

## Taxonomy and Biology of Economically Important Fruit Flies of India

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### ABSTRACT

The major fruit fly pests in India belong to the genus *Bactrocera*: *B. cucurbitae* (Coquillett), *B. dorsalis* (Hendel) and *B. zonata* (Saunders). Other species of *Bactrocera*, such as *B. correcta* (Bezzi), *B. diversa* (Coquillett) and *B. latifrons* (Hendel), although moderate pests, are localized in their distribution. *B. correcta* is occasionally reported to dominate *B. zonata* and *B. dorsalis* on mango. To date, five or six species of the *B. dorsalis* complex have been recorded in India, and at least 10 species may occur there, as well as three or four species of the *B. zonata* complex. *B. tau* (Walker) and *B. scutellaris* (Bezzi) have not been recognized even as moderate pests, whereas *B. caudata* (Walker) is still not fully confirmed in India. The pest status of *B. oleae* Gmelin has not yet been determined by the olive growers. *Dacus ciliatus* Loew sometimes becomes a serious pest of squash melons, dominating *B. cucurbitae*. Amongst the non-dacine species, the capsule fly, *Acanthiophilus helianthi* (Rossi), and *Carpomya vesuviana* (Costa) are cause of concern: outbreaks of the capsule fly are sometimes serious on safflower, and *C. vesuviana* (ber fly) appears to be becoming a major pest of ber. The useful fruit flies include some species that damage local weeds. *Procecidochares utilis* (Stone), a native of Mexico, is well established on crofton weed. Several other useful fruit fly species, such as *Dacus persicus* Hendel, *Ensina sonchi* (Linnaeus), *Urophora stylata* (Fabricius), and *D. sororcula* (Wiedemann), attack weeds belonging to *Calotropis*, *Sonchus*, *Cirsium* and *Bidens*, respectively. Taxonomic, biological and economic information on all these species is given, including data from SEM studies to determine useful but previously unknown taxonomic characters.

## INTRODUCTION

India is a major producer of fruits and vegetables, which constitute important source of nutrition for its enormous population. To date, with increasing globalization, it has become a challenge for this country not only to feed its own population but also to export fruits and vegetables to various developed countries. This requires strict quality control and restrictive quarantine measures. For example, the export of mango is increasing despite concern that fruit fly pests might be shipped along with these fruits. Being unable to use ethylene dibromide fumigation, because of residue problems, the best method at the moment would appear to be through determining resistant varieties or concerning innovative control methods.

There are about 325 species of fruit flies occurring in the Indian subcontinent, of which 205 are from India alone. The major pest species belong to the genus *Bactrocera*: *B. cucurbitae*, *B. dorsalis* and *B. zonata*, while other species, such as *B. correcta*, *B. diversa* and *B. latifrons*, are still localized in their distribution. *B. versicolor* (Bezzi) (an earlier synonym of *B. dorsalis*), is very similar to *B. zonata*, but it differs from the latter in the presence of a black spot at the apex of the scutellum and in having a narrow (but complete) costal band. It is recorded from sapodilla (*Manilkara zapota*) and guava. *B. nigrofemoralis* White and Tsuruta (known as *B. nigrotibialis* in the Indian literature) was reported from south India on *Coffea canephoria* (Narayanan and Batra, 1960). It is known from South India and Sri Lanka and the only confirmed host is *Terminalia catappa* (Tsuruta and White, 2001). *B. (Tetradacus) minax* (Enderlein) (also known as *Callantra minax* and *Polistomimetes minax* in the Indian literature), or Chinese citrus fly, is another fruit fly that needs monitoring. It is a pest of citrus and has already been recorded from northern India as causing heavy damage to tangerine (*Citrus reticulata*). *Carpomya vesuviana* Costa has extended its intensity of infestation in various parts of India, causing concern to the growers of ber (*Zizyphus mauritiana*) both in northern and southern India. The infestation is becoming so serious that sometimes not a single fruit is spared.

The purpose of this publication is to summarize the knowledge on the economically important tephritid species of India, including their taxonomy, biology and economic importance.

## TAXONOMY AND BIOLOGY

Nomenclature in this section is mostly based on Norrbom *et al.* (1999).

### A. DACINE PESTS

#### Genus *Bactrocera* Macquart

#### Subgenus *Zeugodacus* Hendel

Species belonging to the subgenus *Zeugodacus* are recognized by having prescutellar setae and usually two pairs of scutellar setae, although in *B. cucurbitae* only the apical pair is present. There are three main pest species in this subgenus: *B. cucurbitae*, *B. tau* and *B. caudata*. Of these, *B. cucurbitae* is not only the most dominant but also a major pest. *B. tau* usually inhabits hilly or semi-hilly regions and attacks many cucurbits and tomatoes. *B. caudata* was also known in the Indian literature as *B. maculipennis* Doleschall. Although *B. caudata* had been recorded

earlier from India, doubts still persist about its true distribution. White and Elson-Harris (1992) reported a few specimens of this species from India in the collection of the Natural History Museum, London. This collection appears to be quite old, perhaps from pre-partition India. The author still doubts the occurrence of *B. caudata* in India.

#### Key to species of the subgenus *Zeugodacus*

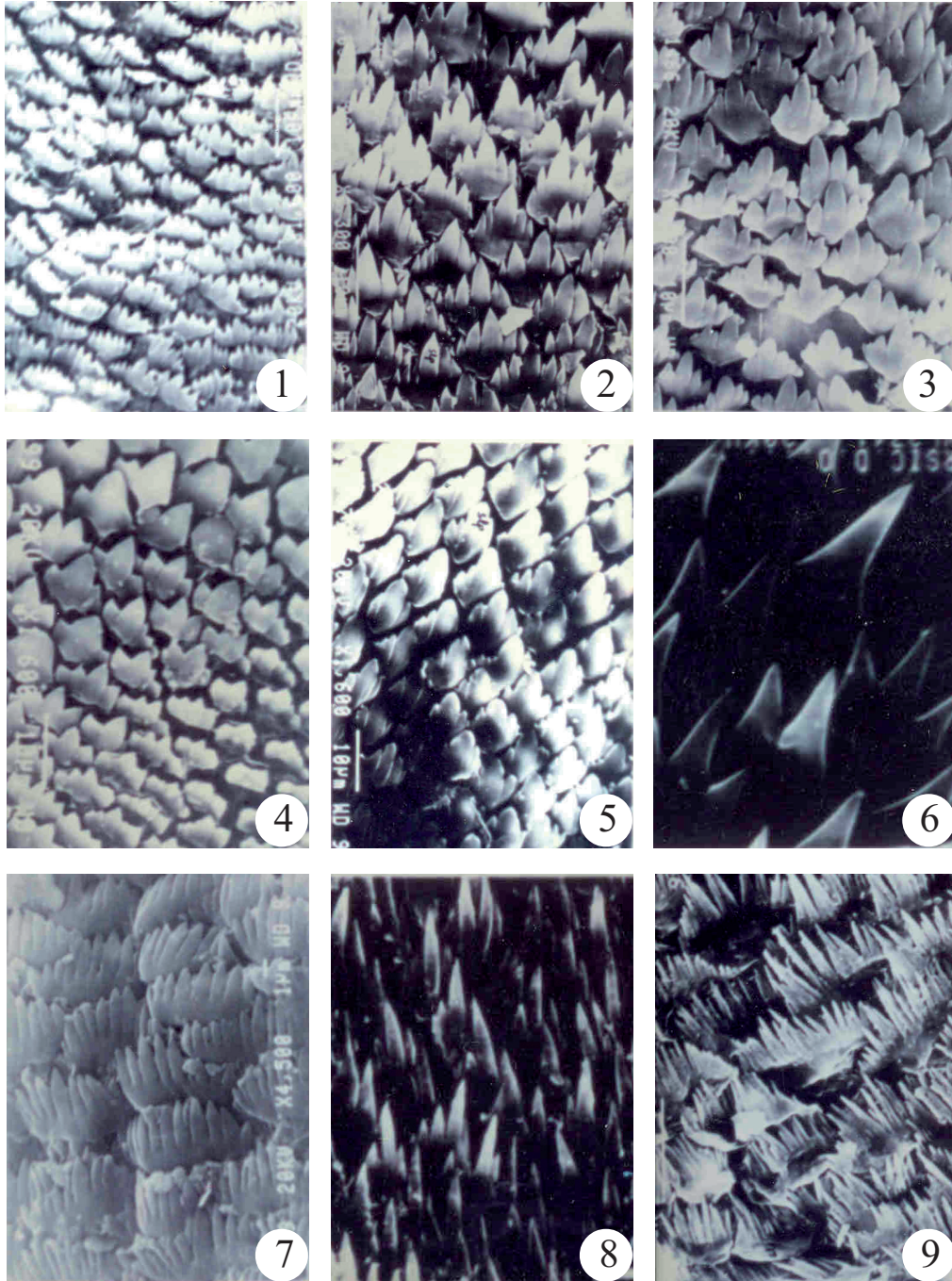
1. Wings with costal band incomplete, with small isolated spot covering apex of vein  $R_{4+5}$ , no marks over crossveins R-M and DM-Cu; 3 pairs of frontal setae; scutellum with black spot at apex; attacks cucurbits, especially pumpkin and gourds (India, Pakistan, Nepal, Bangladesh, Myanmar, Thailand) ..... ***scutellaris* Bezzi**
- Wings with costal band complete, dark and expanded apically; other characters variable...2
2. Costal band with large apical spot, almost covering apical part of cells  $r_{2+3}$  and  $r_{4+5}$ ; crossveins R-M and DM-Cu thickly infuscated; 3 frontal setae; scutellum yellow; attacks cucurbits, tomato, brinjal, capsicum, guava, grapes (Widespread throughout the Oriental Region including China, Japan, Ryukyu Islands, much of the Pacific including New Guinea, Solomon Islands, Bismark Islands and Australia; also Mauritius, Kenya and Tanzania) ..... ***cucurbitae* (Coquillett)**
- Costal band with narrower apical spot; no infuscations on crossveins R-M and DM-Cu; number of frontal setae and scutellum color variable ..... **3**
3. Face with brown or black spot in antennal furrow; no line across mouth opening; costal band dark and expanded into spot near apex of cell  $r_{2+3}$  extending across vein  $R_{4+5}$ ; attacks cucurbit fruits and tomatoes (tropical Asia) ..... ***tau* (Walker)**
- Face without brown or black spot in antennal furrow, with black line across mouth opening; costal band thinner and slightly expanded at vein  $R_{4+5}$ ; attacks cucurbit flowers and fruits (Tropical Asia possibly excluding India) ..... ***caudata* (Walker)**

#### ***Bactrocera* (*Zeugodacus*) *cucurbitae* (Coquillett) (Fig. 1)**

*B. cucurbitae* is a serious pest of many cucurbits and is considered the foremost fruit fly pest of India. It is the only species that is uniformly widespread, attacking a large array of cucurbit fruits in India. It has been observed to withstand all kinds of adverse climatic conditions from the plains to the hilly tracts. It is easily recognized while at rest by its predominant orange-brown color, postsutural yellow stripes, facial spots, and a characteristic wing pattern. The species is extremely variable morphologically especially in body coloration, chaetotaxy and wing markings. Under scanning electron microscope the teeth of denticles of the eversible membrane of ovipositor are 7-9 in number, similar and quite short (Fig. 1).

*B. cucurbitae* is commonly known as the “melon fly” due to its preference for melons. In India it destroys, either partially or completely, over 60% of the cucurbit crops. It attacks mostly cucurbits but sometimes also tomato, watery rose-apple, and other plants (Kapoor and Agarwal, 1983). It is reported to be associated with about 150 host plants. However, this number may not be correct as some records are not confirmed rearing records. It has also been reported to develop in stem galls induced by gall midges (*Lasioptera toombii* (Grover); Diptera: Cecidomyiidae) on ivy gourd (*Coccinia grandis*) (Bhatia and Mahto, 1968). Batra (1968) recorded *B. cucurbitae* attacking cucurbit flowers and adults resting in swarms in association with other *Bactrocera* species on the underside of guava leaves during winter. There are unconfirmed reports of *B. cucurbitae* attacking jack fruit (*Artocarpus heterophyllus*) in Assam.

BIOTAXONOMY OF TEPHRITOIDEA



Figs. 1-9. SEM photographs of denticles on the eversible membrane of the ovipositor of *Bactrocera* and *Dacus* species. 1. *B. cucurbitae*. 2. *B. tau*. 3. *B. scutellaris*. 4. *B. zonata*. 5. *B. dorsalis*. 6. *B. oleae*. 7. *B. diversa*. 8. *D. ciliatus*. 9. *D. persicus*.

During the hot summer months (i.e., April-June) attacks on cucurbits by *B. cucurbitae* often occur together with *Dacus* (*Didacus*) *ciliatus* Loew. Dominance of the former to date has not allowed the latter to increase in number, but recent observations in certain northern and central territories of India have shown that *D. ciliatus* has begun to dominate *B. cucurbitae* and started to increase in number. Indeed, flies reared from infested fruits of bitter gourd and squash melons were more often *D. ciliatus* than *B. cucurbitae*. From July onwards *D. ciliatus* declines in abundance, except in ivy gourd where the infestation continues until October. During July-August infestations of *B. cucurbitae* are so severe that almost all cucurbits are attacked resulting in heavy damage. In some cases the entire crop is lost. The most vulnerable hosts are bitter gourd, ribbed gourd, bottle gourd, long melons, squash melons, snap melons, and cucumber. The infestation continues until the appearance of fruit crop in October. Intensity of attack diminishes considerably after October, except sometimes in American chillies and tomatoes. In Bangalore *B. cucurbitae* also damages musk melons from January to March (Sarode *et al.*, 1981).

Control of *B. cucurbitae* is problematic because it has numerous hosts. Only integrated methods of control appear to be effective. Chemical control, although quite prevalent, is risky. The farmers show little concern for the residual effect of chemicals, being more concerned about profit. The vegetables are brought to the market long before the chemicals have broken down.

***Bactrocera* (*Zeugodacus*) *tau* (Walker) (Fig. 2)**

This species is widely distributed in the Oriental region, and it is often confused with its ecological homolog, *B. caudata*. It has been known as *Chaetodacus tau* (Walker), *Dacus caudatus* var. *nubilus* Hendel, *D. hageni* Meijere, *D. nubilus* Hendel, *D. tau* (Walker), *Dasyneura tau* Walker, *Zeugodacus bezzianus* Hering and *Z. nubilus*. It attacks a wide range of cucurbitaceous plants, tomatoes and fleshy fruits such as jack fruit, guava, mango, sapodilla and wax apple. The species is fairly well distributed across the whole of the Indian subcontinent and commonly occurs in the hilly tracts of northern India, attacking all kinds of cucurbits and tomatoes. The species is easily recognized by the orange-brown scutum marked with lateral and medial yellow stripes, facial spots not interconnected, and wing with a costal band expanded into a large apical spot. Males are attracted to cue lure. Mahmood (1999) has recently discovered a complex of *tau* species but further research is required in order to clarify this discovery. The teeth on each denticle of the eversible membrane are 5-7 in number, large and pointed (Fig. 2).

***Bactrocera* (*Zeugodacus*) *caudata* (Fabricius)**

This species has also been known as *Bactrocera maculipennis* Doleschall, *Chaetodacus caudatus* Fabricius and *Zeugodacus caudatus* (Fabricius). It is easily recognized by being predominantly black with lateral and medial yellow scutal stripes; face with a black line across mouth opening or with the black spots in the antennal furrows extended laterally and almost forming a line across the mouth opening; and wing with costal band expanded into an apical spot. The species is similar to *B. tau* (Walker); both species are ecological homologs. *B. tau* differs in having a predominantly orange-brown scutum, costal band expanded into a comparatively larger apical spot and the two oval facial spots clearly separated.

*B. caudata* is distributed in Indonesia (Java, Sumatra), Malaysia, Myanmar, Taiwan, Thailand, Vietnam and Brunei. The species was also recorded from India and Nepal (Kapoor *et*

*al.*, 1976; Kapoor and Malla, 1979; Munro, 1984; White and Elson-Harris, 1992). Munro's record is based on 'one male and one female from DehraDun, 1925, det. G.D. Bhasin.' Other records, such as that of White and Hancock (1997), also appear to be based on old collections of pre-partition India. The author doubts its occurrence in India.

***Bactrocera (Zeugodacus) scutellaris (Bezzi)* (Fig. 3)**

*B. scutellaris* is distributed throughout almost the whole of the Indian subcontinent, Myanmar and Thailand. It is similar to *B. cucurbitae* in having 3 frontal setae, but differs in other characters. It attacks various cucurbits, especially pumpkin and gourds. It is noteworthy that the species is quite active in cool climates and is becoming an important fruit fly pest in some areas of Himachal Pradesh. The species is attracted to cue lure. The teeth on each denticle of the eversible membrane of ovipositor are comparatively narrow with rounded apices (Fig. 3).

**Subgenus *Bactrocera* Macquart**

This subgenus is recognized by having only the apical scutellar seta and by the short posterior surstylar lobe (at most twice as long as the anterior lobe) as compared to the long posterior surstylar lobe (at least 6 times as long as the anterior lobe) in *Zeugodacus*. It includes the majority of the pest species. The major pests are *B. zonata* (Saunders) and *B. dorsalis* (Hendel), and the species complexes associated with them that, in the case of *B. zonata*, require confirmation. The other species of interest are *B. correcta* and *B. latifrons*, both of which are of occasional concern to vegetable and fruit growers.

**Key to species of the subgenus *Bactrocera***

1. Face with transverse dark markings adjacent to antennal furrows, sometimes joined to form line across ventral facial margin; wing without complete costal band (Oriental) ..... ***correcta* (Bezzi)**
- Face with spot in each antennal furrow; wing with or without complete costal band ..... **2**
2. Wing without distinct costal band; apex of cell  $r_{4+5}$  with brown spot; thorax and abdomen pale orange ..... ***zonata* (Saunders)**
- Wing with distinct costal band extending from wing base to near wing apex; color of thorax and abdomen variable ..... **3**
3. Costal band distinctly expanded near apex of cell  $r_{2+3}$  to form spot extending across vein  $R_{4+5}$ ; abdomen predominantly red brown; rarely with distinct T-shaped mark on tergites 3-5; anepisternal stripe broad (Oriental) ..... ***latifrons* (Hendel)**
- Costal band usually not expanded to form spot; abdominal tergites 3-5 always with distinct black T-shaped mark; anepisternal stripe narrow ..... ***dorsalis* complex.....4**
4. Prescutellar vitta narrow (0.15 mm wide or less) and parallel-sided; facial spots large, oval, separate (not connected by streak); thorax black with broad medial dark band and broad lateral yellow stripes or vittae; costal band narrower than in *dorsalis*, complete, reaching vein  $R_{4+5}$  or extending slightly beyond it; no infuscations in basal cell; aculeus length 1.55-1.80 mm; on mango, guava etc.; attracted to methyl eugenol (India, Sri Lanka) ..... ***caryeae* Kapoor**
- Prescutellar vitta broad (more than 0.15 mm wide), parallel-sided or narrowed only slightly posteriorly; other characters variable ..... **5**
5. Costal band confluent with vein  $R_{2+3}$  and extending apically (at most a very slight swelling at

- apex of  $R_{4+5}$ ; pleural area ventral to postpronotal lobe pale, brown; aculeus short (1.4-1.6 mm); major pest of mango, guava and many other fruits; attracted to methyl eugenol (Oriental, introduced into Hawaii and Mariana Islands) ..... **dorsalis (Hendel)**
- . Costal band covering vein  $R_{2+3}$ , of uniform width or with slight apical expansion; other characters variable ..... **6**
6. Forefemur with large elongate oval black spot posteroapically; median longitudinal dark band on abdominal tergites 3-4 narrow; shining spots on tergite 5 fuscous; host unknown; males attracted to cue lure (southern India) ..... **vishnu Drew and Hancock**
- . Forefemur usually with dark fuscous spot posteroapically; median longitudinal dark band on abdominal tergites 3-4 comparatively broader and without broad dark lateral margin on tergite 3; without pale coloration around base of prescutellar seta; dark markings present around bases of orbital setae; major pest, on *Averrhoa carambola*, *Sygygium samarangensis* (= *Eugenia javanica*), mango and guava; attracted to methyl eugenol (Malaysia, Indonesia; Borneo; Thailand; India: Andaman Islands; French New Guinea; Surinam) ..... **carambolae Drew and Hancock**

***Bactrocera (Bactrocera) zonata* Saunders (Fig. 4)**

*B. zonata* is prevalent in almost all of south-east Asia. It is one of the main species of the *zonata* group. The other species are *B. affinis* Hardy, *B. versicolor* Bezzi, *B. correcta* and a new species related to *B. affinis* from India alone. It is red-brown in color with two postsutural lateral vittae; lacking median postsutural vitta. Costal band incomplete and without anal streak. Teeth of each denticle on the eversible membrane of ovipositor are 4-6 in number, short and broadly triangular (Fig. 4). *B. zonata* has now spread to several other parts of the world, such as the Near East and Egypt. It has also been reported from a few places in Europe. The IAEA and FAO are currently working to prevent its further spread. *B. zonata* is similar in distribution to *B. cucurbitae* and attacks more than 50 host plants, including guava, peach and mango. Since it prefers peach and guava, it is commonly referred to as “peach fruit fly” or “guava fruit fly”. It attacks soft and tender fruit. During April to June the attack on peaches is sometimes so severe that it destroys the entire crop. With the beginning of monsoon, i.e., from July onwards, it prefers guava, and the attack is always severe. Mango is also attacked at this time, but in India this is mixed with attack by *B. dorsalis* too. *B. zonata* occasionally outnumbers *B. dorsalis* on mango. From the beginning of November till March its activity declines but on the appearance of ber during spring its attack causes concern to ber growers.

***Bactrocera (Bactrocera) n. sp.***

The chromosomal characters of *B. zonata* and this new species show clear-cut differences. White and Elson-Harris (1992) studied specimens in the Natural History Museum, London, belonging to this species. These specimens were collected on leaves of custard apple (*Annona reticulata*) from India. They were found to differ from true *B. zonata* in the shape of their aculeus tip, which has a pair of preapical ‘steps’ similar to *B. affinis*. *B. affinis* differs from *B. zonata* in lacking prescutellar acrostichal setae. Thus, these three species may form a *zonata* complex.

***Bactrocera (Bactrocera) correcta* (Bezzi)**

*B. correcta* is distributed throughout the Indian subcontinent and Thailand but has also invaded places distant from Asia. A few specimens of this species were intercepted in California in 1986, but the species did not establish there (Weems, 1987). Two flies were

captured in Florida in 1999, and a single male was found in Florida in a fruit fly detection trap in 2001 (Steck, 2002). If unchecked, *B. correcta* has the potential to become a major pest of citrus, peach and several kinds of tropical and subtropical fruits there. *B. correcta* is attracted to methyl eugenol. It constitutes a new threat to fruit growers in Europe and the Middle East. It is recognized by a predominantly black scutum with lateral yellow stripes; face with lines above the mouth opening usually joining in the center; and wing with a reduced pattern. In India it usually occurs in association with *B. zonata* and *B. dorsalis* (Kapoor, 1989), and has similar hosts. Its distribution in India is peculiar: it is found in isolated pockets, never uniformly distributed, due to the dominance of ecological homologues such as *B. zonata* and *B. dorsalis*. In recent years it has increased its intensity of attack in some parts of India, dominating the other two species on guava and mango. Its numbers start increasing by late June or early July, when other fruit fly species are still low in number. In Tamil Nadu this species is showing signs of dominance over *B. zonata* and *B. dorsalis* on guava for the first time, indicating that *B. correcta* may become a major threat to guava in south India.

*B. bangaloriensis* Agarwal and Kapoor (1983) is now a synonym of *B. correcta*.

#### ***Bactrocera (Bactrocera) latifrons* (Hendel)**

*B. latifrons* is widely distributed in the oriental region. It is easily recognized by the predominantly black scutum with lateral yellow stripes, facial spots, predominantly orange abdomen; and costal band expanded into an apical spot. It is a serious pest of solanaceous crops including chili (*Capsicum* sp.). In the Indian subcontinent it has been reared from eggplant (*Solanum melongena*) and *S. sisymbriifolium* (Perkins, 1938; Narayanan and Batra, 1960). Udayagiri (1987) reared it from berries of *Solanum vivarum* in Karnataka. Recent collections have shown its predominance in southern India and its potential threat for other parts of India. It was introduced into Hawaii in 1983 (Vargas and Nishida, 1985).

#### ***Bactrocera (Bactrocera) dorsalis* complex**

*B. dorsalis* has been a serious problem as far as control is concerned, mainly because it is a complex (probably of 8-10 species) in India. To date only five such species are known with certainty; an additional two species require confirmation. A good account of the separation of various species of this complex is given by Drew and Hancock (1994). The Indian species of this complex are: *B. caryeae* (Kapoor), *B. poonensis* (Kapoor), *B. dorsalis* (Hendel), *B. carambolae* Drew and Hancock, *B. vishnu* Drew and Hancock, *B. occipitalis* (Bezzi) (still doubtful in India), and *B. kandiensis* Drew and Hancock. The latter species is so far known only from Sri Lanka but is believed to be present also in southern India. *B. caryeae* was earlier merged with *B. dorsalis* (Kapoor, 1993) but is now a distinct species. White and Elson-Harris (1992) note that it is the same species that Bezzi (1916) misidentified as *Chaetodacus ferrugineus incisus* Walker, and many other subsequent records of *B. incisus* (Walker) were also referred to *B. caryeae*. Accordingly, true *B. incisus* is a Burmese species and not a member of the *dorsalis* complex. The confirmed hosts of *B. caryeae* are mango, guava, *Solanum verbascifolium* and a wild host, patana oak (*Caryea arborea* Roxb.). The species is distributed in southern India and Sri Lanka. Clausen *et al.* (1965) recorded various hosts for *B. dorsalis* and *B. incisus*, and these have been referred to *B. caryeae* Kapoor (White and Elson-Harris, 1992). These hosts are robusta coffee (*Coffea canephoria*), tangerine (*Citrus reticulata*) and *Ficus* sp. Rao (1956) reported *B. dorsalis* on banana (*Musa paradisiaca*) which was also attributed to this

species by White and Elson-Harris (1992). *B. poonensis* is still known from its original locality, i.e., Poona (now Pune), where it was collected in 1905 (Kapoor, 1971) on *Accinum sanctum*. *B. occipitalis* was reported by the present author (Kapoor, 1993) from a single female from south Andaman collected in 1986. This species is known from the Philippines and Borneo, and the presence of a single specimen from the Andamans in India is attributed to its chance entry rather than to regular occurrence (not a single specimen of this species has since been collected from any part of India). This specimen might belong to *B. andamanensis* Kapoor, which may also fall within this complex. *B. poonensis*, *B. kandiensis* and *B. occipitalis* are not included here because of their doubtful economic and distribution status.

***Bactrocera (Bactrocera) carambolae* Drew and Hancock**

In general characteristics this species is similar to *B. dorsalis* and *B. occipitalis* but differs from both in having narrower lateral dark patterns on tergites 3-5 (broader and continuous pattern in *B. occipitalis*), a more pointed apex of aculeus and usually a large elongate dark spot (more common in females) on the forefemur posteroapically. The species is presently known from Andaman Islands in India. Males are attracted to methyl eugenol. Its primary hosts include *Averrhoa carambola*, *Syzygium samarrangense* (= *Eugenia javanica*), and secondary hosts are guava and mango. It constitutes a potential threat to similar hosts in other Indian territories.

***Bactrocera (Bactrocera) caryeae* (Kapoor)**

Kapoor (1971) described this species from the many unidentified fruit fly specimens present in the collection of the Division of Entomology, Indian Agricultural Research Institute, New Delhi. The holotype is no longer in good condition. A male specimen of this species was collected from Coorg (Karnataka) in southern India by B. Fletcher in 1914 on *Caryea arborea* fruits. The species is currently widely distributed in southern India as well as Sri Lanka (Drew and Hancock, 1994). It attacks guava and mango. The species seems to be confined for the present to the southern parts of the Indian subcontinent. It is similar to *B. kandiensis* Drew and Hancock from Sri Lanka in having narrow lateral postsutural vittae, apex of femora darker, narrow anal streak and a reduced band of microtrichia anterior to basal cell. It is easily separated from the latter in possessing very broad lateral longitudinal dark fuscous to black bands on abdominal tergites 3-5 (Drew and Hancock, 1994).

***Bactrocera (Bactrocera) dorsalis* (Hendel) (Fig. 5)**

This species has been known as *Dacus ferrugineus* (Fabricius) in the Indian literature. It is also called the "oriental fruit fly" due to its wide distribution in the oriental region. It is a serious pest of mango. *B. dorsalis* also attacks guava but mostly in association

with *B. zonata*; rarely infestation is also seen on jamun (*Eugenia jambolana* Lamk.) and other fruits. It is also known to attack more plant species than any other in India. The teeth on each denticle on the eversible membrane are similar to each other (Fig. 5).

***Bactrocera (Bactrocera) vishnu* Drew and Hancock**

*B. vishnu* is another species of the *B. dorsalis* complex described by Drew and Hancock (1994) from Kodaikanal, a famous hill resort of southern India. The host is not known as it was collected using cue lure as attractant. It is similar to *B. carambolae* in the general color pattern of the thorax, wing and abdomen but differs in having a large elongate oval black spot on the apex of the forefemur, a narrow median dark band on abdominal tergites 3-5 and fuscous

shining spots on tergite 5.

#### **Subgenus *Daculus* Speiser**

This subgenus is easily distinguished in not having anterior supra-alar and prescutellar setae; abdomen flexible; scape short; tergite 3 of male with pecten; wing pattern narrow; no postsutural stripes; without microtrichia over cell bm; and no anal stripe. It is known in India by only one species, i.e., *Daculus oleae* (Gmelin) which is discussed below.

#### ***Bactrocera (Daculus) oleae* Gmelin (Fig. 6)**

*B. oleae* is distributed throughout much of Europe, Africa, the Middle East, northern India and north-west Pakistan. It is a serious pest of olives and involves millions of dollars in its control every year. It is easily recognized by the predominantly black scutum (sometimes this color does not extend laterally, making the lateral area red-brown, especially in African specimens (White and Elson-Harris, 1992)); no yellow stripes on thorax; facial spots present; abdomen orange medially and black laterally, and wing with a reduced pattern. Fletcher (1917) was the first to report it from India and Pakistan. Later, Pruthi and Bhatia (1938) and Narayanan and Batra (1960) reported *B. oleae* from north-west India on wild and cultivated olives. The teeth on each denticle of the eversible membrane are few but sharply pointed (Fig. 6).

#### **Subgenus *Paratridacus* Shiraki**

This subgenus includes a single species, *Dacus diversa* Coquillett, which can easily be separated from similar fruit fly species by the presence of prescutellar setae; males without pecten on abdomen; and costal band not expanded near apex of vein  $R_{4+5}$ .

#### ***Bactrocera (Paratridacus) diversa* Coquillett (Fig. 7)**

*B. diversa* has invaded almost the whole of the Indian subcontinent and Thailand. It is easily recognized by its predominantly black scutum with bright yellow stripes. The male's face is entirely yellow without facial spots (another diagnostic feature), whereas the female's face has a black transverse line dorsal to the mouth opening. The female has a characteristic long ovipositor, whereas the male abdomen is without pecten. The teeth in each denticle of the eversible membrane of the ovipositor are 7-10 in number and resemble a human hand (Fig. 7). Preferred hosts are various gourds, pumpkin, *Luffa* spp. and sometimes also banana, guava, jamun and citrus. Its presence in the field coincides with other *Bactrocera* species, such as *B. cucurbitae* and *B. zonata*, which prevents its increase in number. It is usually reared in very low numbers along with *B. cucurbitae* (barely four-five specimens along with 200-300 specimens of *B. cucurbitae*). It has also been seen congregating on undersides of leaves of guava and mango alone or in association with *B. dorsalis* or *B. zonata*.

#### **Genus *Dacus* Fabricius**

This genus is known in India by three subgenera, *Didacus* Collart, *Leptoxyda* Macquart and *Callantra* Walker. The latter does not include any species that are economically important in India. The other two subgenera are known in India by one species each: *D. (Didacus) ciliatus* Loew and *D. (Leptoxyda) persicus* Hendel. Members of the genus *Dacus* are recognized by

having all the abdominal tergites fused into a single plate, at most with weak transverse sutures that form the boundaries between segments. The larvae of some species attack fruits and flowers of cucurbits, and those of other species attack pods of Asclepiadaceae (such as *Calotropis procera*) and thus are beneficial. There is only one pest species in this genus, which is dealt with below.

### Subgenus *Didacus* Collart

The members of this subgenus are recognized by having the abdomen club-shaped, rigid, with tergites fused; no anterior supra-alar setae; tergite 3 of male with pecten; face with black spots; no yellow stripes on thorax and no microtrichia in cell bm.

#### *Dacus (Didacus) ciliatus* Loew (Fig. 8)

This species is usually referred to as the 'Ethiopian fruit fly' and has also been known as *Dacus brevistylus* Bezzi in the Indian subcontinent. Due to its preference for melons it is also called the 'Ethiopian melon fly'. It was first recorded from some parts of India by Bhatia (1939), infesting a large variety of melons and wild cucurbits. Squash melon and ivy gourd are the most preferred hosts. The species was earlier kept in low profile due to the dominance of its ecological homolog, *B. cucurbitae*. Both species can be reared together from various cucurbit fruits from May to July. Recent observations have shown the dominance of *D. ciliatus* over that of *B. cucurbitae* in some parts of India, Nepal and Pakistan. Its dominance has been attributed to its short preoviposition and incubation periods and greater reproductive potential (Qureshi *et al.*, 1987). Its increasing attack on squash melon and bitter gourd in some parts of northern India is of concern to vegetable growers.

The species is easily recognized in being predominantly orange with black facial spots; a yellow spot covering most of the katatergite, anatergite orange, midfemur orange yellow, and wing with costal band extremely narrow in cell  $r_{2+3}$  but dilated apically near and beyond vein  $R_{4+5}$ ; abdominal tergites fused to form hemispherical capsule, with oval black spots on either side of tergite 3. The teeth in each denticle on the eversible membrane of the ovipositor are numerous, closely set and comparatively slender (Fig. 8).

## B. NON-DACINE SPECIES

### (i) Minor pests

There are three pest species in this group, which are discussed below.

#### *Carpomya vesuviana* Costa

*C. vesuviana* is a primarily Palaearctic species widespread in the Indian subcontinent. It is specific to *Zizyphus* and attacks Indian jujube (*Zizyphus mauritiana*), common jujube (*Z. jujube*) and *Z. nummularia*. Clausen *et al.* (1965) recorded it from common guava but that is doubtful, as it has never been reported from this host again. It also attacks wild bers, such as *Z. rotundifolius* and *Z. sativus* (Lakra and Singh, 1984). The fly causes considerable damage, sometimes up to 90% in northern India. The attack on ber starts in November, when the fruit is small and tender. Sometimes off-season attack on ber is also noticed (Sohi *et al.*, 1990).

The fly is easily distinguished in having distinctive pattern of black marks on the scutum and scutellum, and distinct yellow and brown bands on the wings. *Carpomya zizyphus* Agarwal and

Kapoor (1986) was synonymized with *C. vesuviana* by Kapoor (1993), as the former was found to be an aberrant individual of the latter (also commented by White and Elson-Harris, 1992).

***Carpomya pardalina* (Bigot)**

It is commonly called the “Baluchistan melon fly”. It is a serious pest of melons in Baluchistan and other Middle East countries. Narayanan and Batra (1960) reported its distribution in Jalandhar (Punjab) and Pusa (Bihar) in India. Zaka-Ur-Rab (1984), while mentioning its distribution in India and Pakistan, also recorded its hosts as *Cucumis lanatus*, *C. melo*, *C. sativus*, *C. trigonus*, *Cucurbita maxima* and *C. pepo*. The species seems to have not made its presence felt due to the dominancy of its ecological homologs, especially *B. cucurbitae* and *D. ciliatus*. It is easily distinguished in being orange yellow with a shiny yellow and black pattern on scutum and scutellum and characteristic pattern of yellow bands on the wing. The species is sometimes confused with *C. vesuviana*, but its color pattern and also strong ocellar setae (absent in *C. vesuviana*) and broad gena (narrower in *C. vesuviana*) easily separate it from the latter. The fly lays eggs in the skin of water melons. The larvae on hatching penetrate the fruit, feed on pulp and develop inside the fruit. On attaining full maturity the larvae drop on the ground or sometimes remain inside the fruit for pupation.

***Acanthiophilus helianthi* (Rossi)**

*A. helianthi* (the “capsule fly”) is a primarily Palaearctic species distributed in Africa, Asia and Europe and fairly well represented in the Indian subcontinent. It attacks safflower (*Carthamus tinctorius*). The attack is sometimes so serious that not a single flower head is spared resulting in almost total loss of seeds. In India, the fly was reported from Delhi damaging safflower and sunflower (Bhatia and Singh, 1939; Pruthi and Bhatia, 1940). Menon *et al.* (1968) reported total destruction of a corn-flower crop (*Centaurea americana*) due to this fly in Delhi. Similar serious infestations were also reported from various parts of India (Vaishampayan *et al.*, 1970; Verma *et al.*, 1974; Jakhmola and Yadav, 1983; Chaudhary *et al.*, 1983). It also attacks soybean in Madhya Pradesh (Rawat and Singh, 1979). Surprisingly, its infestation is often mixed with another fruit fly species, *Craspedoxantha octopunctata* Bezzi on corn-flower and sunflower but in very low numbers. Another fruit fly species, *Chaetostomella completa* Kapoor, Mella and Ghosh also attacks corn flower in India (Agarwal and Kapoor, 1982). The capsule fly also attacks young buds from mid-December to April. Some varieties of safflowers have been found resistant to this fly (Jakhmola and Yadav, 1980). *C. americana* is an exotic species, and *A. helianthi* infests related host plants in India. The species is easily recognized by having the body black (although the black obscured by a dense gray microtrichia) and wing with characteristic diffused pattern.

**(ii) Species yet to gain attention**

*Euphranta (Rhacochlaena) cassiae* (Munro) has been noticed as a pest (sometimes with moderate to high intensity) of amaltas or Indian laburnum, *Cassia fistula*. It attacks the pods of this tree. Since this is an ornamental plant and has medicinal value, the fly needs immediate control measures.

*Bamboo fruit flies*. Fruit fly pests of bamboo belong to several genera, such as *Taeniostola* Bezzi, *Phaeospilodes* Hering, *Chaetellipsis* Bezzi, *Acroceratitis* Hendel, *Gastrozona* Bezzi and *Xanthorrhachis* Bezzi in the oriental region (Kovac *et al.*, 2006, this volume). *Acroceratitis*

*ceratitina* Bezzi and *Phaeospilodes bambusae* Hering have been collected on thorny or spiny bamboo, *Bambusa arundinacea* (Retz.) Willd.; *Chaetellipsis paradoxa* Bezzi and *P. bambusae* on *B. burmanica* Gamble (wild bamboo), and *Acroceratitis striata* (Froggatt) from feathery bamboo, *B. vulgaris* Schrad. in southern India and Sri Lanka. *A. striata* and *A. ceratitina* have also been found to attack giant bamboo (*Dendrocalamus giganteus* Munro) and solid bamboo (*D. strictus* Nees) in Sri Lanka and possibly in other parts of India as well.

*Trupanea amoena* (Frauenfeld) and *T. stellata* (Fuessly) have been found damaging commercially grown marigold flowers (*Calendula officinalis* Linn.) in India (Nirula, 1942; Trehan, 1947).

### C. BENEFICIAL FRUIT FLY SPECIES

Beneficial fruit flies play an important role in the natural regulation of many weeds. About twenty species of fruit flies have been used as biocontrol agents of adventive weeds around the globe and most of them belong to the subfamily Tephritinae. Almost all these weeds belong to the plant family Asteraceae (=Compositae) (White and Elson-Harris, 1992). Julien (1987) cataloged the released biocontrol agents and their target weeds. Harris (1989) listed 18 species of fruit flies released worldwide for the control of various weeds. White and Elson-Harris (1992) and Kapoor (1993) also gave some account of such useful fruit flies.

In India the importance of fruit flies as biocontrol agents was first realized in 1963, when *Procecidochares utilis* Stone (gallfly) was imported for release in Darjeeling, Tamil Nadu and Uttar Pradesh for the control of the introduced weed known as mau or pamakani (*Agerartina adenophorum* (Sprengel) King and Robinson (Rao *et al.*, 1971; Sankaran, 1973, 1990; Swaminathan and Raman, 1981)). The fly has not only established in the Darjeeling district in eastern India but has also migrated to Nepal (Kapoor and Malla, 1978a, b). In a few areas control has been up to 90%. The fly lays eggs on unopened leaflets of the weed. On hatching, the maggots bore into the stem and eat the tissue, resulting in swelling and the formation of galls. The larvae form cavities while eating the tissue, and pupation also takes place inside the cavities. The adults emerge from the gall through holes made by the larvae.

*Urophora stylata* (Fabricius) is another useful fruit fly in Europe and temperate Asia which attacks thistles, such as *Cirsium* and *Carduus* species, and is quite effective in controlling thistles. It has been released in a few countries against thistles and is now well established in Australia (White and Elson-Harris, 1992). It has been reported from India by Agarwal *et al.* (1992) without any host record, and it may be present in cooler areas of the whole of the Indian subcontinent. *U. solstitialis* (Linnaeus), which also attacks thistles, might also be present in the Indian region. *U. cardui* (Linnaeus) is presumed to be found in the Indian subcontinent, attacking canadian thistle, *Cirsium arvense* (L.) Scop., and inducing multilocular stem galls.

*Ensina sonchi* (Linnaeus) is another important species that is closely associated with widespread members of Asteraceae. The species is oligophagous and widespread over Europe, temperate and tropical Asia, Ethiopia, Peru and the Hawaiian Islands. It attacks weeds such as *Sonchus arvense* L. (perennial sow thistle) and related plants.

*Dioxyyna sororcula* (Wiedemann) is a fruit fly that is both harmful and useful. It attacks several species of Asteraceae including weeds, and is quite useful in the natural regulation of these weeds. It attacks *Bidens* species, also known as beggarticks. *Bidens biternata* L. is commonly found in almost all grain fields, gardens, wastelands and along road sides. The infestation rate of this fly on this weed can be as high as 60-80% in northern India (Grewal and

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Kapoor, 1984). Eggs are laid in the open flowerheads, and maggots develop inside the unripened seeds. They completely eat out the endosperm of the seed thereby destroying it. Pupation also takes place inside the seed. Jakhmola (1983) recorded it as a serious pest of niger weed (*Guizotia abyssinica* Cass.) in central India. Niger weed is a herb, native to tropical Africa, and is now cultivated in India because of its edible seeds and oil used for cooking and other industrial purposes. It is therefore necessary to control this fruit fly on this crop.

*Tephritis cardinalis* Hardy and *Terellia serratulae* (Linnaeus). Hardy (1974) reported *T. cardinalis* in flowerheads of the thistle, *Carduus edelbergi* in Pakistan and possibly in the whole Indian subcontinent. *T. serratulae* also attacks this thistle as well as *Cirsium alfovcinus* in Pakistan (Baloch and Khan, 1973). The larvae attack seeds and tissues of flower heads thereby preventing seeds from spreading. Since this thistle is also common in India, the fly may be attacking it in India too.

*Dacus* (*Leptoxyda*) *persicus* Hendel is the only dacine fruit fly that is a biocontrol agent. It attacks only ak plant or sodom apple, *Calotropis procera* (Ait.), which is of African origin. The distribution of this fly is closely associated with its host plant. This fly is easily distinguished by its abdomen being little widened and broadly rounded in the male, with the apex of the last segment truncate; a characteristic rounded ridge on lateral margin; no pecten on tergite 3 of male; mesonotum with 2 large black markings on either side; wing veins yellow, costal band broad, not ending in a club; no anal stripe; ovipositor long, longer than the preabdomen. The larvae of this fruit fly bore inside the host pods and destroy their content. Parihar (1984) worked out the biology of *D. persicus* under the name *D. longistylus* Wiedemann. The teeth of each denticle on the eversible membrane of ovipositor are numerous, with pointed apices, quite long and little apart from each other (Fig. 9).

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