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TAXONOMIC NOTES ON *PSYLLAPHYCUS DIAPHORINAE* (HYMENOPTERA: ENCYRTIDAE) AND ITS HOST ASSOCIATIONS IN PAKISTAN

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ABSTRACT

The encyrtid wasp, *Psyllaphycus diaphorinae* Hayat, was reared from nymphs of Asian citrus psyllid, *Diaphorina citri* Kuwayama, on *Citrus* spp. and *Murraya* sp. collected in Faisalabad, Punjab, Pakistan. This discovery is a new host record for *P. diaphorinae*, which previously had been known only from India from a different, congeneric host. Taxonomic notes on this little known species are given, illustrations of both sexes are provided, and its potential as a prospective classical biological control agent against *D. citri* is discussed. A correction to the diagnosis of the genus *Psyllaphycus* Hayat is made: both sexes have the mandible with 2 teeth and a wide truncation.

Key Words: congeneric host, *Diaphorina citri*, *Citrus*, *Murraya*, diagnosis

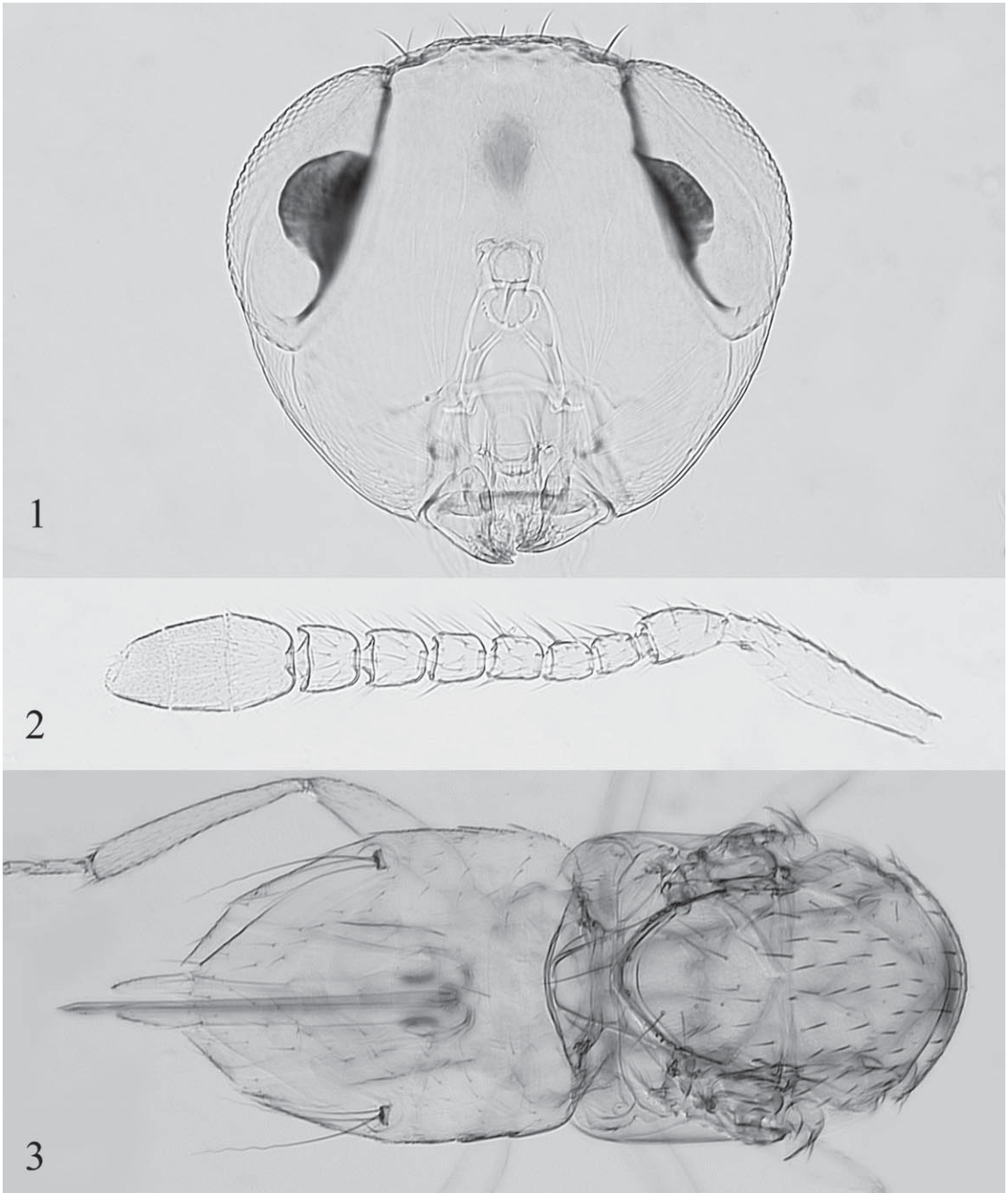
RESUMEN

Un parasitoide encírtido, *Psyllaphycus diaphorinae* Hayat, fue criado de ninfas del psílido asiático de los cítricos, *Diaphorina citri* Kuwayama, recolectados sobre *Citrus* spp. y *Murraya* sp. en Faisalabad, Punjab, Pakistán. Este descubrimiento es un registro nuevo de insecto hospedero para *P. diaphorinae*, que antes se conocía en India sólo sobre un hospedero congénico. Se proveen notas taxonómicas sobre esta especie poco conocida, ilustraciones de ambos sexos y se comenta sobre su potencial como un agente de control biológico clásico de *D. citri*. Se hace una corrección en el diagnóstico de género *Psyllaphycus* Hayat: ambos sexos tienen la mandíbula con 2 dientes y un truncamiento ancho.

Palabras Clave: hospedero congénico, *Diaphorina citri*, *Citrus*, *Murraya*, diagnóstico

The Asian citrus psyllid, *Diaphorina citri* Kuwayama (Hemiptera: Sternorrhyncha: Liviidae), established in California, USA, in 2008, and this prompted interest in developing a classical biological control program for this pest (Hoddle 2010, 2012). Previous surveys for hymenopteran parasitoids of *D. citri* in its presumed area of origin, the Indian subcontinent and southeast Asia, indicated 2 species attacking nymphs, *Diaphorencyrtus aligarhensis* (Shafee, Alam and Agarwal) (Encyrtidae) and *Tamarixia radiata* (Waterston) (Eulophidae), as the most common (Husain & Nath 1927; Halbert & Manjunath 2004). Husain & Nath (1927) published surveys for parasitoids of *D. citri* in the Punjab of modern day Pakistan and India and recorded 9 species, of which just 1, *T. radiata*, was formally described (Waterston 1922). The identities of the remaining 8 species and their associated hyperparasitoids are un-

known but could be of use for *D. citri* biological control. As part of a classical biological control program against *D. citri* in California, CDH and MSH undertook 5 surveys for parasitoids associated with nymphs of *D. citri* on citrus (kinnow ["King"] (*Citrus nobilis* Lour.) × "Willow Leaf" (*Citrus deliciosa* Ten.)) and sweet orange [*Citrus × sinensis* (L.) Osbeck] and orange jasmine, *Murraya paniculata* (L.) Jack (Sapindales: Rutaceae), across several citrus production areas (e.g., Faisalabad, Sargodha, and Toba Tek Singh) in Punjab, Pakistan, during 2010-2012 (Hoddle 2010, 2012). Among the parasitoids reared from *D. citri* collected from a citrus orchard in Faisalabad, there were 20 encyrtids; of those 2 females and 2 males were point- and slide-mounted (and additionally 1 female and 5 males were preserved in ethanol as voucher specimens) and identified by SVT as *Psyllaphycus diaphorinae* Hayat, which previ-



Figs. 1-3. *Psyllaphycus diaphorinae* female (Faisalabad, Punjab, Pakistan): 1) head, frontal view; 2) antenna; 3) mesosoma and metasoma.

ously was known only from India (Hayat 1972, 2006). Here we provide taxonomic notes on this little known species and provide illustrations to facilitate its recognition, and also assess variation by comparing specimens from Pakistan to those from India. Additionally, 2 encyrtid females

were reared in Faisalabad from *Diaphorina aegyptiaca* Puton on *Cordia myxa* L. (Scrophulariaceae) but unfortunately these were not preserved. Hayat (1972) described *P. diaphorinae* from the Indian state of Punjab based on specimens reared from *D. aegyptiaca* [as *D. cordiae* Crawford] on

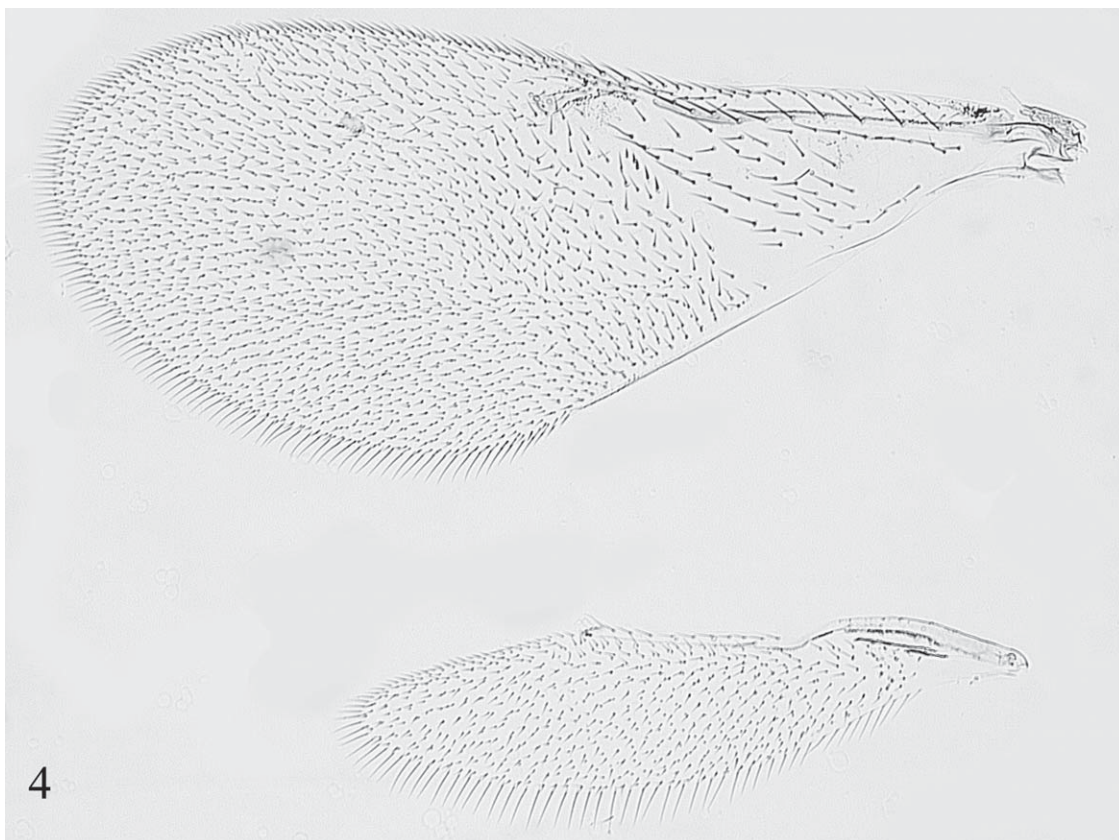


Fig. 4. *Psyllaphycus diaphorinae* female (Faisalabad, Punjab, Pakistan): fore and hind wings.

“*Cardia ruyxa*”, which is an apparent misspelling of *Cordia myxa*, and also on those reared in Maharashtra from a *Diaphorina* sp. (the host plant is unknown).

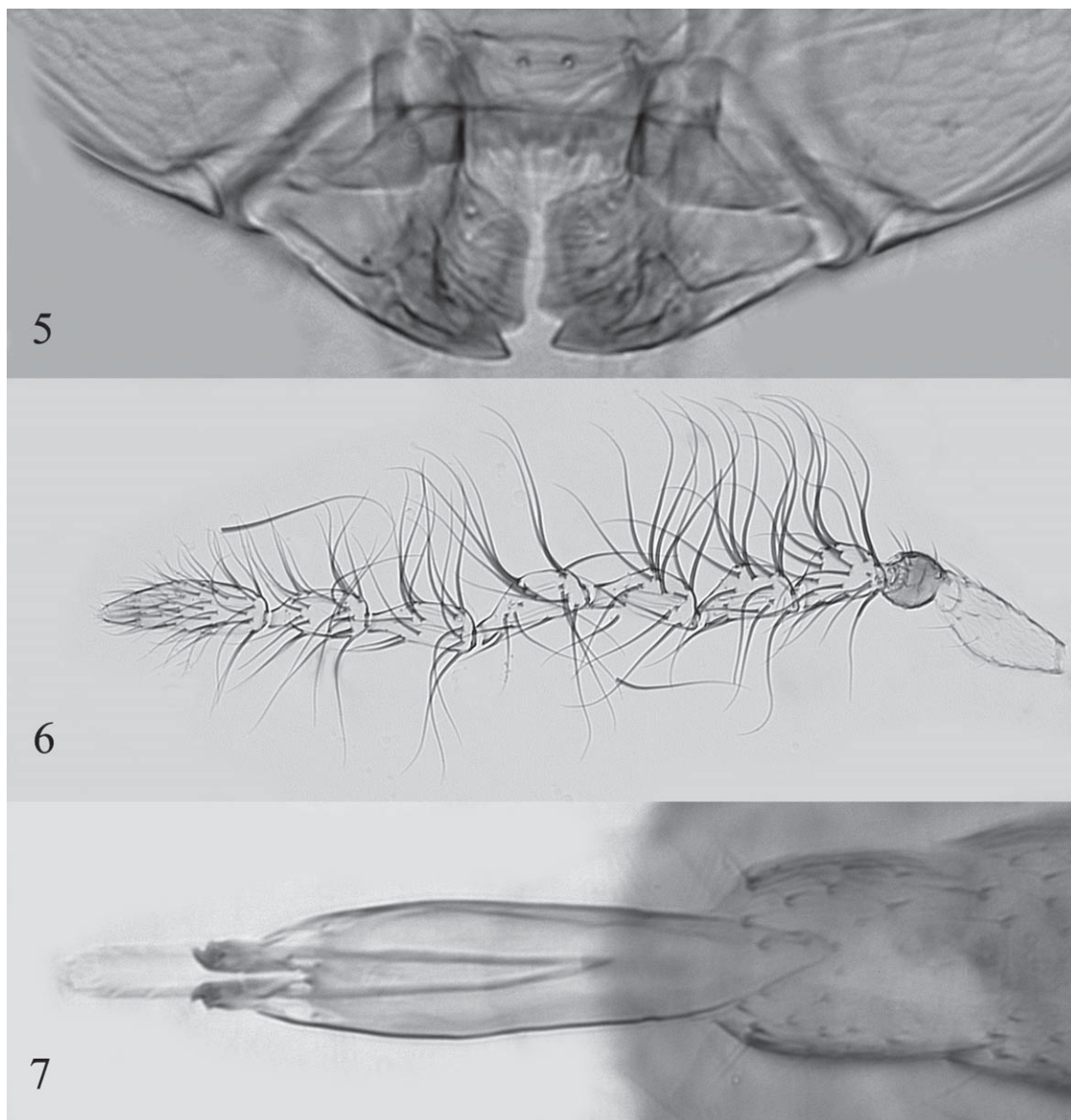
TAXONOMIC NOTES ON *PSYLLAPHYCUS* *DIAPHORINAE*

All figures in this report are reproduced in color in the online supplementary document at <http://purl.fcla.edu/fcla/entomologist/browse>. The figures in the supplementary document are referred to below as Suppl. Figs. 1-3, Suppl. Fig. 4, Suppl. Figs. 5-7, Suppl. Figs. 8-12 and Suppl. Figs. 13-14.

Psyllaphycus diaphorinae Hayat 1972: 208-209. Type locality: Maur, Punjab, India. HOLOTYPE female (NZSI, National Zoological Collections, Zoological Survey of India, Kolkata [= Calcutta], West Bengal, India (Hayat 2006; Hayat et al. 2011) although initially Hayat (1972) had indicated its depository as ZDAMU, Insect collection, Department of Zoology, Aligarh Muslim University, Aligarh, Uttar Pradesh, India), not examined. Subsequent references: Hayat 1979: 321

(material examined); Noyes & Hayat 1984: 332 (list); Hayat 1986: 127 (catalog); Mani 1989: 1011-1012 (redescription); Fatima & Shafee 1994: 54-55 (host association, distribution); Hayat 2006: 189 (references, host associations, distribution), 433 (illustrations); Hayat et al. 2011: 10 (holotype and paratype depositories, incomplete).

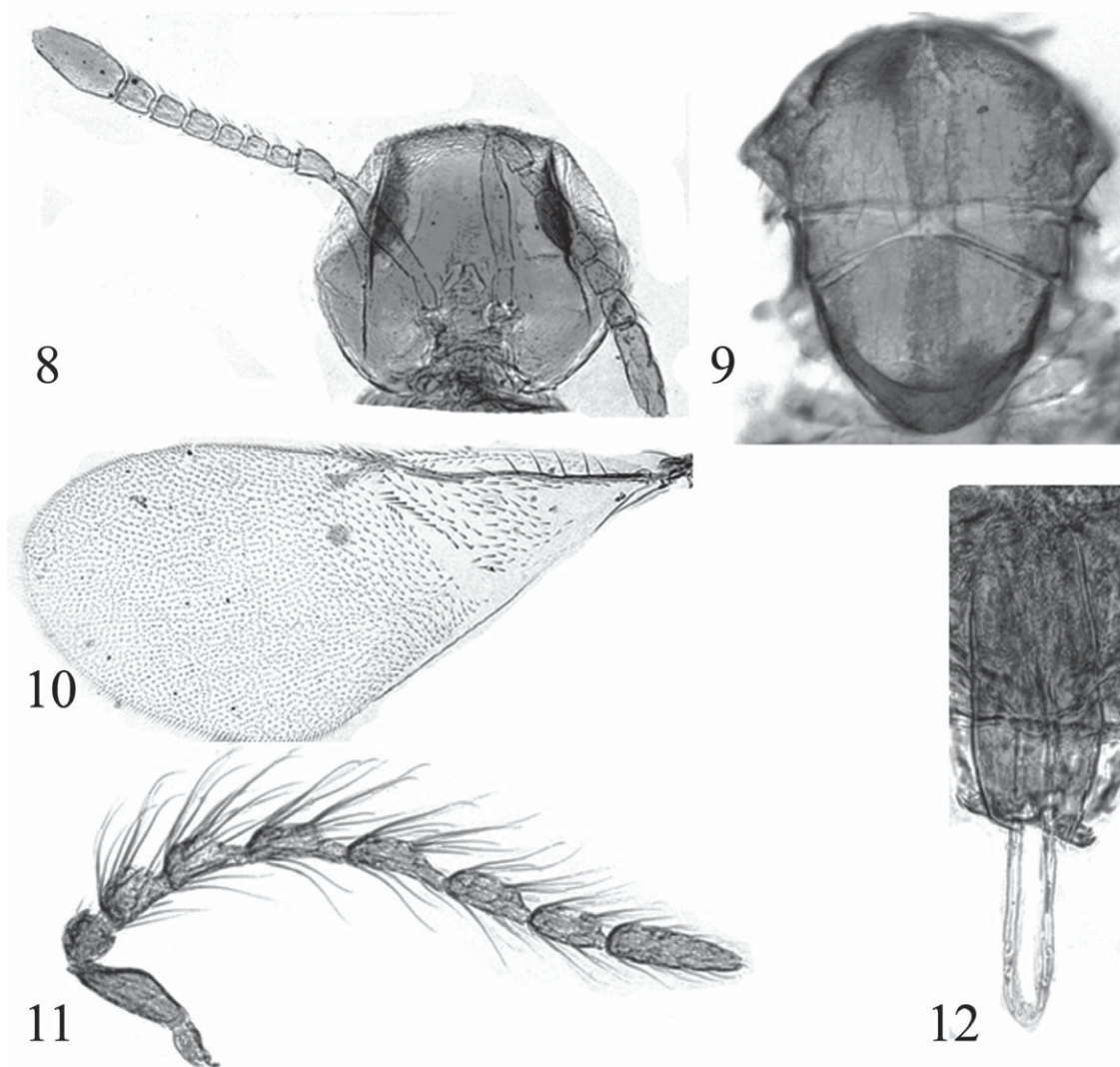
Female of this species has a yellow head with a small brownish spot on the frontovertex (Fig. 1; Suppl. Fig. 1) and an orange-yellow body (Fig. 13; Suppl. Fig. 13); body of the male is notably darker (Fig. 14; Suppl. Fig. 14). Whereas Noyes & Hayat (1984) indicated and Hayat (1972, 2006) illustrated that in the genus *Psyllaphycus* Hayat the mandible has 1 tooth and a wide truncation, in our material of *P. diaphorinae* from the Pakistan Punjab the mandible clearly has 2 teeth and a wide truncation in both sexes (Figs. 1 and 5; Suppl. Figs. 1 and 5). It is possible that this discrepancy in the number of mandibular teeth might have occurred because of the angle at which the uncleaned paratypes from Maharashtra were mounted. Also, the female frontovertex, mesoscutum, and scutellum are seemingly not as setose in the specimens from Pakistan (Fig. 3; Suppl. Fig. 3) when com-



Figs. 5-7. *Psyllaphycus diaphorinae* male (Faisalabad, Punjab, Pakistan): 5) mandibles; 6) antenna; 7) genitalia.

pared to *P. diaphorinae* from Maharashtra (Fig. 9; Suppl. Fig. 9). The female antenna of the Indian (Maharashtra) *P. diaphorinae* (Fig. 8; Suppl. Fig. 8), as illustrated by Hayat (2006, Fig. 1110), may have different proportions of the funicle segments: the sixth is slightly longer than wide whereas it is clearly wider than long in 2 out of 3 specimens from Pakistan (Fig. 2; Suppl. Fig. 2) although in the third specimen it is as in those from Maharashtra. Additionally, the male paratype from Maharashtra has setae on the funicle segments that are relatively somewhat shorter (Fig. 11; Suppl. Fig. 11) when compared to those from the Pakistan Punjab (Fig.

6; Suppl. Fig. 6); the phallobase is shorter, about 3 × as long as broad excluding the parameres, and the digiti also appear shorter (Fig. 12; Suppl. Fig. 12) than in the male from Pakistan (Fig. 7; Suppl. Fig. 7), each digitus bears 2 denticles, the inner larger than the outer. The wings of the Indian and the Pakistan Punjab specimens are very similar (Figs. 4 and 10; Suppl. Figs. 4 and 10). We consider these differences to be quite minor and likely due to intraspecific (possibly host-induced or geographic, or both) variability, and therefore confirm that specimens from the Pakistan Punjab are indeed *P. diaphorinae*.



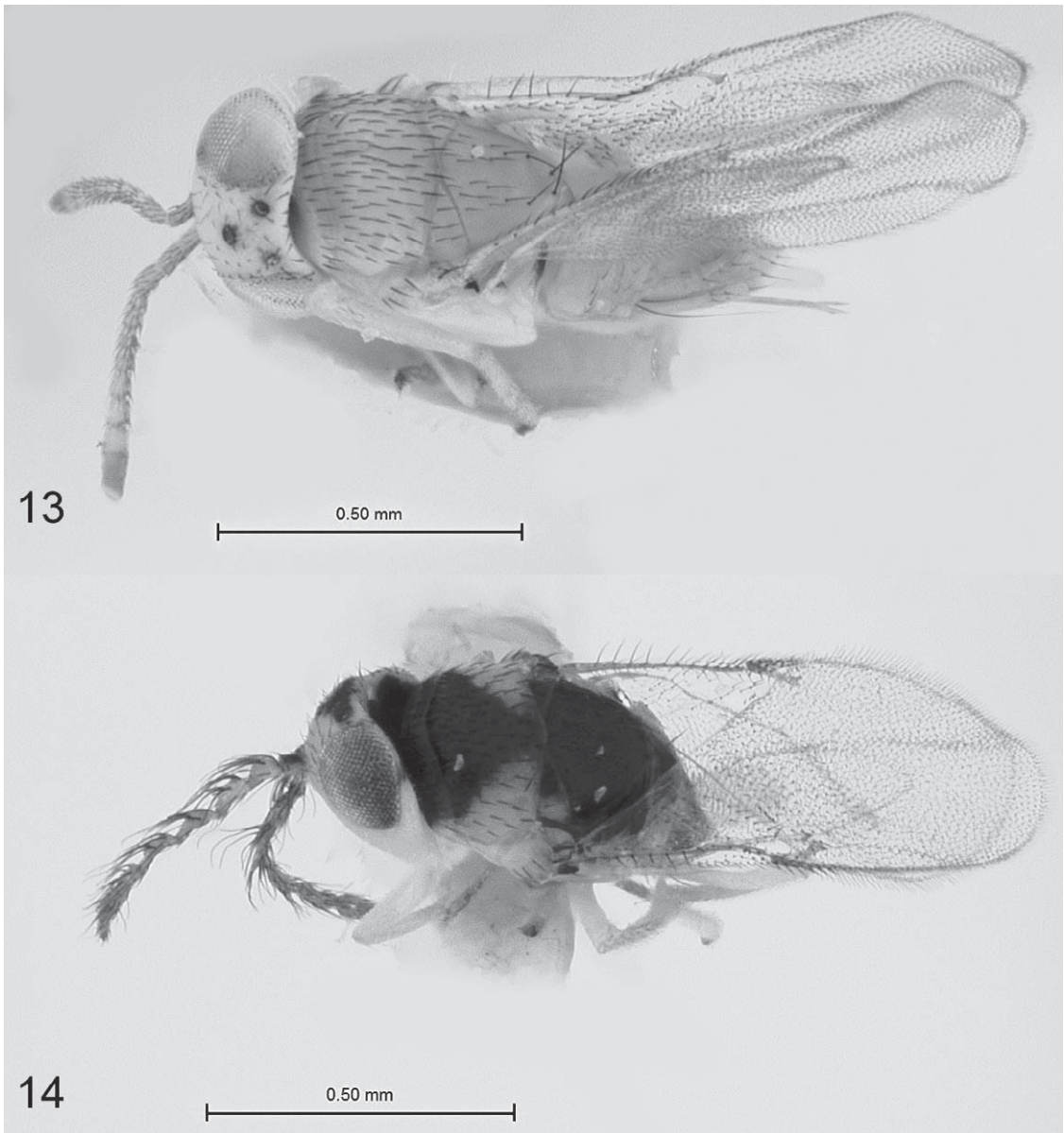
Figs. 8-12. *Psyllaphycus diaphorinae* (paratypes, Manmad, Maharashtra, India): 8) female head and antenna; 9) female mesoscutum and scutellum; 10) female fore wing; 11) male antenna; 12) male genitalia.

Material Examined

All voucher specimens are deposited in UCRC, Entomology Research Museum, Department of Entomology, University of California, Riverside, California, USA.

PAKISTAN, Punjab, Faisalabad, University of Agriculture Faisalabad Postgraduate Agricultural Research Station (PARS), citrus orchard near Jhang Road, N 31° 23.607' E 73° 01.432', 181 m asl, M. S. and C. D. Hoddle: parasitized nymphs of *D. citri* collected from *Citrus* spp. and *Murraya* sp. 29-X-2011, parasitoids emerged 9-XI-2011 in UCR ([Department of Entomology] University of California, Riverside, Riverside Co., California, USA) quarantine laboratory under Shipping

and Receiving (S&R) #11-167 [1 male on point, UCRC ENT 328032 and 1 female on slide, UCRC ENT 328034]; parasitized nymphs of *D. citri* collected from the same plants 3-XI-2011, 1 male on slide [UCRC ENT 328033] and 1 female on point [UCRC ENT 328031] parasitoids emerged, respectively, 14-XI-2011 and 15-XI-2011 in UCR quarantine laboratory under S&R #11-167. Additionally 1 female and 5 males in ethanol (emerged from parasitized nymphs of *D. citri* 6-16-XI-2011 in UCR quarantine laboratory under S&R #11-167) from the same locality in Pakistan, collected 30-X-3-XI-2011 on *Citrus* spp. Also examined were the following paratypes of *P. diaphorinae*: 1 female and 1 male on slides and 2 females and 1 male on cards [ZDAMU], all reared from *Diapho-*



Figs. 13, 14. *Psyllaphycus diaphorinae* (Faisalabad, Punjab, Pakistan), habitus: 13) female; 14) male.

rina sp. in Manmad, Maharashtra, India, 9-X-1967, M. Hayat. Two female and 2 male paratypes from the type locality were deposited by M. Hayat in BMNH, Natural History Museum, London, England, UK, and USNM, National Museum of Natural History, Washington, District of Columbia, USA (1 female and 1 male in each).

Remarks

We are not certain if *P. diaphorinae* is a primary parasitoid of *D. citri*; it was quite rare in

our numerous rearings from this psyllid host in Punjab, Pakistan. Therefore we assume its principal host could be *D. aegyptiaca* on *Cordia myxa*; apparently it only occasionally parasitizes *D. citri* infesting rutaceous hosts. At least in the Pakistan Punjab it was collected only once, in Oct 2011, comprising just 2% of *D. citri* parasitoids reared (*T. radiata* dominated at 96% of the reared material [1,012 specimens collected], and 2% [i.e., 20 specimens] were *D. aligarhensis*). Therefore, we conclude that potential of *P. diaphorinae* as a perspective agent for the classical biological control

against *D. citri* in the New World to be low even if it were proven to be a primary parasitoid. Because only 16 specimens of this species emerged in quarantine, and it was uncertain as to whether or not they were primary parasitoids of *D. citri*, some of them were immediately preserved for identification. Since no additional *P. diaphorinae* were reared from subsequent collections in Pakistan, colonies could not be established on *D. citri* in quarantine.

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