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**GEPHYRAULUS MANGIFERAE (FELT), N. COMB. (DIPTERA:  
CECIDOMYIIDAE): A MANGO PEST FROM INDIA NEWLY RECORDED  
FROM THE WESTERN HEMISPHERE**

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*Abstract.*—*Dasineura mangiferae* Felt (**n. comb.**) transferred here to the genus *Gephyraulius*, is a cecidomyiid native to India that lives in and destroys the flowers of mango, *Mangifera indica* (Anacardiaceae). It is reported here from Guadeloupe, French West Indies, as the first record for the Americas. Adults of both sexes and the pupa and larva are redescribed with illustrations. This gall midge is discriminated from its congeners as well as from *Procontarinia mangiferae* (Felt), a second pest of mango inflorescences from India already in the West Indies and South America. *Gephyraulius* was previously known only in the Palearctic Region from nine species, all infesting flowers of Brassicaceae. *Procystiphora indica* Grover and Prasad from India is also moved to *Gephyraulius* (**n. comb.**).

*Key Words:* Diptera, Cecidomyiidae, gall midges, Guadeloupe, mango pest

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In 2004 a cecidomyiid, *Dasineura mangiferae* (Felt), was discovered in Guadeloupe, French West Indies, among inflorescences of mango, *Mangifera indica* L. (Anacardiaceae). This is the first notice of this gall midge in the Americas. Native to India where it is widely distributed, this gall midge is a serious pest there (Venkatsubba 1940, Prasad 1971). It has also been recorded from Hawaii (Anonymous 1981) where it is evidently an immigrant. Larvae feed in developing flowers that become enlarged and distorted into conical galls.

This insect was first described as *Dasineura mangiferae* by Felt (1927) from a series of females reared from mango flowers in southern India. Noth-

ing further was noted at that time concerning its biology. Felt recognized that the species "present[ed] marked peculiarities for the genus" and only tentatively placed it in *Dasineura*. Grover and Prasad (1966) and Prasad (1967, 1971) studied the biology and morphology of all stages of this species in India. Grover and Prasad (1966) placed it in *Procystiphora* because of the strongly modified ovipositor. *Procystiphora* is a Holarctic genus of three species on Cyperaceae and Juncaceae. The particular conformation of the modified ovipositors of those species is different from that found in the present species (see below). In our search for a generic home for this species, it was a surprise to find



that *D. mangiferae* fits satisfactorily into *Gephyraulius*. This genus is otherwise known from nine species from the western and central Palearctic Region (Gagné 2004) that feed in flowers of Brassicaceae in the same way as does *D. mangiferae* on mango. The new addition considerably broadens the regional and host distribution of *Gephyraulius*. *Procystiphora indica* Grover and Prasad (1966), another species from mango flowers in India and with a generally similar ovipositor, is also transferred to *Gephyraulius* here.

One other Indian gall midge, *Procontarinia mangiferae* (Felt), is already known from mango in the West Indies and Brazil (Gagné 1994, 2004). It also feeds on the inflorescence, where it forms swellings on growing tips and buds. This species arrived with mango stock, presumably from India, by the early 20th century and was named by Felt (1911) from specimens from St. Vincent, West Indies, and named again by Tavares (1918) from Bahia, Brazil. It is one of several species of Old World gall midges that were named first from New World colonizations.

#### MATERIALS AND METHODS

Adults were reared in the laboratory from larvae collected in mango inflorescences. Some larvae and resulting pupae and adults were killed and stored in 70% ethyl alcohol. Specimens for microscopic study were mounted on glass slides in Canada balsam using the method outlined in Gagné (1989, 1994) and some pupae were critical-point dried and mounted on stubs for SEM photographs. The syntypes of *G. mangiferae* are part of the Felt Collection on loan to the Systematic Entomology Laboratory, USDA, from the New York State Museum in Albany. The other study specimens are deposited in the National Museum of Natural History, Washington, DC (USNM). In the description

that follows, anatomical terminology of the adult stage follows McAlpine et al. (1981) and that of the larval stage follows Gagné (1989).

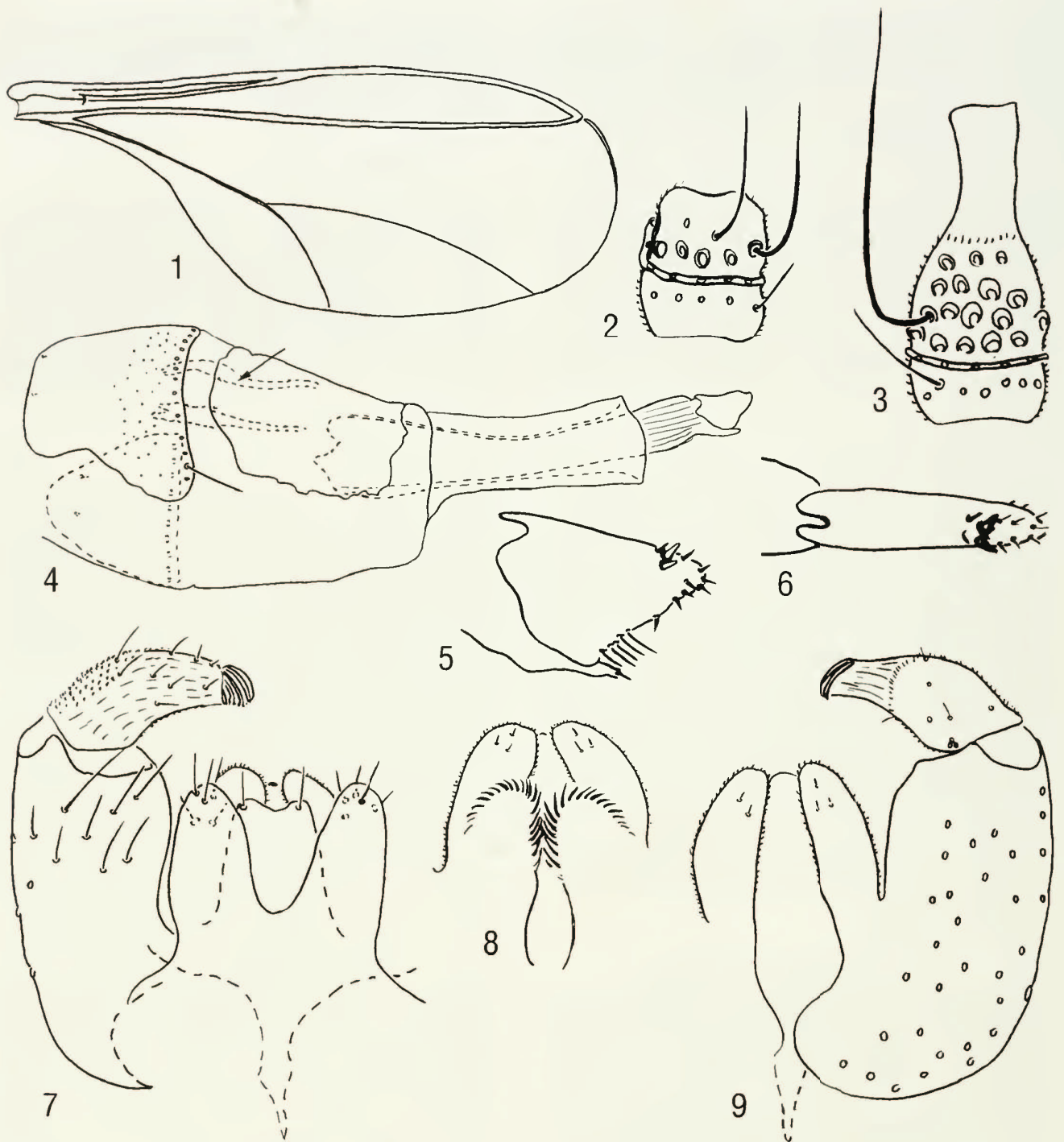
#### *Gephyraulius* Rübсаamen 1916

Diagnosis.—Adult habitus generally similar to that of *Dasineura*: adult extensively covered with scales among other setation; antennal flagellomeres sexually dimorphic, those of male (except apicalmost) with distinct necks, those of female without; palpus 4-segmented; wing with  $R_5$  vein shorter than wing, joining C definitely anterior to wing apex; tarsal claws with strong teeth; empodia as long as claws; pulvilli about half length of claws. Third-instar larva completely covered with verrucae and with complete set of larval papillae present, the dorsals, pleurals, ventrals, and terminals with long setae.

*Gephyraulius* is unique among Dasineurini for the following combination of characters: female 7th and 8th tergites and 7th sternite (Fig. 4) larger and more strongly sclerotized than preceding tergites and sternites, the 8th tergite additionally with elongate anterior apodemes that extend beneath the 7th tergite, and the 7th sternite trapezoid; distal half of ovipositor stiff, pigmented, becoming bilaterally compressed toward apex, culminating in narrow, strongly sclerotized, glabrous, fused cerci (Figs. 5–6) with a large pair of sensoria situated dorsally just posteriad of a series of short dorsoapical setae; female pupa (Fig. 16) with elongate 7th and 8th segments to accommodate modified postabdomen. See also Solinas 1982, Sylvén and Solinas 1989, and Sylvén and Tastás-Duque 1993 for illustrations of a range of species, especially the last for SEM photographs and authoritative comments on the ovipositor of several species on Brassicaceae.

Discussion.—*Gephyraulius* belongs to the cecidomyiine supertribe Lasiopteridi





Figs. 1-9. *Gephyraulus mangiferae*. 1, Wing. 2, Female third flagellomere (ventral). 3, Male third flagellomere (ventral). 4, Female postabdomen, seventh segment to end, arrow indicating anterior apodeme of eighth tergite (dorsolateral). 5, Fused female cerci (enlarged, lateral). 6, Same (dorsal). 7-9, Male terminalia. 7, Right gonopod not shown (dorsal). 8, Parameres (dorsal). 9, Left gonopod not shown (ventral).

and the tribe Dasineurini. Except for the female postabdomen, the included species could pass for *Dasineura* and presumably descended from an ancestor of some part of the large polyphyletic aggregate of 448 described species (Gagné 2004) now assigned to *Dasineura*.

Of interest in this context is *Dasineura amaramanjarae* Grover (1965) because it is also known from mango inflorescences in India, but shows no particular resemblance in either sex to *Gephyraulus*. Its male genitalia in particular are an oddity for *Dasineura*. Because the gono-



coxites conspicuously bulge out mesally near midlength and the gonostyli are extremely elongate and narrow, *D. amar-amanjarae* appears to fit instead in *Jaapiella* Rübisaamen.

In the key to genera of Neotropical Lasiopteridi in Gagné 1994, *Gephyraulius* will run to *Dasineura*. The characters of *Gephyraulius* that separate it from *Dasineura* are: the modified female postabdomen, including the strongly sclerotized 7th and 8th terga and the bilaterally flattened ovipositor with its stiff, glabrous, fused cerci (Figs. 4–6); the medially angled parameres and the foreshortened gonostyli of the male genitalia (Figs. 7–9), which presumably serve to accommodate the shape of the ovipositor; and the lengthier posterior end of the female pupa conforming to the robust and stiff adult postabdomen inside (Fig. 16).

*Gephyraulius mangiferae* (Felt),  
**new combination**  
 (Figs. 1–16)

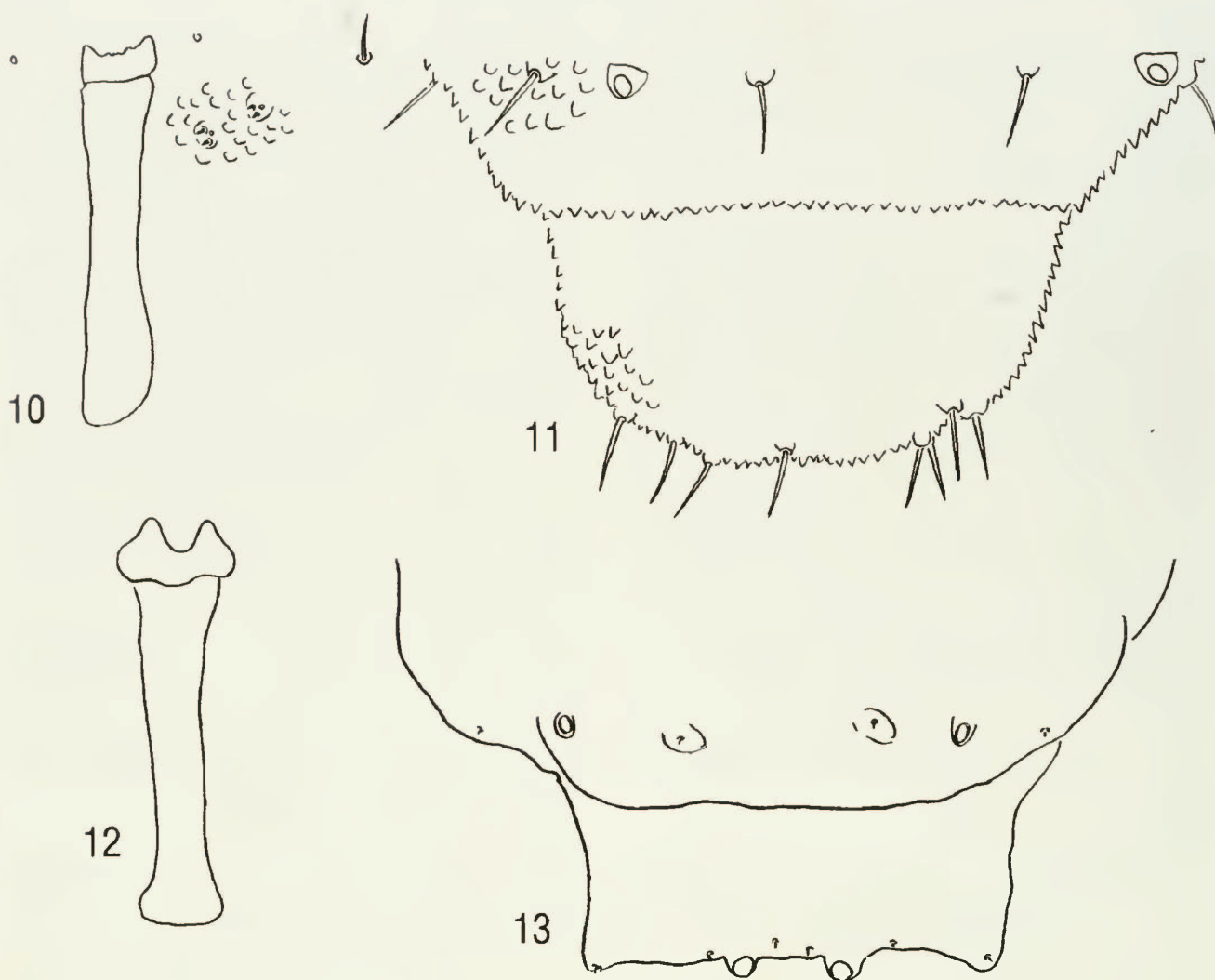
**Adult.**—*Head:* Eyes nearly contiguous at vertex, separated by diameter of 1 or 2 facets, facets circular, closely approximated except about  $\frac{1}{2}$  facet diameter apart near midheight. Vertex of occiput rounded. Frons with setae mixed with scales. Labella hemispherical in frontal view, with several setae. Antenna: Scape and pedicel spheroid, each wider than long; 11–13 flagellomeres present, first and second connate, distal two in female usually fused; male first through penultimate flagellomeres (Fig. 3) with definite necks; female flagellomeres (Fig. 2) without necks.

*Thorax:* Scutum with 2 lateral and 2 dorsocentral rows of setae mixed with scales. Scutellum with a group of setae and scales on each side. Anepisternum with scales on dorsal third, anepimeron with row of setae, pleura otherwise lacking vestiture. Wing (Fig. 1): length,

1.3–1.5 mm in male ( $n = 7$ ), 1.3–1.5 mm in female ( $n = 8$ );  $R_5$  meeting C appreciably anterior to wing apex; C broken at juncture with  $R_5$ ; Cu forked.

*Male abdomen:* First through fifth tergites rectangular, with single row of posterior setae continuous across tergite, 1–2 lateral setae each side, 2 trichoid anterior sensilla, and elsewhere covered with scales; sixth and seventh tergites generally similar to preceding except unsclerotized posteromesally and posterior setae present only laterally; eighth tergite short, especially posteromesally, without vestiture except for anterior trichoid sensilla; sternites 2–8 with mostly single row of posterior setae, another single row of setae, not continuous across sclerite near midlength, and with anterior pair of trichoid sensilla. Genitalia (Figs. 7–9): gonocoxite cylindrical; gonostylus short, setulose on most of venter, ridged on most of dorsum; paramere with short, dorsal, long-setulose lobe and long, linear, short setulose ventral lobe flanking aedeagus, ventral lobe directed mesally; cercus rounded and setose apically; hypoproct divided apically into 2, rounded lobes, each with long seta; aedeagus shorter than parameres, its apex flat.

*Female abdomen* (Figs. 4–6): First through sixth tergites and sternites as in male; seventh and eighth tergites and seventh sternite longer and more sclerotized and more darkly pigmented than preceding sclerites; seventh tergite trapezoid, widest apically with single, continuous row of posterior setae, scattered scales on posterior half, and anterior pair of trichoid sensilla; eighth tergite roughly rectangular, slightly longer than seventh, with pair of anterior apodemes extending beneath seventh tergite, an anterior pair of trichoid sensilla the only vestiture. Ovipositor elongate, protrusible, sparsely covered with short setae, distal half bilaterally flattened, rigid, with stiffening ridges, slightly more than twice length of



Figs. 10–13. 10, 11, *Gephyraulus mangiferae*. 10, Larval spatula with associated papillae. 11, Larval eighth and terminal segments (dorsal). 12–13, *Procontarinia mangiferae*. 12, Larval spatula. 13, Larval eighth and terminal segments (dorsal).

eighth tergite, fused cerci high, very narrow, smooth, asetulose, with setae only at tapered apex and ventrally, a large pair of sensoria situated dorsally just posteriad of a series of short dorsoapical setae. Hypoproct soft, linear, with two small apical setae.

Pupa (Figs. 14–16).—Cephalic sclerite with two raised bumps, each with 2 papillae, one with elongate seta, the other without seta. Abdomen evenly covered with spicules on all surfaces. Seventh and 8th abdominal segments enlarged, longer than preceding segments.

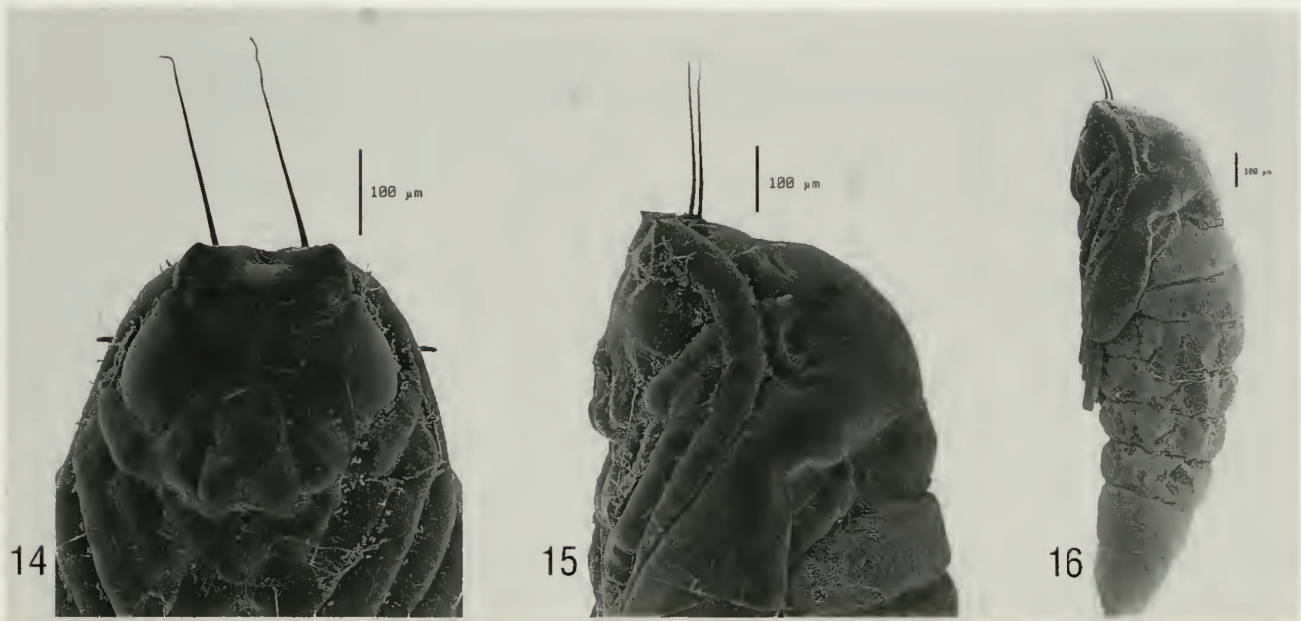
Third-instar larva.—Yellow-orange. Antenna about twice as long as wide. Cephalic apodemes as long as head

capsule. Spatula (Fig. 10) anteriorly divided into two short, nearly equilateral teeth or roughly erose (Fig. 10) and with long, parallel-sided posterior shaft. Papillae following pattern basic for supertribe Lasiopteridi (Gagné 1989, fig. 19).

Type series.—Syntypes, four ♀, two on each of two slides, from mango flowers, Coimbatore, India, II-8-1924, Y.R. Rao coll., Felt Collection No. 3452, deposited in New York State Museum, Albany.

Other specimens examined.—GUADELOUPE: Belair, Vieux-Habitants, from flowers of mango, IV-14-2004, GR3032, 5 ♂, 5 ♀; same data except V-17-2004, GR3080, 3 ♂, 3 ♀, 5 pupae, 3 larvae; same data except II-17-2005,





Figs. 14–16. Pupa of *Gephyraulus mangiferae*. 14, Head and thorax (ventral). 15, Same (lateral). 16, Female pupa (lateral).

GR3127, 2 ♂, 3 ♀. HAWAII: Hilo, 1-4-1981, E. Yoshioka, 5 ♂, 5 ♀. INDIA: vic. Allahabad, P. Grover, 4 ♂, 4 ♀, 6 larvae.

Remarks.—*Gephyraulus mangiferae* differs in its genitalia from congeners on Brassicaceae. The male gonostyli are shorter than those of any other species and the ventral lobe of the parameres is uniquely inclined mesally. The dorsal edge of the female fused cerci as seen in lateral view is fairly straight (Fig. 5), whereas it is definitely concave in all other non-mango species.

This species was once placed in *Procystiphora* by Grover and Prasad (1966) but the ovipositor of that genus is shaped differently. The 7th and 8th abdominal tergites of *Procystiphora* are narrower than in *Gephyraulus*, the 8th without anterior subdermal apodemes and longitudinally divided for most of its length, and the 7th sternite is elongate and rectangular; the ovipositor is strongly bilaterally compressed, particularly the distal half, and the fused cerci are narrow, sharply tapered and pointed, their surface covered with short setae. For figures see Gagné 1975 and Meyer 1984. *Procystiphora* is a Holarctic genus

of three species that live in culms of *Juncus* and *Carex* (Gagné 2004).

Grover and Prasad (1966) and Prasad (1967, 1971) reported four larval instars for *G. mangiferae*, but they apparently took for evidence of different instars the relative sclerotization of the spatula, whether it was weakly or strongly developed. A late second instar may sometimes show the spatula of the developing third instar inside (Gagné and Doane 1999); also, an early third instar may not have a fully developed and pigmented spatula when newly molted. Where close observation of actual molts and/or head capsule measurements have been made, only three instars can be accounted for in Cecidomyiidae (cf. Solinas 1965, Wyatt 1967, Parnell 1969, Gagné and Hatchett 1989, Gagné and Doane 1999).

Larvae of both *Gephyraulus mangiferae* and *Procontarinia mangiferae* mature simultaneously on mango but can be easily distinguished. Larvae of *G. mangiferae* are covered with rough verrucae, have a rounded posterior end and mostly long setae (Fig. 11), and the anterior margin of the spatula is shallowly



notched (Fig. 10). Larvae of *P. mangiferae* are smooth, have a quadrate posterior end in dorsoventral view (Fig. 13), setae no longer than wide, and the anterior margin of the spatula is deeply lobed (Fig. 12). Adults of the two are also distinct: the  $R_5$  wing vein of *G. mangiferae* is fairly straight and joins C noticeably anterior to the wing apex (Fig. 1) while that of *P. mangiferae* is definitely curved apically and joins C far behind the wing apex.

**Biology.**—According to Venkatsubba (1940) and Prasad (1967, 1971) females lay one or more eggs among sepals and petals of unopened flower buds. In India eggs hatch in less than two days and the larvae begin to feed on the developing reproductive parts of the flower. The attacked flower bud becomes enlarged and conical and no fruit is produced (fig. P-2, p. 43, Prasad 1971). Larvae are fully developed in about 8 days and usually pupate in situ, although some full-grown larvae left the flowers and dropped to the soil; the pupal stage lasts four to five days (Prasad 1967). See Solinas and Bucci (1982) for a detailed study of the development of *Gephyraulus diplotaxis* (Solinas) and the progress of apparently similar damage in Italy to flowers of *Diplotaxis muralis* (L.) D.C. (Brassicaceae).

*Gephyraulus indica* (Grover and Prasad),  
**new combination**

We have not seen type specimens of this species and rely for this determination on Grover and Prasad 1966. The descriptions and drawings of that paper indicate that the ovipositor of *G. indica* is longer, more gradually attenuate, less stiff and less pigmented than that of *G. mangiferae* and its fused cerci are longer, more tapered, and more setose. Grover and Prasad (1966) offered also dorsal and ventral views of the male genitalia of *G. indica* but the dorsal view (Fig. 9b) appears to fit the genitalia of *G. mangi-*

*ferae*, while their Fig. 9a clearly shows longer gonopods and gonostyli for *G. indica* and parameres that are straighter and not apically inclined towards the aedeagus.

According to Grover and Prasad (1966), eggs of *G. indica* are laid in young buds and larvae feed on the internal organs of the flower and prevent fruiting, which is essentially the same damage as for *G. mangiferae*. A biological difference given for the two species is that the larvae of *G. mangiferae* appear usually to pupate in the flowers while those of *G. indica* drop to the soil to pupate. The larva of *G. indica* was not described in detail in Prasad (1971). The ranges of the two species appear to be at least partly contiguous in India.

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