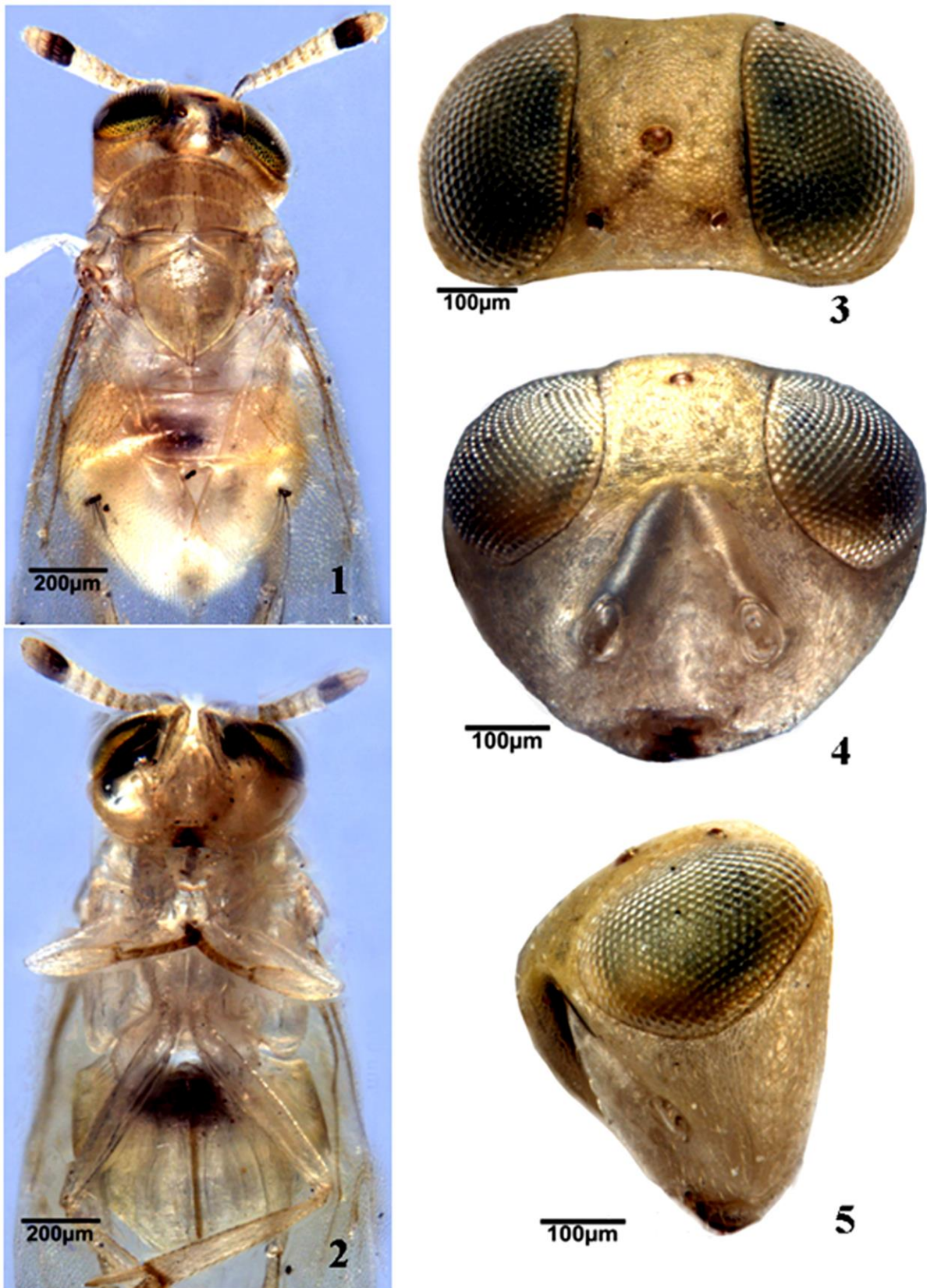
urn:lsid:zoobank.org:act:5B2FA1AD-E89C-4A97-B301-4B2E0D380546

Description of Female (Figs 1-13):

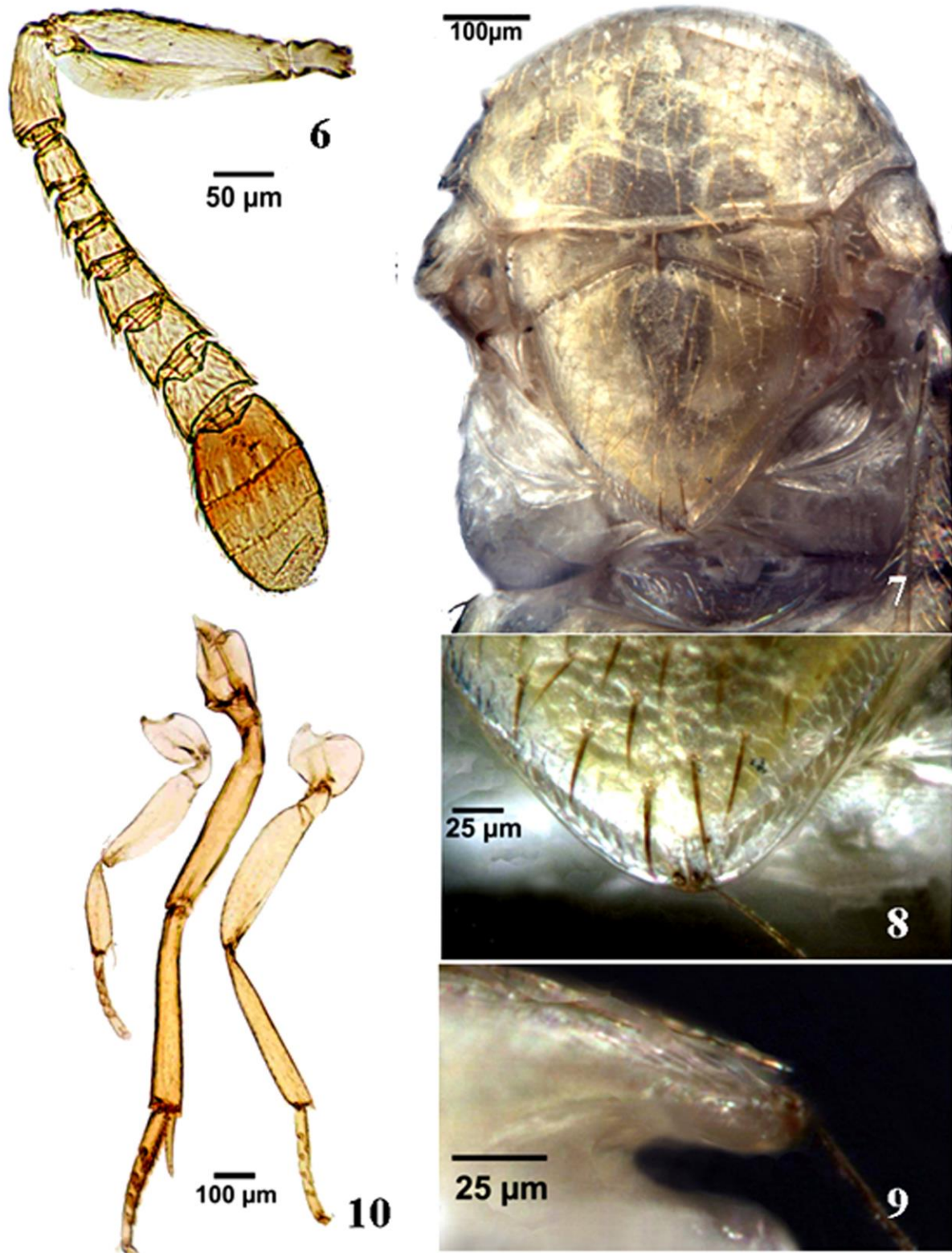
Length. 0.98–1.4 mm (1.2 ± 0.17 mm, $n = 4$), Holotype. 1.4 mm.

Color/Sculpture. Body (Figs 1–2) Head, pronotum, mesoscutum, axillae, tegulae and scutellum light yellow dorsally; rest of mesosoma on lateral sides and venter, metanotum, propodeum, and legs off white; metasoma completely off white. Head with scrobes, antennal prominence, malar space whitish; frontovertex with small, polygonal reticulate sculpture; scrobes and malar area with weakly elongate-reticulate sculpture; frontovertex with about 40–50 small pale setae arranged roughly in four rows, apart from a row of setae along inner margin of each eye; gena, inter-torular prominence, and mouth margin with sparse setae. Eyes gray, aetose. Mandible dark reddish brown apically and whitish at basal two-thirds. Maxillary and labial palpi off-white. Antenna (Fig. 6) light yellow, distal half of flange of scape and a small area on distal frontal side of pedicel suffused light brown and club with basal segment completely and middle segment at basal third dark brown. Pronotum, mesoscutum, axillae and scutellum with faint delicate reticulate sculpture; pronotum with about 20 long setae along collar, mesoscutum with about 8-10 horizontal rows, axillae with 8–10 and scutellum with 12–14 horizontal rows of yellowish setae; scutellar flange with a pair of closely placed long yellow setae, anterior to these setae two pair of light brown setae with length about half of discal setae. Fore wing (Fig. 11) suffused light brownish yellow, veins and discal setae yellowish, a distal band of black setae present at the sub apical area of disc, beyond this dark band subapical portion of wing without yellowish fumation; Hind wing hyaline. Legs (Fig. 10) completely off white with tarsi lightly suffused with brownish tinge, pretarsi apically darker. Metasoma at the middle of basal tergite with a dark diffused spot, cercal plates and cercal setae dark brown to black; stylets of ovipositor brownish.

Structure. Head, in dorsal view (Fig. 3), with anterior and occipital margins slightly concave and convex, respectively; eyes not reaching occipital margin posteriorly; frontovertex fully exposed, $1.4\times$ as long as wide and at level of anterior ocellus $0.3\times$ head width (200:617); ocelli almost in a right angled triangle, apical angle about 88° ; anterior ocellus larger than posterior ocellus which is two-thirds the diameter of anterior ocellus; POL $3.5\times$, OCL $1.27\times$, and OOL $0.75\times$ as long as diameter of anterior ocellus (132: 47: 28: 37). Head, in frontal view (Fig. 4), about $0.8\times$ (446: 554) as high as wide; scrobes moderately deep, not meeting dorsally; toruli half their length below the line joining lower margins of eyes, widely separated, torulus $1.8\times$ (75: 42) as high as wide; ITD $1.7\times$, TMD $0.9\times$, TED $1.26\times$ height of torulus (= 126: 74: 95: 75). Head, in profile (Fig. 5), with anterior margin angled at right angle; malar space $0.44\times$ (200: 446) head height, $0.68\times$ eye height; eye $1.14\times$ (290: 254) as high as wide. Antenna (Fig. 6) with scape widest at distal two-thirds, $2.6\times$ (177: 67) as long as wide; pedicel conical, $2.27\times$ (91: 40) as long as wide; funicle 6-segmented, all segments



Figures 1–5. *Paraphaenodiscus udayveeri* sp. nov., female (holotype). **1**, dorsal view of body; **2**, ventral view of body; **3**, head in dorsal view; **4**, head in frontal view; **5**, head in profile.



Figures 6–10. *Paraphaenodiscus udayveeri* sp. nov., female. (holotype) **6**, antenna; **7**, dorsal view of mesosoma; **8**, dorsal view of scutellar flange; **9**, lateral view of scutellar flange; **10**, legs – pro-, meso and metaleg (from left to right).

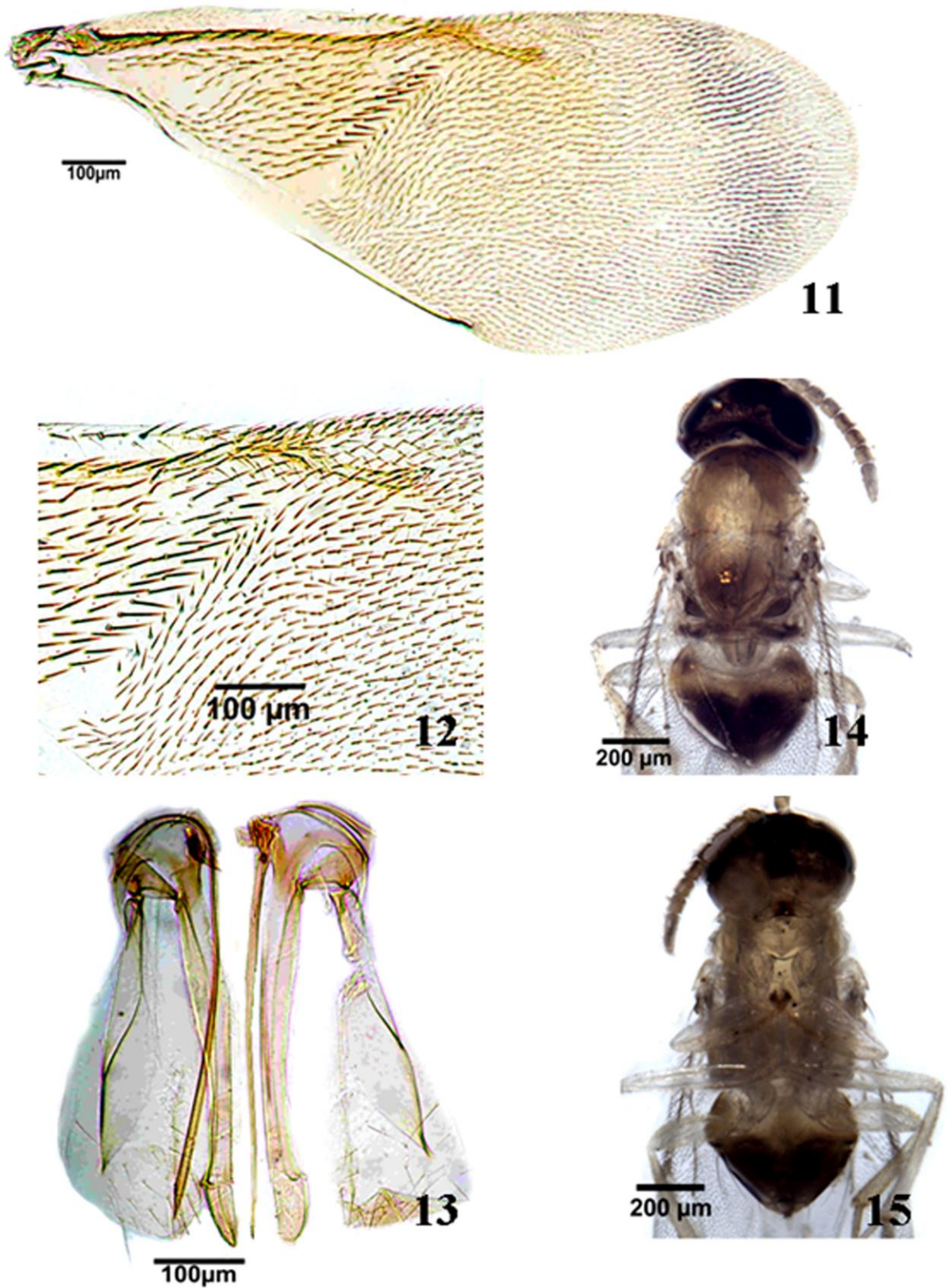
wider than long except F1 slightly longer than wide (35: 33), F2 1.34× (35: 26), F3 1.25× (39: 31), F4 1.37× (48: 35), F5 1.33× (56: 42) and F6 1.5× (66: 44) as wide as long; club 3-segmented, slightly obliquely truncate, 1.68× (143: 87) as long as wide. Mesosoma (Fig. 7) slightly convex from side to side 1.24× (670: 540) as long as wide; visible part of pronotum a narrow stripe; mesoscutum, 2.1× (545: 259) as wide as long; scutellum not as convex as mesoscutum, slightly longer than wide (321: 313) and about a fifth longer than mesoscutum (313: 259), distal half of lateral sides flanked (Fig. 8); scutellar flange distally (Fig. 9) 0.14× scutellum length (45: 321); propodeum narrow in about middle third, and totally hidden under the scutellar flange. Fore wing (Figs 11, 12) 2.35× (1267: 539) as long as wide; postmarginal vein 1.27× and stigmal vein 2.0× marginal vein length (83: 132: 65). Mesotibial spur distinctly longer than mesobasitarsus (172: 165); mesotibial apical rim with 8–10 pegs; basitarsus with 22–24, second tarsomere with 10–12, third tarsomere with 8, and fourth tarsomere with 6–8 pegs. Metasoma (Fig. 1) almost as long as wide (555: 511), 0.8× mesosoma length (555: 670), pointed apically, with cercal plates situated at middle; hypopygium reaching halfway; ovipositor sheaths not exerted; ovipositor (Fig. 13), 0.96× as long as mesotibia (497: 514).

Description of Male (Figs 14-24):

Length. 0.836–1.123 mm (0.94 ± 0.95 mm, $n = 6$).

Color/Sculpture. Yellowish brown to dark brown areas on head, meso- and metasoma (Figs 14, 15). Head (Figs 16–18) with dorsal half above toruli and antennal prominence dark brown to black with metallic reflections; frontovertex metallic green with yellowish to golden reflections with uneven reticulate punctuate sculpture and scattered with two rows of punctuate setae; scrobal area and antennal prominence with metallic greenish blue with violet reflections, scrobes smooth not meeting dorsally, sides of scrobes and antennal prominence with reticulate sculpture with small pale setae; eyes grays aetose, ocelli with pinkish touch. Mandibles with three acute teeth which are dark reddish brown, rest yellowish. Dorsal post-occiput above foramen dark brown; rest of head whitish. Antenna (Fig. 19) with scape whitish and rest of segments pale yellowish brown, with similar colored setae. Legs similar to those of female. Mesosoma (Fig. 20) dorsally yellow with following brownish fumations: pronotum dorsally and dorsal half of frontal area, anterior third of mesoscutum, whole of scutellum, metanotum and propodeum; scutellum and at middle line, metanotum and sides of propodeum darker; scutellum at apex with light green metallic reflections; Fore wing (Fig. 21) and hind wing hyaline with black setae and yellowish brown veins. Metasoma (Fig. 20) dorsally with anterior two terga pale yellowish; sides of first tergum and middle third of second with light brown suffusion; middle half of third and fourth and rest whole of terga dark brown with light reddish metallic reflections; ventrally distal half brown.

Structure. Head, in dorsal view (Fig. 16) with anterior margin deeply concave, posterior margin almost straight or slightly convex, 2.2× (380: 170) as wide as frontovertex at level of anterior ocellus; sides of frontovertex narrowly diverging from anterior of middle ocellus; ocelli arranged in right-angled triangle; POL 2.42×, OOL 0.5×, and OCL 0.6× diameter of median ocellus (= 85: 17: 21: 35). Head, in frontal view (Fig. 17), 1.18× as wide as high (376: 316); scrobes shallow, not meeting dorsally; dorsal one-third of torulus on line joining ventral margin of eyes; ITD 1.14×, TED and TMD each 1.24× the height of torulus (= 57: 62: 62: 50). Head, in profile (Fig. 18), with height 2.8× (316: 110) malar space; eye 1.14× (194: 169) as high as wide. Antenna (Fig. 19) with scape short and spindle shaped, 3.16× (114: 36) as long as wide and 1.9× as long as pedicel; pedicel 1.48× (58: 39) as long as wide (58: 39);



Figures 11–15. *Paraphaenodiscus udayveeri* sp. nov., female (holotype, 11–13) and male (paratype, 14–15) **11**, fore wing showing infuscation and setation; **12**, part of fore wing showing venation; **13**, ovipositor; **14**, dorsal view of body; **15**, ventral view of body.

funicle 6-segmented, all segments as wide as long, except F1 clearly longer than wide (48: 44), F2–F6 more or less quadrate, F2 (46: 47), F3 (48: 47), F4 (48: 47), F5 (55: 52) and F6 (52: 45); club un-segmented, $2.17\times$ (113: 52) as long as wide. Mesosoma (Fig. 20) slightly narrower than head (359: 376), $1.28\times$ (462: 359) as long as wide; mesoscutum $1.9\times$ (364: 192) as wide as long; scutellum as long as wide (225: 231). Fore wing (Figs 21, 22) $2.18\times$ (879: 403) as long as wide; length of marginal vein: post marginal: stigmal vein = 39: 68: 78. Mesotibial spur as long as mesobasitarsus length (90). Metasoma almost as long as wide (380:390), $0.82\times$ mesosoma length (380: 462); genitalia (Figs 23-24) with aedeagus length: phallobase length: digitus length = 133: 150: 26; digitus with 1 hook and a spur; phallobase $0.46\times$ (133: 286) mid tibia length.

Variations: There are on variations among females and males except for their sizes. Length of females ranged from 0.98 mm–1.4 mm and that of males from 0.83 mm–1.12 mm

Material examined: Holotype (NFIC-FRI; Accession No. 21945): ♀, on a slide under eight cover glass, labeled “INDIA, Uttarakhand, Dehradun, New Forest, Clutterbuck Road, 15.v.2015, Udayveer Singh Andotra, ex. scales on leaves of *Pterygota alata* in nest of red weaver ant, *Oecophylla smaragdina* (Hymenoptera: Formicidae). **Paratypes** (NFIC-FRI; Accession No. 21945): 4♀, 5♂: 3♀ and 4♂, each specimen card-mounted and pinned separately and 1♂, dissected and mounted on left side of slide with holotype under six covers; same data as holotype; 1♀, on card, “INDIA, Uttarakhand, Dehradun, New Forest, Clutterbuck Road, 20.iii.2010; Sudhir Singh.

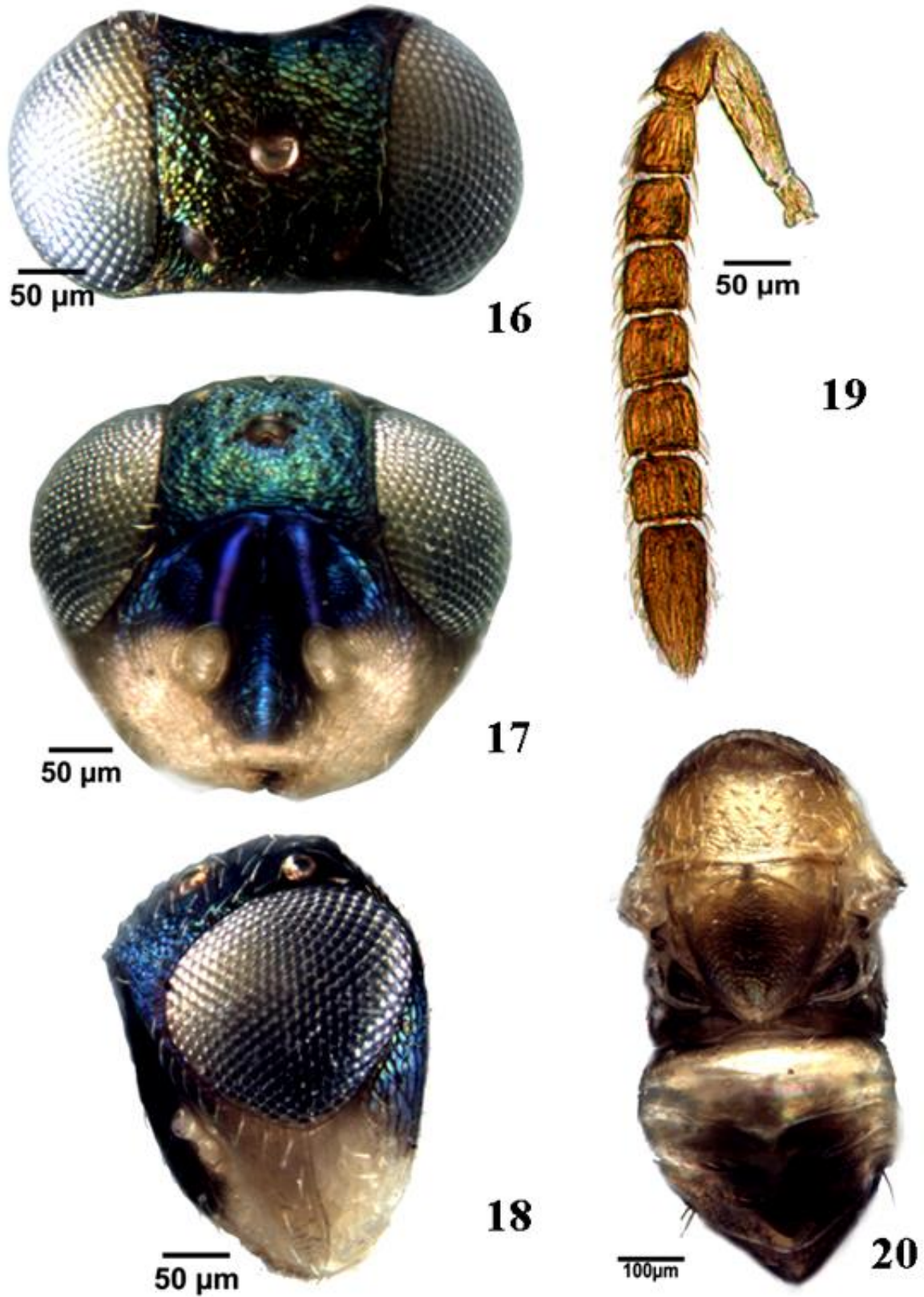
Host: *Coccus* sp. (Hemiptera: Coccidae) on underside the leaves of *Pterygota alata* (Sterculiaceae).

Distribution: India: Uttarakhand.

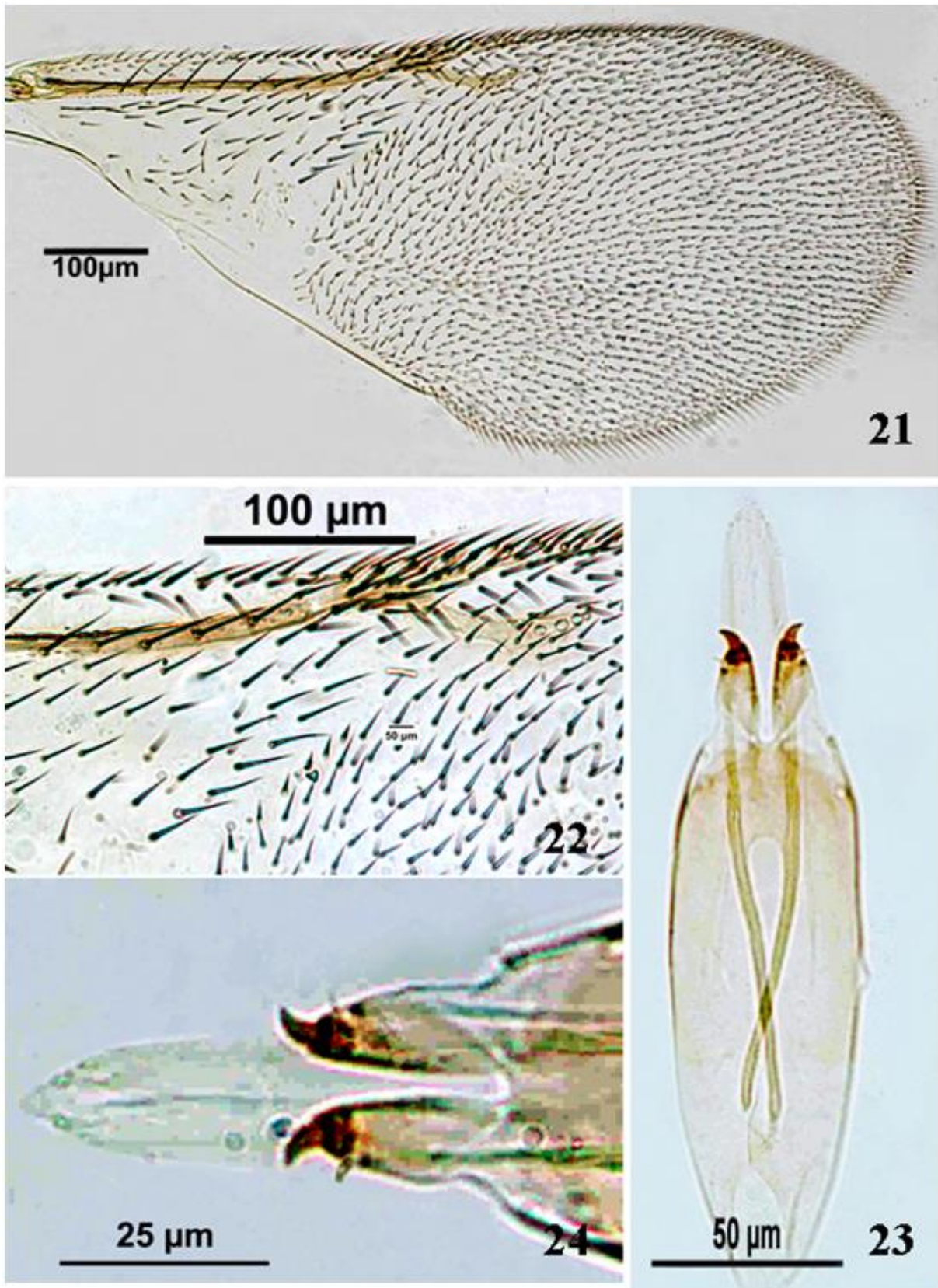
Etymology: The species is named after my son Udayveer who collected some of the red weaver ant nests.

Comments: This is a distinct species with completely pale yellow body and unicolourous funicle segments; cercal plates and ventrally base of metasoma with brownish infuscation which is also visible as a small diffused spot dorsally on the basal tergite.

The species has been very well separated out in the above key and is closest to *chrysocomae* Prinsloo and *pedanus* Prinsloo & Mynhardt. It differs from *chrysocomae* on following characters (characters in bracket are those of *chrysocomae*): Female: ocelli almost in a right angled triangle, apical angle about 88° (acute angled triangle); OOL $1.5\times$ lateral ocellus diameter ($<1\times$ ocellus diameter), TMD $0.9\times$ height of torulus ($0.5\times$); antennal scape, $2.6\times$ ($3\times$) as long as wide; dimensions of funicle segments are also quite different. Male: Head with dorsal half dark brown to black with metallic reflections, below eyes whitish (completely dark brown to black), legs completely whitish (coxae, femora and hind tibia dark brown); all antennal funicle segments, except F1 quadrate (all funicle segments longer than wide). It also differs from *pedanus* on the basis of following characters (characters in bracket are those of *pedanus*): Both sexes are macropterous form (brachypterous), head $3\times$ as wide as frontovertex width at level of anterior ocellus ($2.6\times$); ocelli almost in a right angled triangle, apical angle about 88° (slightly obtuse-angled triangle); Ovipositor $0.96\times$ as long as mesotibia ($1.3\times$), $6.75\times$ III-valvulae length ($5\times$); males color, see above (head completely



Figures 16–20. *Paraphaenodiscus udayveeri* sp. nov., male (paratype). **16**, head in dorsal view; **17**, head in frontal view; **18**, head in profile; **19**, antenna; **20**, meso and metasoma in dorsal view.



Figures 21–24. *Paraphaenodiscus udayveeri* sp. nov., male (paratype). **21**, fore wing; **22**, part of fore wing showing venation; **23**, genitalia; **24**, distal part of genitalia enlarged to show details.

dark brown with metallic green and bronzy reflections) with all antennal funicle segments, except F1, quadrate (all funicle segments at least 2× as long as wide).

Key to species: The key to females of the world species (except palaeartic), based on Girault (1915), Prinsloo (1976), Prinsloo & Mynhardt (1982) and Singh and Agarwal (1993), Hayat (2006) and Hayat & Badruddin in Hayat *et al.* (2008), has been fabricated. *P. rizicola* (Risbec) and *P. ceroplastodesi* (Risbec) could not be accommodated in the key - former for want of insufficient description and latter is based on male.

Key to species of *Paraphaenodiscus* Girault, based on females

- 1 Head entirely brownish-black to black2
- Head generally light brownish yellow to orange5
- 2 Antennal funicle largely pale testaceous; all funicle segments plainly shorter than pedicel; fore wing in macropterous forms with marginal fringe sparse, extremely short, absent along apical wing margin in some specimens 3
- Antennal funicle brownish-black to black; basal funicle segment subequal in length to pedicel; marginal fringe of fore wing well developed in macropterous forms 4
- 3 Scape at least 2× as long as pedicel; pedicel as long as basal two funicle segments combined, F1-3 each slightly longer than wide, F4-5 quadrate and F6 wider than long; frontovertex 0.33× the head width *munroi* Prinsloo
- Scape short, at most 1.5× as long as pedicel; pedicel longer than three basal funicle segments combined; all funicle segments wider than long; frontovertex 0.5× the head width *nesiotes* Hayat
- 4 Head 3.5-4.5× as wide as frontovertex; scutellar flange well developed, extending around the postero-lateral and posterior margins of the scutellum; only macropterous forms known *niger* Prinsloo
- Head 2.5-3.0× as wide as frontovertex; scutellar flange weakly developed, visible as a small, inconspicuous lamella at apex of scutellum; macropterous and brachypterous forms known .. *paralis* Prinsloo & Mynhardt
- 5 Antenna with flagellum variegated, some segments are white 6
- Antenna with flagellum unicolourous, brown or the distal segment sometimes a little darker than preceding ones 9
- 6 . Pedicel sub-equal or marginally longer than F1; antenna pale yellow; F6 and club or only club black; only macropterous forms known 7
- Pedicel long, 1.5× as long as F1; scape, pedicel, some funicle segments and club brown to black 13
- 7 Marginal vein equal to stigmal vein, 2× as long as wide; postmarginal vein short, punctiform; F6 and club black 8
- Marginal vein a little shorter than stigmal, slightly more than 2× as long as wide, only club black *verus* Girault
- 8 Face inflexed; pedicel a little longer than F1; axillae joined in the middle; mesoscutum and scutellum purplish *parus* (Girault)
- Face not inflexed; pedicel subequal to F1; axillae well separated; scutellum more purplish than mesoscutum *wundti* (Girault)
- 9 Antennal funicle and club unicolourous, brown to blackish brown *chrysocomae* Prinsloo
- Entire funicle, or at least most of the segments, notably paler than club 10
- 10 Head less than 3× (usually 2.5-2.6 x) as wide as frontovertex; only brachypterous forms known *pedanus* Prinsloo & Mynhardt
- Head 3× as wide as frontovertex; only macropterous forms known 11
- 11 Head without any mark; ovipositor as long as mid tibia *udayveeri* sp. nov.

- Head with dark marking; ovipositor longer or shorter than mid tibia 12
- 12 Head with mouth margin and lower parts of genae broadly marked with blackish; the occipital surface with an inverted V -shaped blackish mark which extends almost to the fronto-occipital margin; ovipositor longer than mesotibia *africanus* Prinsloo
- Head with mouth margin and genae not marked; the occipital surface with a small median black mark; ovipositor shorter than mesotibia *pavoniae* Risbec
- 13 Head light brown to brown; frontovertex narrow about one-fourth to one-sixth of head width; antenna variegated 14
- Head light yellow; frontovertex about one-third of head width; antennal scape and pedicel brownish yellow, F1-F3 and club dark brown to black, F4-F6 white 15
- 14 Frontovertex narrow, less than one-sixth of head width; scape highly flattened below about 1.66× as long as wide; scape and club black, pedicel and F1-F4 light brown and F5-F6 yellow *monawari* Bhuiya
- Frontovertex about one-fourth of head width; scape flattened below about 3.3× as long as wide; scape, pedicel and F3-F4 white, F1-F2 dark brownish yellow; F6 and club brown to dark brown *rizicola* Risbec
- 15 Antenna with all the funicle segments longer than wide; club slightly shorter than three preceding segments; scape as long as F1-F4 combined, swollen at base and expanded maximum at the middle; brachypterous forms known *indicus* Singh & Agarwal
- Antenna with all funicle segments quadrate to wider than long, except F1 longer than wide; club slightly shorter than preceding four funicle segments; scape as long as basal four and half funicle segments combined, not swollen at base; macropterous form known *ramamurthyi* Hayat & Badruddin

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