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Genus *Binodoxys* Mackauer, 1960 (Hymenoptera: Braconidae: Aphidiinae) from Punjab Province of Pakistan

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Abstract .- Five species of Genus *Binodoxys* Mackauer, 1960 have been reviewed from Punjab Province of Pakistan. Two species namely, *Binodoxys rubicula* and *Binodoxys angelicae* are recorded for the first time from Punjab Province of Pakistan A brief taxonomic redescription of these species together with necessary measurements are presented. New locality records and host records for already recorded species have been given. A key to five species of Genus *Binodoxys* in Punjab Province are presented. The host range, biology and distribution have also been discussed. Eight new host plant associations and fifteen new locality records have been added.

Key words: *Binodoxys*, Hymenoptera, Aphidiinae, Punjab, Pakistan

INTRODUCTION

Many species of the Genus *Binodoxys* have been recorded from different parts of the world (*e.g.* Mackauer, 1959, 1960; Starỳ, 1966, 1979; Starỳ and Schlinger, 1967; Takada, 1968; Mecheloff and Rosen, 1993; Kavallieratos *et al*., 2001) and from neighboring countries (Shujaudin, 1973; Takada and Rishi, 1980; Bhagat, 1982; Raychaudhuri, 1990). Few species have been imported from various parts of the world including India and released as potential biological control agents for the control of different pest aphids (Singh and Agarwala, 1992; Denmark and Porter, 1973; Heimpel *et al*., 2004; Desneux *et al*., 2009).

The biological control of aphids, using the aphid parasitoids, is yet inapplicable in Pakistan due to absence of basic information on Aphidiinae parasitoids. Thirty species of aphid parasitoid have been reported from Pakistan, of which eleven were recorded from Potohar region of Punjab (Starỳ *et al*., 1998; Naeem *et al*., 2005). Starỳ *et al*. (1998) reviewed the aphid parasitoids of Pakistan and listed three species of *Binodoxys*. Bodlah *et al*. (2011) reported *Binodoxys basicurvus* Shujauddin (1973) for the first time from Pakistan. In the course of various surveys that were conducted during 2005-08 for the collection of aphid parasitoids here we are recording the occurrence of *Binodoxys* from Pakistan.

MATERIALS AND METHODS

Samples of parasitized aphids together with plant parts were collected from various public parks during 2005-2008 and then transferred inside plastic bags to the laboratory. The materials were subsequently placed in plastic rearing boxes covered with cloth mesh for ventilation. Mummified aphids were also placed in gelatinized capsules.

The emerged wasps were collected using an aspirator and stored in 99% ethyl alcohol for future work. The parasitoids were identified according to reliable keys (Shujauddin 1973; Raychaudhuri, 1990; Starỳ, 1966). The illustrations were prepared using a Nikon microscope (SMS-1500, with 30x 1-11.25x magnification). Measurements of taxonomically important parts were taken using ocular micrometer in Noif microscope (XSZ 107BN, with 10X10X magnification). The morphological terminology used in this paper follows Sharkey and Wharton (1997).

RESULTS AND DISCUSSION

Genus *Binodoxys* Mackauer, 1960

Binodoxys Mackauer (*Trioxys* Haliday, Subgenus *Binodoxys* Mackauer, Haliday, A. D., 1833. Ent. Mag., 1: 261, 488).

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Antennae filiform, 11 segmented in female and 13 segmented in males (numbers recorded in Pakistan). Head sparsely to thickly haired, round across eyes. Frontal part of mesoscutum with notaulices. Propodeum with complete aerola. Forwing pterostigma more or less triangular, radial vein distinct, extend just beyond the stigma, other veins reduced. Tergite-1 with both primary and distinct secondary tubercles. Hypopygium of female contains prongs originating near apex of last sternite. Ovipositer sheath curved downwards bearing medium to long hairs. *Binodoxys* is very common genus of Aphidiinae parasitoids. It has two sets of tubercles of various sizes and shapes, on the basis of which it can be separated from the *Trioxys* genus (Kavallieratos *et al*., 2001).

KEY TO THE SPECIES OF GENUS *BINODOXYS*

1. Prongs with one long apical seta .....***shillongensis*** Starý
- Prongs with more than one long apical setae 2
2. Prongs with 3 long setae on dorsal part and two simple setae on apical part; Distance between primary and secondary tubercles equal or longer than width at spiracles (Fig. 5D)..... .....***angelicae*** Haliday
- Prongs with 3-4 long setae on dorsal part and two simple setae on apical part; Distance between primary and secondary tubercles sub equal to width at spiracles (Fig. 1E).....3
3. Metacarp (Fig. 1B) slightly (1/6) shorter than length of pterostigma and prongs curved in basal half (Fig. 1F) ....***basicurvus*** Shujauddin
- Metacarp distinctly (1/6-1) shorter than pterostigma (Fig. 2B) 4
5. Propodeum with short transvers carinae (Fig. 2C)..... .....***rubicula*** Shujauddin
- Propodeum (Fig. 4C) with long transvers carinae, prongs with two short apical hairs (Fig. 4E) .***indicus*** Subba Rao and Sharma

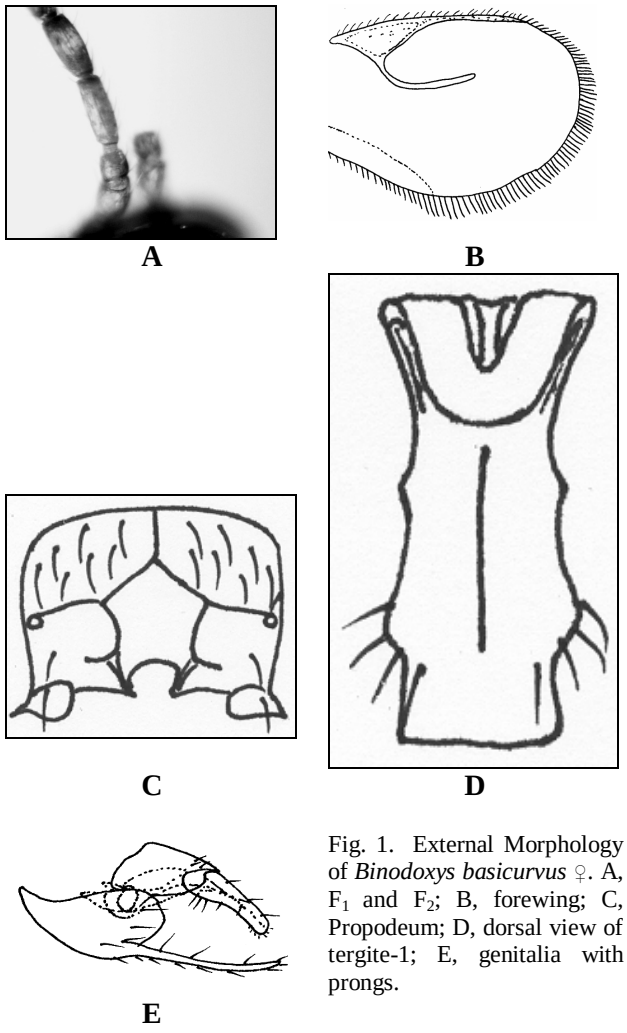

Fig. 1. External Morphology of *Binodoxys basicurvus* ♀. A, F_1 and F_2; B, forewing; C, Propodeum; D, dorsal view of tergite-1; E, genitalia with prongs.

1. *Binodoxys basicurvus* Shujauddin, 1973 (Fig.1)

Binodoxys basicurvus Shujauddin, 1973. Indian J. Ent., 35: 9-10.

Bodlah *et al*. (2011) reported this species for the first time from Pakistan.

2. *Binodoxys rubicula* Shujauddin, 1973

Binodoxys rubicula Shujauddin, 1973. Indian J. Ent., 35: 9-10.

Redescription (*Female*)

Antennae filiform, 11 segmented, F_1 as long as F_2 (Fig. 2A) with dense hairs. Wing metacarp distinctly longer than 1/2 of pterostigma (Fig. 2B). Pterostigma triangular, 3 times longer than wide. Squarish propodeum, about 3/5th as long as wide and distinctly areolated centrally with upper areolae with 6-8 setae and lower with 1 seta only (Fig. 2C). Tergite-1 dorsally smooth, about 3-3.5 times of its width at spiracles with dorsal region with a central longitudinal carina distinct at posterior half (Fig. 2D). Prongs curved in apical half. Head smooth, rounded, sparsely setose; wider than mesosoma. Large oval shaped eyes, sparsely setose and strongly convergent towards clypeus. Temple little shorter than ½ of trsnsverse eye diameter. Gena about 1/4th of longitudinal eye diameter. Clypeus with 4 long setae. Interocular line shorter than transfacial line. First flagellar segment 3 times longer than wide, segments 2-8 almost as long as F_1 and slightly thickened towards apex. Apical segment four times longer

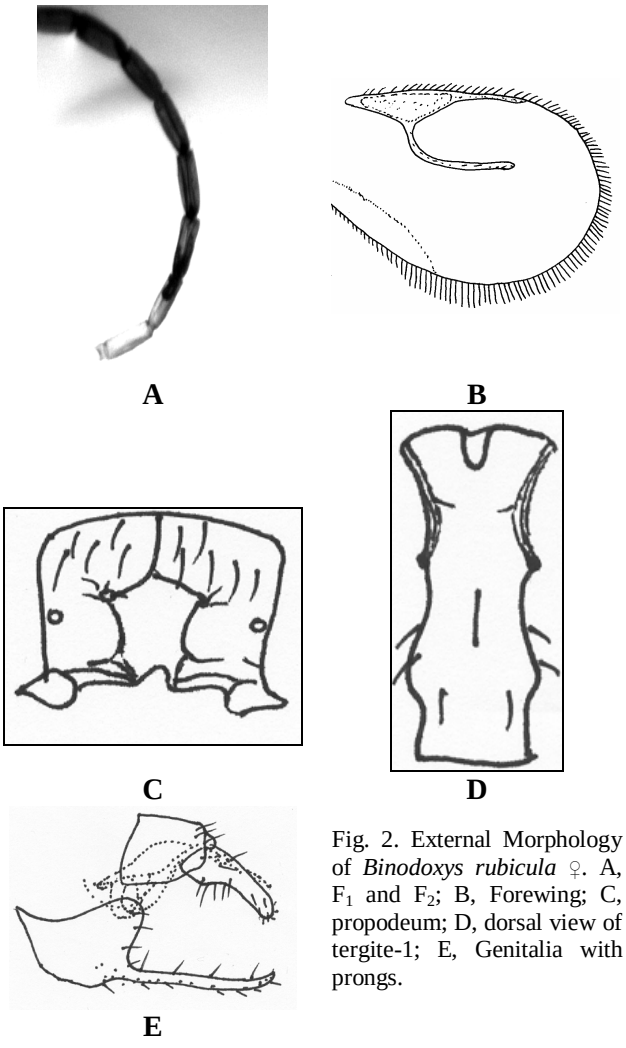

Fig. 2. External Morphology of *Binodoxys rubicula* ♀. A, F_1 and F_2; B, Forewing; C, propodeum; D, dorsal view of tergite-1; E, Genitalia with prongs.

than wide. Mesoscutum anteriorly with distinct crenulate notaulices.Tergite-1 dorsally smooth, long, sparsely setose at secondary tubercles. Genitalia as in (Fig. 2E). Prongs straight in basal half and slightly curved in apical half with 4 long dorsal and 2 apical short setae. Head dark brown. Face yellowish brown, clypeus and malar space yellow. Antennal colouration brown excepting yellow coloured underside of scape. Maxillary and labial palpi yellow colored. Thorax brown excepting prothorax, mesopleura and propodaeum which are yellowish. Wing venation brown. Brown abdomen excepting yellow coloured tergite-1, sternite 6 and 7. Tergite 7-8 yellowish brown.

Male

Similar to female excepting 13 segmented long antennae and dark brown body (legs and tergite-1 brownish).

Measurements

Tentorial index: 0.30-0.34; Interocularline: 0.27; Tranfacial line: 0.14-0.15; Tentoriocular line: 0.03; Transverse eye diameter: 0.12; Longitudinal eye diameter: 0.21-0.22; Genal width: 0.05; F_1 length: 0.14; F_2 length: 0.13; Pterostigma length and width: 0.40 and 0.12; Metacarp: 0.13; Tergite-1 length and width: 0.35 and 0.10.

Material examined

Aphis gossypii on *Hibiscus rosa- sinensis*, Rawalpindi, 28-ii-08, 2♀ and 2♂; Islamabad, 04-iii-05, 2♀; Gujranwala, 16-iii-06, 1♀; Faisalabad, 13-iii-08, 4♀ and 2♂; Lahore, 21-iii-07, 2♀ and 1♂; Multan, 20-iii-06, 2♀ and 1♂.

Comments

This species was firstly recorded from India by Shujauddin in 1973. Raychaudhuri (1990) mentioned its distribution from India, Kashmir, Sikkim and West Bengal on *Aphis ruborum longisetosus* (Borner) and *Brevicoryne brassicae*. In Pakistan, it has been recorded for the first time from *Aphis gossypii* and on *Hibiscus rosa-sinensis* L. (Euphorbiaceae). Specimens collected from Pakistan were compared with description given by Shujaudin (1973) and Raychaudhuri (1990) and found to be morphologically similar excepting negligible size and colour variation with reference to place of collection. Colour variation might be due to environmental factors. In surveys during 2005-2009, it was concluded that its population started from first week of February and ended with the start of April in Punjab Province of Pakistan with the increase of temperature and Hyperparasitism. Maximum population was recorded during second week of March.

3. Binodoxys shillongensis Starý, 1978 (Fig. 3)

Trioxys (*Binodoxys*) *shillongensis* Starý; Stary, P. and Ghosh, A. K., 1978.

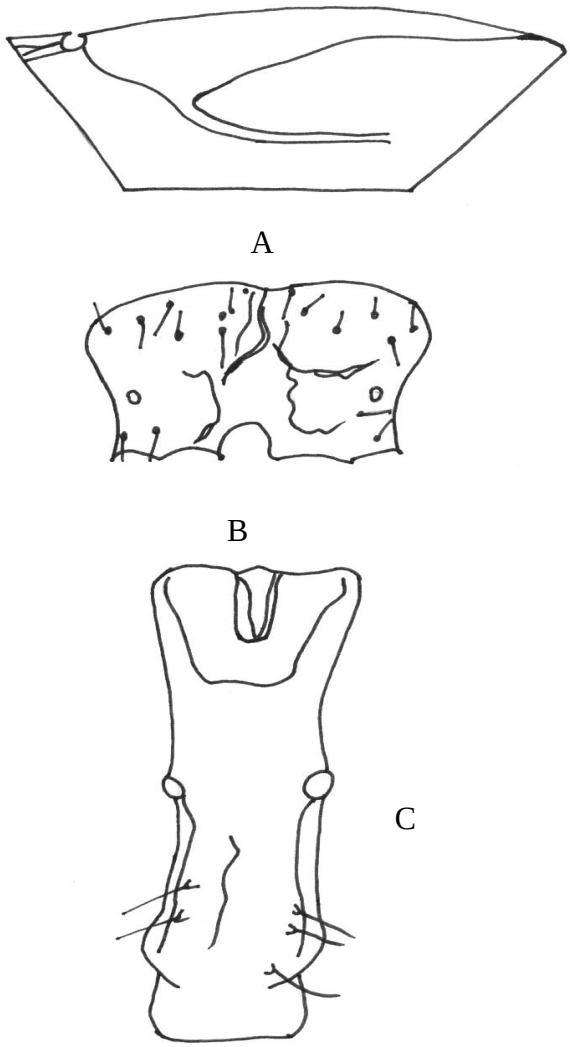

Fig. 3. External morphology of *Binodoxys shillongensis* ♀. A, forewing; B-C, propodeum; C, dorsal view of tergite-1,

Diagnostic characters

Antennae filiform, 11 segmented, F_1 as long as F_2 (Fig. 3A) with moderate hairs.Wing metacarp about 1.9 shorter than pterostigmal length (Fig. 3B). Pterostigma 2.5-3 times of its wide and twice of metacarp. Squarish propodaeum, about 1.2-1.6 times as wide as long, with distinct central areola (Fig. 3C). Tentorial index is 0.33-0.35. Tergite-1 about 3.5-4 times as long as wide at spiracles, with a short longitudinal central longitudinal carina (Fig. 3D).

Material examined

Aphis fabae on *Rumex acutus* L, Rawalpindi, 21-iii-07, 6♀ and 1♂.

Comments

This species was recorded by Naeem *et al.* (2005) from Barani tract of Punjab Province of Pakistan. We have added new locality records. Specimens collected from Pakistan were compared with description given by Raychaudhuri (1990) and found to be morphologically similar.

4. Binodoxys indicus Subba Rao and Sharma, 1958

Trioxys (*Binodoxys*) *indicus* Subba Rao, B. B and Sharma, A. K., (1958) 1959. Indian J. Ent., 20: 199-201.

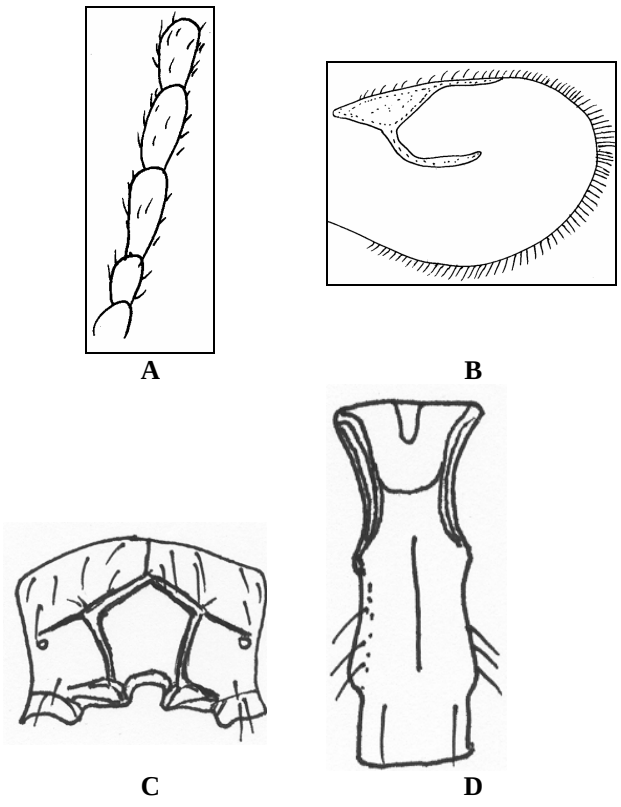

Fig. 4. External Morphology of *Binodoxys indicus* ♀. A, F_1 and F_2; B, Forewing; C, propodeum; D, dorsal view of tergite-1; E, genitalia with prongs.

Diagnostic characters

Antennae filiform, 11 segmented, F_1 a little longer than F_2 with dense hairs (Fig. 4A).Wing metacarp broadly triangular, slightly 1/6 shorter than length of pterostigma and radial vein longer than pterostigma (Fig. 4B). Squarish propodeum 1.2-1.4 times as wide as long at spiracles and with distinct pentagonal areola, upper areolae with 7-8 setae and lower with 1 seta only (Fig. 4C). Tergite-1 with both primary and secondary tubercles, about 2.7 times as long as wide at spiracles, rugose and with distinct central longitudinal carina (Fig. 4D). Prongs as shown in (Fig. 4E).

Material examined

Aphis gossypii on *Hibiscus rosa- sinensis*, Rawalpindi, 28-ii-08, 25♀ and 12♂; Islamabad, 04-iii-05, 32♀ and16♂; Gujranwala , 16-iii-06, 17♀ and 12♂; Faisalabad, 13-iii-08, 34♀ and 22♂; Lahore, 21-iii-07, 32♀ and 10♂; Multan, 20- iii-06, 22♀ and 10♂; Khushab, 24-iii-07, 12♀ and 8♂; Sargodha, 18-iii-06, 18♀ and 9♂; Chakwal, 21-iii-07, 22♀ and 11♂. *Toxoptera aurantii* on paper mulberry, Lahore, 21-iii-05, 22♀ and 12♂; Faisalabad, 23-iii-05, 12♀ and 5♂. *Aphis fabae* on *Rumex acutus*, Khushab, 18-iii-08, 22♀ and 5♂; Chakwal, 25-iii-06, 19♀ and 8♂; Attock, 18- iii-05, 15♀ and 3♂. *Aphis craccivora* on *Taphrosia purpuria*, Layyah, 18-iii-06, 10♀ and 3♂; Bhakher, 28-iii-08, 10♀ and 4♂.

Biology

Field collected mummies took on average 5-6 days to emerge. Mummies are with emergence hole usually at dorsum between or above the siphunculi.

Comments

This was reviewed by Starý *et al*. (1998) from Pakistan. In present study, new localities and host records have been added. Specimens collected from Pakistan were given by Raychaudhuri (1990). They were found to be morphologically excepting variation in body size and colouration and shape of areola.

5. *Binodoxys angelicae* (Haliday, 1833)

Aphidius (Trioxys) angelicae Haliday, 1833: 489.

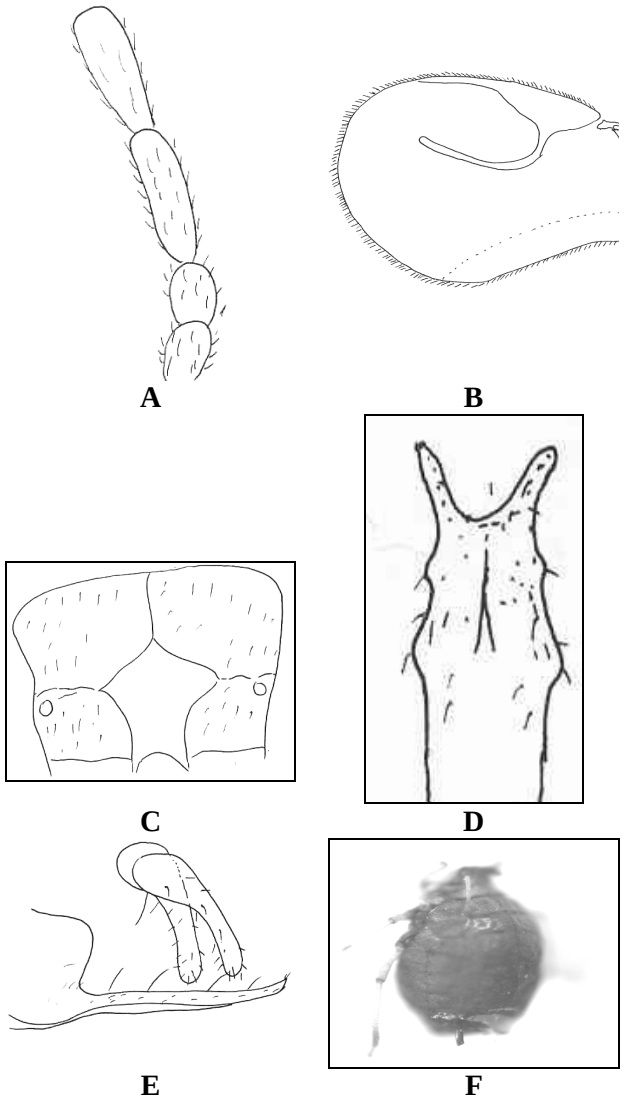

Fig. 5. External Morphology of *Binodoxys angelicae*♀. A, F_1 and F_2; B, Forewing; C, propodeum; D, dorsal view of tergite-1; E, genitalia with prongs; F, mummified *Aphis gossypii*

Trioxys amoplanus Quilis, 1934:13.
Aphidius acalephae Marshall, 1896: 608. n. syn.
Trioxys placidus Gautier, 1922: 302.
Trioxys granatensis Quilis, 1931: 74
Trioxys obscuriformis Quilis, 1931: 77
Trioxys fumariae Quilis, 1931: 81
Trioxys boscai Quilis, 1931: 83
Trioxys (*Trioxys*) *rietscheli* Mackauer, 1959: 170
Trioxys (*Trioxys*) *urticae* Mackauer, 1959171

Trioxys (Binodoxys) angelicae mediterraneus Mackauer, 1960: 142

Redescription (*Female*)

Head transverse in dorsal view, wider than mesosoma, smooth and shiny with sparse medium-length setae. Face with a few setae. Temple more or less equal to transverse diameter of eye. Ocellar triangle slightly acute. Eyes medium-large, oval shaped, convergent toward clypeus, with sparse short setae. Clypeus smooth, with about 4 long setae. Maxillary palpi 4-segmented, labial palpi 2-segmented. Antenna 11 segmented, F_1 about 3 times longer than wide, with or without linear sensoria, slightly longer than F_2 (Fig.5A). Prothorax short, narrowing posteriorly. Mesoscutum smooth and shiny. Notaulices shallow, crenulate, visible only on lateral aspect of segment. Propodeum distinctly carinate, with a wide central pentagonal areola (Fig. 5C). Carinae variable, sometimes strong and straight, sometimes slightly rounded and irregular. Anterior areolae with 4-6 long setae, posterior areolae with 1 long seta. Wing pterostigma widely triangular, 3 times longer than wide, about 0.5 times as long as pterostigma; radius rounded beneath pterostigma (Fig. 5B), becoming straight and almost parallel to metacarp distally. Petiole (Tergite-1) elongate, distance between primary and secondary spiracular tubercles longer than width at spiracles (Fig. 5D). Secondary tubercles wider, slightly more rounded than primary tubercles, situated at about the beginning of segments posterior 1/3. Dorsum variable, sometimes with a central keel and weak elongate striations, sometimes moderately rugose. Prongs long, almost straight, with 3-4 long setae on their dorsal aspect and 2 closely situated simple bristles on the apex. Genitalia as in (Fig. 5E). Ovipositor curved downward.

Head dark brown. Antennal scape, pedicel and F_l yellowish brown, remainder dark brown. Mesosoma dark brown. Wings venation brown. Petiole (Tergite-1) light brown. Prongs yellow. Abdomen dark brown excepting tergite-1 and tergite 2 (brown).

Measurements

Tentorial index: 0.2-0.3; Interocular line: 0.25-0.27; Tranfacial line: 0.14-0.16; Tentoriocular line: 0.02-0.03; Transverse eye diameter: 0.16; longitudinal eye diameter: 0.22; genal width: 0.04; F_1 length: 0.13-0.15; F_2 length: 0.13; pterostigma length and width: 0.34 and 0.12; Metacarp: 0.21; Tergite-1 length and width: 0.30 and 0.14.

Material examined

Aphis gossypii on *Hibiscus rosa- sinensis*, Rawalpindi, 28-ii-08, 35♀ and 22♂; Islamabad, 04-iii-06, 22♀ and18♂; Gujranwala , 16-iii-08, 27♀ and 18♂; Faisalabad, 13-iii-05, 24♀ and 18♂; Lahore, 24-iii-06, 42♀ and 28♂; Multan, 24-iii-05, 32♀ and 20♂; Khushab, 24-iii-07, 32♀ and 28♂; Sargodha, 18-iii-07, 28♀ and 19♂; Chakwal, 25-iii-08, 20♀ and 14♂. *Aphis gossypii* on *Calendula officinalis*, Rawalpindi, 28-iii-07, 18♀ and 9♂; Jhelum, 15-iii-06, 18♀ and 6♂; Gujrat, 18-iii-06, 8♀ and 4♂; Vihari, 24-iii-06, 18♀ and 7♂; Multan, 10-iii-07, 13♀ and 4♂. *Aphis gossypii* on egg plant, Bakhar, 18- iii-06, 6♀ and 2♂.

Biology

Brown mummies, oval to round with emergence hole located anterior to cornicles, between the cornicles or sometimes removing one of the cornicle, was about rounded, bearing an emergence lid sometimes without lid (Fig. 5F). Field collected mummies took on average 5-6 days to emerge. This species is an internal parasite of *A. gossypii*. Pupation is inside in the mummified aphids.

Comments

This species is recorded for the first time from Punjab Province of Pakistan. Specimens collected from Pakistan were compared with description given by Meschloff and Rosen (1993). They were found to be morphologically excepting variation in body size and colouration and shape of areola. Carinae of propodeum varied from strong and straight, sometimes slightly rounded and irregular.

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