Proceedings of 6th International Fruit Fly Symposium
6–10 May 2002, Stellenbosch, South Africa
pp. 23–33

Fruit-fly pests and their present status in India

V.C. Kapoor*

College of Basic Sciences, Punjab Agricultural University, Ludhiana-141004, India

Two hundred species of fruit flies are known from India. Not all are pests. Only 35 to 40 species are so far associated, directly or indirectly, with their host plants. Major pest species belong to the subfamily Dacinae. These belong to the genus *Bactrocera*; e.g. *B. cucurbitae, B. dorsalis* and *B. zonata. B. cucurbitae* is a major pest of almost all cucurbits and damages up to 70% of these fruits. It often competes with *Dacus ciliatus, B. scutellaris* and *B. tau. D. ciliatus* sometimes dominates *B. cucurbitae* in round gourds (tinda) and squash melons (*Citrullus lanatus* var. *fistulossus*). *B. dorsalis* occurs in a complex of at least four species; of these only the true *D. dorsalis* is of greatest importance. *B. zonata* has now surpassed *D. dorsalis* in many mango growing areas. It is believed to occur in a complex of two to three species. Both *B. zonata* and *B. dorsalis* compete strongly with *B. correcta* in guava in some important fruit-growing areas in India, which sometimes becomes a major threat. Other fruit fly species are currently confined to the Andaman and Nicobar Islands, and their entry into mainland India need to be very carefully monitored.

INTRODUCTION

The family Tephritidae, commonly called fruit flies, are of great economic importance. At present, some 4352 species (including subspecies) in 483 genera are known around the world. These include the most serious pests of fruits and vegetables, and are responsible for damage to these commodities worth millions of dollars each year. In India only 200 species (including three doubtful ones) in 71 genera and five subfamilies are known today (Figs 1–4). A list of all such species following the latest classification by Norrbom *et al*. (1999) is given at the end of this paper (Appendix 1). Every year these species cause damage to various fruits and vegetables in India worth over 30 000 million rupees, and in particular to major fruits like mango, guava, citrus. There is as yet not a single fruit fly pest species in India which has been successfully controlled, nor any area declared free from fruit fly pests. The pest status of various fruit flies is discussed below according to subfamilies.

PHYTALMINE FRUIT FLIES

These flies belong to the subfamily Phytalminae. There are at present 17 species in the tribe Acanthonevrini, and eight well-known genera such as *Acanthonevra, Hexacinia, Ptilona, Rioxa, Diarrhegma, Phorelliosoma, Sophira* and *Themara*. There is not a single species currently associated with any plant host in India (Figs 1, 4) although in other countries such as Australia and Papua New Guinea the larvae of some phytalmines are known to develop in fruits such as wild figs (*Ficus* spp.) (Hardy 1986). *Rioxa sexmaculata* (Wulp) has been reared from the seeds of the rubber tree in Malaysia (Yunus & Ho 1980). Some species have been found associated with bamboo in African countries while a few species of the genera *Acanthonevra* and *Diarrhegma* have been reared from decomposing tree trunks (Hardy 1986; Dodson & Daniels 1988). This suggests that if species of such genera are thoroughly searched for around such hosts, there is a possibility of linking them with their hosts in India.

*Address for correspondence: 18FF, Prem Vihar, S.B.S. Nagar, Pakhowal Road, Ludhiana-141002, India.
E-mail: vc_kapoor@yahoo.com

DACINE FRUIT FLIES

These flies belong to the subfamily Dacinae and are included in only one tribe, Dacini. These are not only the most widely distributed fruit flies the world over but include almost all major pests of fruits and vegetables (Kapoor 2000). Currently, 43 species are known in two well-known genera, *Bactrocera* and *Dacus*. The genus *Bactrocera* includes 36 species in 11 subgenera (Figs 1, 4). Of these only 16 species are economically important in causing minor to major economic losses to various fruits and vegetables in India (Fig. 4). The major pest species in order of their intensity of damage to various crops include *B. cucurbitae, B. zonata* and *B. dorsalis* (Kapoor 1989). Then follow the other species such as *B. correcta, B. diversa, B. latifrons, B. tau* and *B. scutellaris*. The other genus, *Dacus,* includes only seven species in three subgenera, *Callantra, Dacus* and *Leptoxyda*. Only one species, *D. ciliatus,* is a well-known pest of various cucurbits.

Bactrocera cucurbitae is a very versatile species and is known to be associated with over 140 plant hosts. It can withstand extremely adverse climatic conditions both in plains and hilly areas. Although it is relatively easy to identify from its body colouration and wing spots, it often creates problems in its identification due to widespread

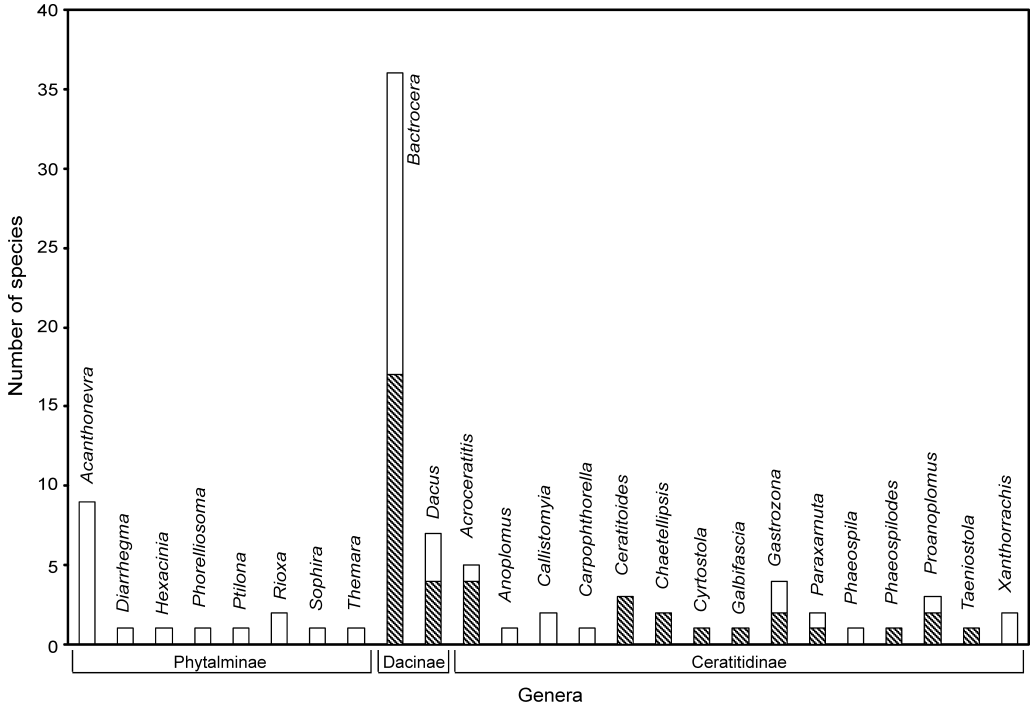

Fig. 1. Relative occurrence of Indian fruit fly species in the subfamilies Phytalminae, Dacinae and Ceratitidinae. Shaded areas show number of species with host plant records.

variations in body colouration, chaetotaxy, wing and facial spots. As a result it is often misidentified as *B. tau* or *B. caudata* although the latter is now totally absent in India. In India, *B. cucurbitae* destroys either partially or completely over 60% of the vegetable crops (mainly cucurbits). Sometimes the entire cucurbit crop is destroyed. It has also been reported to attack tomatoes and jack fruit, although these reports are believed to be mostly due to misidentification with *B. tau*. It has also been reported to attack pods of cowpea (*Vigna unguiculata* subsp. *sesquipedalis*), wilted cucumber and bitter gourd vines in Kerala during November and December (Matthew *et al*. 1999). Recently, it has also been found to attack *Brassica oleracea* var. *gongylodes* in the Andaman Islands (Ranganathan *et al*. 1999). Studies have been made on the inheritance of resistance in bitter gourd to *B. cucurbitae* (Tewatia & Dhankhar 1996).

Bactrocera cucurbitae continues its dominance over cucurbits and thus always remains in strong competition with its ecological homologues, *D. ciliatus, B. tau* and *B. scutellaris*. During hot summer months (April–June) it often causes infestation together with *D. ciliatus*. During these months *D. ciliatus* dominates *B. cucurbitae* in bitter gourd and squash melons in some areas. *D. ciliatus* prefers little gourd (*Momordica charantia*) in Gujarat (Patel & Patel 1998) and other areas. From July onwards *D. ciliatus* starts declining, except in ivy gourd where it continues infestation until October. Similarly, *B. cucurbitae* also competes with *B. tau* and *B. scutellaris*, especially on cucurbits. Sometimes *B. scutellaris* is a serious pest of cucurbits in some semi-hilly areas of Himachal Pradesh. Currently, there is no control method for *B. cucurbitae* and the species continues to severely affect vegetable growers, especially small-scale farmers as well as backyard gardeners. It has frustrated the backyard gardeners so much that in most areas they have stopped growing cucurbits.

***dorsalis–zonata–correcta* complex**

This is one of the most important fruit fly pest complexes in India. All three species attack almost similar hosts, e.g. mango and guava. *B. zonata* also attacks peaches and so is also known as the peach fruit fly. *B. correcta* sometimes also heavily infests jamun and peach. It also attacks grapes (Mani 1992). *B. zonata* and *B. dorsalis* are two other major pests. A few years ago *B. dorsalis* used to be the second most important fruit fly pest in India but for the past 10 years or more *B. zonata* has surpassed it not only in the intensity of attack but also in the size

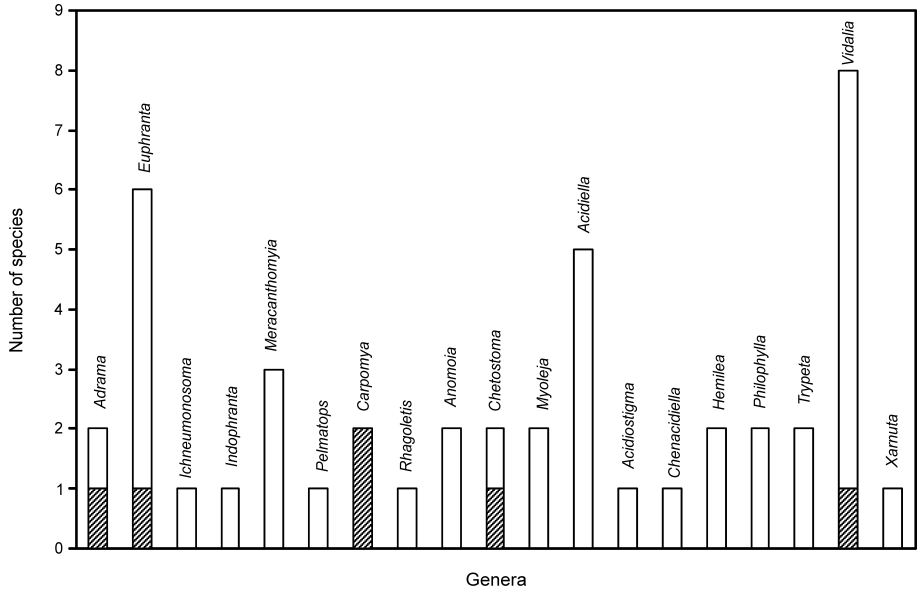

Fig. 2. Relative occurrence of Indian fruit flies in the subfamily Trypetinae. Shaded areas show number of species with host plant records.

of its host range.

Recently, more than three times more *B. zonata* than *B. dorsalis* have been recorded during weekly trapping of fruit flies in Pusa, Bihar (Agarwal *et al*. 1999). Previously, few people experienced difficulty in the identification of both these fruit fly pest species. However, when they did not respond well to various control measures, serious doubts existed about the accuracy of their identification. These doubts were found correct when it was determined by fruit fly taxonomists (Grewal 1982; Grewal & Kapoor 1985; Drew & Hancock 1994) that both these species form complexes. The occurrence of these complexes has further complicated not only the correct species/fruit damage association but also control.

The *zonata* complex currently comprises two species, true *B. zonata* and a new species close to it (Kapoor 1993) but differs in setal character on the eversible membrane of the ovipositor as well as in chromosomal taxonomy. White & Elson-Harris (1992) have referred to some specimens belonging to this new species. These specimens were collected on leaves of custard apple (*Anona reticulata*) from India and differ from true *B. zonata* in the shape of the aculeus tip, such as a pair of preapical 'steps'. Intensive surveys in India and adjoining countries may reveal more species in this complex.

Bactrocera dorsalis is now definitely known by a complex of at least four species in India (Drew & Hancock 1994), and is prevalent throughout almost all of India. *B. dorsalis* infestation in Punjab varies from 30% to 85% in different cultivars of mango (Mann 1996). *B. caryeae* is prevalent in southern India and Sri Lanka. Both these species attack guava and mango. *B. zonata* and *B. correcta* are also associated with these fruits. This complicates not only the differentiation of the larval forms of these species but also control programmes.

There is a need to determine the complete bioecology of these sibling species in order to understand their population dynamics, fruit infestation and behaviour, and also to determine characters for both adults and immature forms.

Another sibling species in the *dorsalis* complex is *B. carambolae*. The species is presently known from the Andaman Islands in India but is widespread in the Orient (Drew & Hancock 1994). Its primary hosts are kamrakh (*Averrohoa carambola*) and wax jambu (*Syzygium samarrangense*), and secondary hosts are guava and mango. It has also been reported infesting devdaru (*Polyalthia longifolia*), *Fagraea racemosa* and papaya (Ranganathan & Veenakumari 1999) on the Andaman and Nicobar Islands.

Bactrocera vishnu Drew & Hancock is the fourth species of this complex known from southern India, but so far is not associated with any host plant. *B. poonaensis* Kapoor was also included in this complex but it has now been synonymized with *B. incisa* (Walker), which does not fall into the *dorsalis* complex. There is every likelihood that *B. kandiensis,* known from Sri Lanka, is also present on mango in

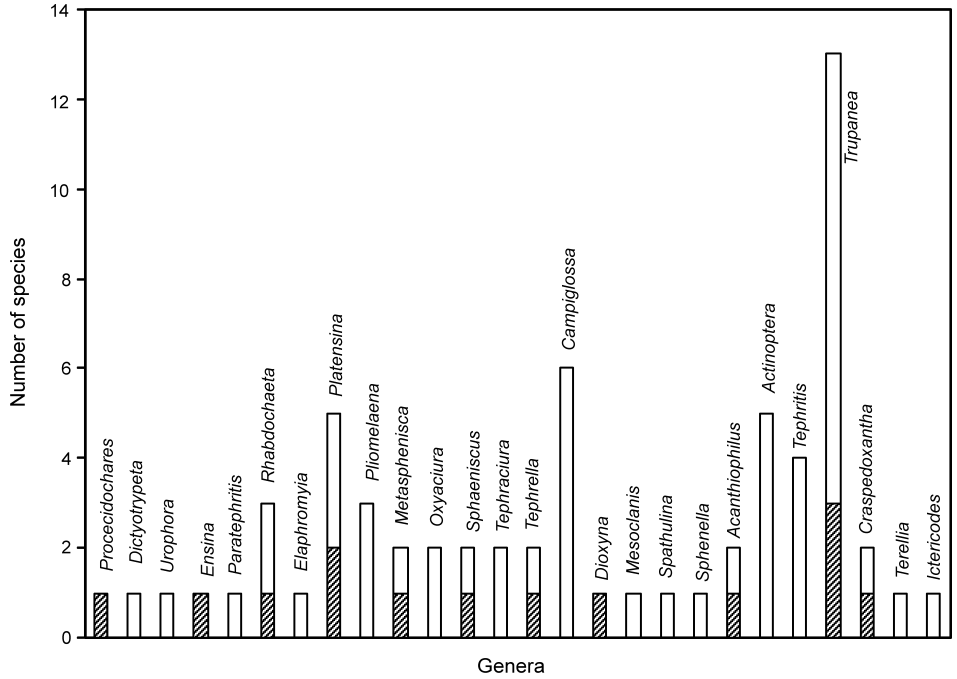

Fig. 3. Relative occurrence of Indian fruitfly species in the subfamily Tephritinae. Shaded areas show number of species with host plant records.

South India. Thus, various pest species of the *B. dorsalis* complex have created the most unusual situation with regard to their correct identification, and consequent effective control. This is causing great problems in the export of fruits such as mango to developed countries. These countries have restrictions on the importation of these fruits from areas where these species are prevalent.

Efforts are now being made to utilize various other characteristics such as wing image analysis and aedeagal length to easily separate species of the *dorsalis* complex (Adsavakulchai *et al.* 1999; Baimai *et al.* 1999; Mahmood 1998, 1999a; Iwahashi 1999; Wee & Tan 2000; Nakahara *et al.* 2000).

Bactrocera correcta is another fruit fly pest outside the *zonata-dorsalis* complex, but co-occurs with both these species in mango and common guava. A few specimens are sometimes also reared from infested peaches where *B. zonata* is dominant. Populations of *B. correcta* in guava orchards, when co-occurring with *B. dorsalis* and *B. zonata,* have been the cause of concern for the fruit growers in southern India. Populations are up to 80% higher than those of both *B. zonata* and *B. dorsalis.* Outside the Orient *B. correcta* has also been detected in quarantine interceptions in Florida and California in the U.S.A., but has never become established. It has also been reported as a serious pest of ber (*Zizyphus* sp.) in Karnataka (Balikai 1999). *B. bangaloriensis* Agarwal & Kapoor, described from Bangalore, has now been synonymized with *B. correcta*.

Bactrocera tau Walker is another dacine of economic importance. It attacks cucurbits and tomatoes in India. Infestation intensifies when the population of *B. cucurbitae* is low. Competition between the two species is frequently seen in cucurbit hosts. The species has occasionally been reported as a serious pest of cucurbits in semi-hilly areas of the state of Himachal Pradesh. Recent studies have shown that *B. tau* is the predominant species infesting cucurbits in this state (Sood & Nath 1999). It is widespread in India but is often misidentified as *B. caudata*. The latter species is not present in India although it has been reported earlier. *B. tau* has also been reported to occur in a complex with *B. zahadi,* a new species described from southern India, Bhutan, Sri Lanka, Myanmar, Pakistan and Nepal by Mahmood (1999b), who described seven species, including three new ones in this Asian complex. Other new characters are also being studied in various species of the *B. tau* complex (Baimai *et al.* 2000) to facilitate their separation.

Bactrocera scutellaris (Bezzi), although a minor pest of cucurbits, also co-occurs with *B. cucurbitae. B. scutellaris* sometimes competes strongly with

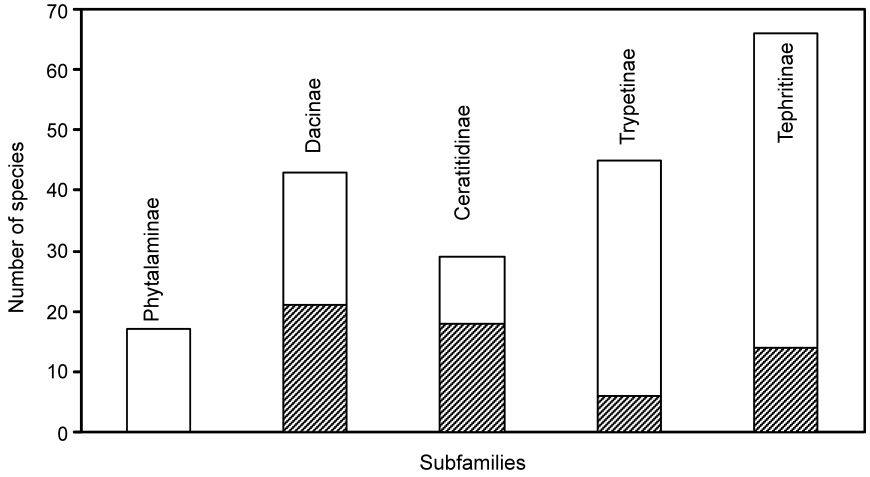

Fig. 4. Relative occurrence of subfamilies of Indian fruitfly species (total 200). Shaded areas show number of species with host plant records.

B. cucurbitae and replaces it on some cucurbits, as recently noticed by the author in Himachal Pradesh in India. *B. latifrons* (Hendel) was never thought to occur in India and the earlier reports were believed to be misidentifications or due to its chance entry in southern India. But the species has now become well established in this region and in other places, and attacks both chillies and brinjals.

Bactrocera diversa Coq. attacks the floral parts of cucurbits and its distribution mostly coincides with that of *B. cucurbitae*. It is still a minor pest as *B. cucurbitae* always competes strongly with it and does not allow *B. diversa* to increase in numbers. Whenever infested cucurbits are incubated, *B. cucurbitae* easily outnumbers *B. diversa*.

Bactrocera albistrigata has recently been described as a pest of *Syzygium* spp. as well as cloves, *Scolopia spinosa, Polyalthia longifolia, Calaphyllum inophyllum, Guettarda speciosa* and *Anglaia argentea*. It also infests guavas on the Great Nicobar Islands (Ranganathan & Veenakumari 1999). These authors also described two new records as *Bactrocera mcgregori* attacking *Gnetum gnemon* and *Bactrocera* sp. on *C. inophyllum*.

Bactrocera oleae (Gmelin) is host-specific and is a pest of olives throughout Europe, the Middle East and Africa, and has twice been reported from northern India. It has not yet been recorded as a serious pest. Narayanan & Batra (1960) associated it with wild and cultivated olives in Himachal Pradesh. Commercial olive cultivation is currently being considered, and a few cultivars have been selected for cultivation in Jammu and Kashmir where *B. oleae* has been considered a threat. Control measures for this species are given by Shant (1999).

Nath (1973) recorded *B. minax* causing a high incidence of damage to tangerine or mandarin (*Citrus reticulata)* in northern India. *B. minax* is also a serious pest of mandarins in Bhutan (Schoubroeck 1999).

The genus *Dacus* currently comprises seven species – five in the subgenus *Callantra* and one each in the subgenera *Didacus* and *Leptoxyda*. Amongst these species, *D. ciliatus* is the only one which is close to major pest status. It attacks a wide variety of melons and wild cucurbits. The species always remains in close competition with its ecological homologue, *B. cucurbitae*. Both species have been collected from various cucurbit fruits from May to July. Recent observations have shown that *D. ciliatus* has started displacing *B. cucurbitae* on cucurbits such as squash melons and bitter gourd on the Indian subcontinent. This was attributed to its short preoviposition and incubation periods, together with a greater reproductive potential (Qureshi *et al.* 1987). The species prefers small fruits for oviposition. From August *B. ciliatus* infestation in cucurbits becomes almost negligible due to the dominance of *B. cucurbitae,* but infestations continue until October/November on ivy gourd.

Dacus (Leptoxyda) persicus Hendel is another species whose larvae attack pods of akund, (*Calotropis procera*), which grows as a weed but has some medicinal value.

CERATITIDINE FRUIT FLIES

These flies belong to the subfamily Ceratitidinae which is known in India by 29 species, 18 of which are known with complete or incomplete host

records (Figs 1, 4). The species attack grasses and bamboo. Hancock (1999) and Hancock & Drew (1999) have discussed all these species. The larvae bore into the sheath of the host plant and feed on the pulp, thus rendering the shoots hollow, which finally collapse and rot. None of the species has yet attained even minor pest status. They cause occasional damage of no economic significance.

TRYPETINE FRUIT FLIES

These fruit flies belong to the subfamily Trypetinae which includes 45 species of which five have complete or incomplete host record (Figs 2, 4). Only one species, *Carpomya vesuviana* Costa causes significant damage to ber (*Zizyphus mauritiana*). It attacks various cultivars of *Zizyphus mauritiana* all over India, especially in the states of Rajasthan, Madhya Pradesh, Haryana, Delhi, Uttar Pradesh, Gujarat, Karnataka and Maharashtra (Balikai 1999; Kapoor 1989, 2000). The infestation ranges from 15% to 80%, particularly in cv. Gola. Infestation usually starts in November but has also been noticed at other times (Sohi *et al.* 1990). Infestation sometimes occurs together with either *B. correcta* or *B. zonata,* but their populations remain quite low. Efforts are currently being made to find varieties of ber which are resistant to ber fruit fly (Sharma *et al.* 1998; Arora *et al.* 1999).

Euphranta (Rhacochlaena) cassiae is often regarded as a serious pest of amaltas, or Indian Laburnum (*Cassia fistula*). It has recently been recorded attacking the pods of this tree in such large numbers that hundreds of specimens of this fruit fly can be collected by either incubating the infested pods or by sweeping. Since the plant is usually ornamental or of some medicinal value, this species is not regarded as a pest.

Another species, *Chetostoma completa* Kapoor & Agarwal, is sometimes regarded as a serious pest of cornflower (*Centaurea cyanus*), either independently or in association with capsule fly, *A. helianthi* Rossi (Agarwal & Kapoor 1982).

Carpomya pardalina (Bigot), commonly called Baluchistan melon fly, is a pest of melons in Baluchistan, Pakistan and India. The female oviposits through the skin of melons, and the larvae feed on the pulp, finally rendering the fruit unfit for human consumption. The species is not a serious pest. It is thought that populations in India remains low due to competition from other fruit fly species, especially *B. cucurbitae.*

Adrama determinata (tea seed fly) is a pest of tea seeds in the eastern parts of the Orient. It has also been recorded from southern India and Assam, but has never been recovered from infested tea seeds. This species needs to be constantly monitored for its presence or infestation around tea-growing areas in India (Kapoor 1993).

TEPHRITINE FRUIT FLIES

These fruit flies belong to the subfamily Tephritinae, which is known by the highest number of species, 66 (33% of the total). The complete or incomplete host record of only 14 of these species is known (Figs 3, 4). Species of this subfamily can either be pests or beneficial. Some species are utilized as biological control agents of various noxious seeds in various countries.

Procecidochares utilis Stone, a native of New Zealand, was introduced into India in 1963 for the control of crofton weed, *Ageratina adenophora,* and it has now fully established on this weed in India and Nepal (Kapoor 1993). Other beneficial tephritine fruit flies belong to genera such as *Ensina, Urophora, Tephritis, Terellia.*

Some other species have been classified as pests. The most notable example is the capsule fly, *A. helianthi*. This species has now been classified as a serious pest of safflowers (*Carthamus tinctorius*) throughout almost all India. It has also been found attacking cornflower, *C. cyanus,* sometimes together with other fruit flies such as *Craspedoxantha octopunctata* or *Chetostoma completa*. Efforts are now being made to screen varieties resistant to capsule fly in Madhya Pradesh and Gujarat.

Dioxyna sororcula (Wied.) is another fruit fly that attacks a wide range of composite plants, including weeds. Jakhmola (1983) reported it as a serious pest of Niger weed (*Guizotia abyssinica* Cass.) in central India. This weed, a native of tropical Africa, is now cultivated in India for its edible seeds and oil used for cooking.

There are a number of other fruit fly species of minor importance in India, e.g. *Platensina acrostacta* causes galls in *Jussiaea*; *Sphaeniscus atilius* attacks flower heads of many Compositae and Labiatae; *Metasphenisca bifaria* bores pods of *Barleria alba*; *Tephrella variegata* forms galls in *Inula cappa*; *Trupanea amoena* infests flowers of *Vernonia cinerea* and together with *T. stellata* it also damages marigold flowers (*Calendula officinallis* Linn.) (Kapoor 1993).

SUMMARY

Two hundred species of fruit flies in five subfamilies are currently known from India. Of these only 35–40 species have been associated with

their host plants. Major pest species belong to the genus *Bactrocera,* namely *B. cucurbitae, B. zonata* and *B. dorsalis.* All three are problematical in their identification, either due to structural variations or complexes. In addition, the following species are of minor importance although occasionally pose problems to fruit growers: *D. ciliatus, B. correcta, B. latifrons, B. tau* and *B. scutellaris* in Dacinae; *C. vesuviana* in Trypetinae, and *A. helianthi* in Tephritinae. It is therefore very important that the taxonomy of all these species be thoroughly worked out, together with intensive surveys to co-relate other fruit fly species with their hosts. The distribution of the Indian fruit fly species is also incompletely known and there is thus an urgent need to undertake such studies. Finally, studies on the taxonomy, zoogeography and bioecology of the fruit fly species will go a long way towards improving their management, thus leading to the production of higher quality fruits and vegetables to meet local use as well as for export.

REFERENCES

ADSAVAKULCHAI, A., BAIMAI, V., PRACHYABRUED, W., GROTE, P.J. & LERTLUM, S. 1999. Morphometric study for identification of the *B. dorsalis* complex (Dipt.: Teph.) using wing image analysis. *Biotropia* 13:37–48.

AGARWAL, M.L. & KAPOOR, V.C. 1982. *Acanthiophilus helianthi* (Rossi) and *Chetostoma completa* Kapoor *et al.,* serious pest of *Centaurea cyanus* in India. *Journal of Entomological Research* 6(1):102–104.

AGARWAL, M.L., KUMAR, P. & KUMAR, V. 1999. Population suppression of *B. dorsalis* (Hendel) by *B. zonata* (Saund.) (Dipt.: Teph.) in North Bihar. *Shashpa, India* 6(2): 189–191.

ARORA, P.K., NIRMAL KAUR, BATRA, R.C. & MEHROTRA, N.K. 1999. Physico chemical characteristics of some ber varieties in relation to fruit fly incidence. *Journal of Applied Horticulture* Lucknow, India, 1(2): 101–102.

BAIMAI, V., PHINCHONGSAKULDIT, J. & SUMRANDOE, C. 2000. Cytological evidence for a complex of species within the taxon *B. tau* (Dipt.: Teph.) in Thailand. *Biological Journal of the Linnean Society* 69 (3): 399–409.

BAIMAI, V., PHINCHONGSAKULDIT, J. & TIGVATTON ANONT, S. 1999. Metaphase karyotypes of fruit flies of Thailand. IV. Evidence for six new species of *B. dorsalis* complex. *Cytologia* 64(4): 371–377.

BALIKAI, R.A. 1999. Pest scenario of ber (*Zizyphus mauritiana* Lamarck) in Karnataka. *Pest Management in Horticultural Ecosystems* 5(1): 67–69.

DODSON, G. & DANIELS, G. 1988. Diptera reared from *Dysoxylum gandichaudianum* (Juss.) Miq. at Iron range, northern Queensland. *Australian Entomology Magazine* 15: 77–79.

DREW, R.A.I. & HANCOCK, D.L. 1994. The *Bactrocera dorsalis* complex of fruit flies (Dipt.: Teph.: Dacinae) in Asia. *Bulletin of Entomological Research, Suppl.* No. 2, pp. 1–68.

GREWAL, J.S. 1982. Cytotaxonomy and evolution of fruit flies (Dipt.: Teph.). Ph.D. thesis, Punjab Agricultural University, Ludhiana, India.

GREWAL, J.S. & KAPOOR, V.C. 1985. Chromosomal analysis of some species of the genus *Dacus* Fab. (Dipt.: Teph.). *The Nucleus* 28(3): 208–215.

HANCOCK, D.L. 1999. Grass-breeding fruit flies and their allies of Africa & Asia (Dipt.: Teph.: Ceratitidinae). *Journal of Natural History* 33(6): 911–948.

HANCOCK, D.L. & DREW, R.A.I. 1999. Bamboo-shoot fruit flies of Asia (Dipt.: Teph.: Ceratitidinae). *Journal of Natural History* 33(5) 633–775.

HARDY, D.E. 1986. Fruit flies of the subtribe Acanthonevrina of Indonesia, New Guinea and Bismarck and Solomon Islands (Dipt.: Teph.: Trypetinae: Acanthonevrini). *Pacific Insect Monograph* 42: 1–191.

IWAHASHI, O. 1999. Distinguishing between the two sympatric species of *B. carambolae* and *B. papayae* (Dipt.: Teph.) based on aedeagal length. *Annals of the Entomological Society of America* 92(5): 639–643.

JAKHMOLA, S.S. 1983. Niger grain fly, *Dioxyna sororcula* (Wied.), a serious pest of niger in central India. *Journal of the Bombay Natural History Society* 80: 439–440.

KAPOOR, V.C. 1989. Indian Sub-continent. In: Robinson, A.S. & Hooper, G. (Eds) *Fruit Flies: Their Biology, Natural Enemies and Control.* World Crop Pests – 3A, 3B. 59–62. Elsevier, Amsterdam.

KAPOOR, V.C. 1993. *Indian Fruit Flies (Insecta: Dipt.:Teph.).* International Science Publ., New Hampshire, U.S.A.

KAPOOR, V.C. 2000. Fruit flies (Dipt.:Teph.): status, bioecology and management strategies. In: Upadhyay, R.K. Mukerji, K.G. & Dubey, O.P. (Eds) *IPM Systems in Agriculture.* 123–142. Aditya Books, New Delhi, India.

MAHMOOD, K. 1998. Identification of pest species in the oriental fruit fly, *B. dorsalis* (Hendel) complex (Dipt.: Teph.) using a probabilistic method. *Pakistan Journal of Zoology* 30(1): 47–50.

MAHMOOD, K. 1999a. Verification of specific status of pest species allied to *B. dorsalis* (Hend.) (Dipt.: Teph.) using allozyme electrophoresis. *Pakistan Journal of Zoology* 31(2): 159–165.

MAHMOOD, K. 1999b. Taxonomy of the *B. tau* (Dipt.: Teph.) complex in Asia. *Pakistan Journal of Zoology* 31(3): 219–235.

MANI, M. 1992. *Bactrocera correcta* on grapevine in India. *FAO Plant Protection Bulletin* 40: 162.

MANN, G.S. 1996. Seasonal incidence and buildup of *B. dorsalis* (Hendel) on mango in Punjab. *Journal of Insect Science* 9(2): 129–132.

MATTHEW, M.P., REKHA, C.R. & GOPALAKRISHNAN, T.R. 1999. New hosts of melon fly, *B. cucurbitae* (Coq.). *Insect Environment* 5(3): 120.

NAKAHARA, S., MASAKI, M., KANEDA, M., SUGIMOTO, T. & MURAJI, M. 2000. Identification of *B. dorsalis* complex species (Dipt.: Teph.: Dacinae) by PCR-RELP analysis. I. A study in variation in mitochondrial DNA D-loop region. *Research Bulletin, Plant Protection Services, Japan* 36: 37–41.

NARAYANAN, E.S. & BATRA, H.K. 1960. *Fruit Flies and Their Control.* ICAR Publications, New Delhi, India.

NATH, D.K. 1973. *Callantra minax* (End.) (Teph.: Dipt.), a new record of a ceratitinid fruit fly on orange fruits (*Citrus reticulata* Blanco) in India. *Indian Journal of Entomology* 34: 246.

NORRBOM, A.L., CARROLL, L.E., THOMPSON, F.C., WHITE, I.M. & FREIDBERG, A. 1999. Systematic database of

names, pp. 65–252. In: Thompson, F.C. (Ed) *Fruit Fly Expert Identification System and Systematic Information Database. Myia* 9: 1–524.

PATEL, P.K. & PATEL, C.B. 1998. Preference of hosts for oviposition by fruit fly, *Dacus ciliatus* Loew. *Indian Journal of Entomology* 60: 320.

QURESHI, Z.A., HUSSAIN, T. & SIDDIQUI, Q.H. 1987. Interspecific competition of *D. cucurbitae* and *D. ciliatus* in mixed infestation on cucurbits. *Journal of Applied Entomology* 104(4): 429–432.

RANGANATHAN, H.R. & VEENAKUMARI, K. 1999. Notes on the dacine fruit flies (Dipt.: Teph.) of Andaman and Nicobar Islands. II. *Raffles Bulletin, Zoology* 47(1): 221–224.

RANGANATHAN, H.R., SURYANARAYANA, M.A. & VEENAKUMARI, K. 1997. Papaya – a new host record of carambola fruit fly, *B. carambolae* Drew & Hancock. *Insect Environment* 3: 37.

RANGANATHAN, H.R., VEENAKUMARI, K. & RAJ, S.M. 1999. Brassica oleracea (Brassicaceae) – a host of the melon fly. *Insect Environment* 5(1): 12–13.

SCHOUBROECK, F.V. 1999. *Learning to Flight a Fly: Developing Citrus IPM in Bhutan*. Wageningen Agricultural University Publications, the Netherlands.

SHANT, P.S. 1999. Olive (*Olea europae*a Wall.) cultivation in Jammu and Kashmir. *Scientific Horticulture* 6: 71–78.

SHARMA, V.P., LAL, O.P., ROHIDAS, S.B. & PRAMANICK, P.K. 1998. Varietal resistance in ber (*Zizyphus mauritiana* Lamk.) against the fruit fly, *C. vesuviana* Costa (Dipt.: Teph.) under field conditions. *Journal of Entomological Research* 22(1): 61–67.

SOHI, A.S., SOHI (Jr.), A.S. & SANDHU, G.S. 1990. Unusual occurrence of *Carpomyia vesuviana* Costa during monsoon in Punjab. *Journal of Insect Science* 3(2): 188.

SOOD, P. & NATH, A. 1999. Fruit flies associated with cucurbits in Himachal Pradesh. *Journal of Hill Research* 12(1): 52–54.

TEWATIA, A.S. & DHANKHAR, B.S. 1996. Inheritance of resistance to melon fly, *B. cucurbitae* in bitter gourd *(Momordica charantia). Indian Journal of Agricultural Science* 66: 617–620.

WEE, S.L. & TAN, K.H. 2000. Sexual maturity and infraspecific mating success of two sibling species of the *B. dorsalis* complex. *Entomologia Experimentalis et Applicata* 94(2): 133–139.

WHITE, I.M. & ELSON-HARRIS, M.M. 1992. *Fruit Flies of Economic Significance: Their Identification and Bionomics*. CABI, Wallingford, U.K.

YUNUS, A. & HO, T.H. 1980. List of economic pests, host plants, parasites and predators in West Malaysia (1920–1978). *Bulletin of the Ministry of Agriculture, Malaysia* 153: 1–538.

Appendix 1. Checklist of Indian fruit fly species.

FAMILY TEPHRITIDAE

A. SUBFAMILY PHYTALMINAE

Tribe Acanthonevrini

I. Gen. ***ACANTHONEVRA*** Macquart

1. *A. dunlopi* (Wulp)
2. *A. formosana* Enderlein
3. *A. fuscipennis* Macq.
4. *A. gravelyi* Munro
5. *A. hemileina* Hering
6. *A. imparata* Hering
7. *A. inermis* Hering
8. *A. vaga* (Wied.)
9. *A. vidua* (Bezzi)

II. Gen. ***DIARRHEGMA*** Bezzi

10. *D. modestum* (Fab.)

III. Gen. ***HEXACINIA*** Hendel

11. *H. radiosa* (Rondani)

IV. Gen. ***PHORELLIOSOMA*** Hendel

12. *P. ambitiosum* Hering

V. Gen. ***PTILONA*** Wulp

13. *P. confines* (Walk.)

VI. Gen. ***RIOXA*** Walker

14. *R. parvipunctata* de Meij.
15. *R. sexmaculata* Wulp

VII. Gen. ***SOPHIRA*** Walker

Subgen. ***Sophira*** Walker

16. *S. phlox* Munro

VIII. Gen. ***THEMARA*** Walker

17. *T. maculipennis* (Westwood)

B. SUBFAMILY DACINAE

Tribe Dacini

IX. Gen ***BACTROCERA*** Macq.

(i) Subgen. ***Asiadacus*** Perkins

18. *B. brachycera* (Bezzi)

(ii) Subgen. ***Bactrocera*** Macq.

19. *B. affinis* (Hardy)
20. *B. albistrigata* de Meij.[1]
21. *B. andamanensis* Kapoor
22. *B. biguttata* (Bezzi)
23. *B. correcta* (Bezzi)
24 *B. digressa* Radhakrishanan

***dorsalis* complex (25–28)**

25. *B. dorsalis* Hendel[1]
26. *B. carambolae* Drew & Hancock[1]
27. *B. caryeae* (Kapoor)[1]
28. *B. vishnu* Drew & Hancock
29. *B. incisa* (Walk.)
30. *B. latifrons* (Hendel)[1]
31. *B. limbifera* (Bezzi)
32. *B. scutellaria* (Bezzi)
33. *B. versicolor* (Bezzi)
34. *B. zonata* (Saund.)[1]

(iii) Subgen. ***Bulladacus***

35. *B. mcgregori* (Bezzi)[1]

(iv) Subgen. ***Daculus*** Speiser

36. *B. oleae* (Gmelin)[1]

(v) Subgen. ***Javadacus*** (Hardy)

37. *B. pallescentis* (Hardy)
38. *B. trilineata* (Hardy)[1]

(vi) Subgenus ***Gymnodacus*** Munro

39. *B. calophylli* (Perkins & May)[1]

(vii) Subgen. ***Paratridacus*** Shiraki

40. *B. diversa* (Coq.)[1]
41. *B. garcinae* Bezzi[1]

(viii) Subgen. ***Parazeugodacus*** Shiraki

42. *B. bipustulata* (Bezzi)

(ix) Subgen ***Sinodacus*** Zia

43. *B. watersi* (Hardy)

(x) Subgen. ***Tetradacus*** Miyake

44. *B. minax* (End.)[1]

(xi) Subgen. ***Zeugodacus*** Hendel

45. *B. assamensis* White & Evenhuis
46. *B. atrifacies* Perk.
47. *B. freidbergi* White & Evenhuis
48. *B. caudata*[2] Fab.
49. *B. cucurbitae* (Coq.)[1]
50. *B. duplicata* (Bezzi)
51. *B. gavisa* (Munro)
52. *B. scutellaris* (Bezzi)[1]

Tau **complex**

53. *B. tau* (Walk.)[1]
54. *B. zahadi* Mahmood

X. Gen. ***DACUS*** Fab.

(i). Subgen. ***Callantra*** Walker

55. *D. crabroniformis* (Bezzi)
56. *D. longicornis* (Wied.)[1]
57. *D. icariiformis* Enderlein
58. *D. polistiformis* Senior-White
59. *D. sphaeroidalis* (Bezzi)[1]

(ii) Subgen. ***Didacus*** Collart

60. *D. ciliatus* Loew[1]

(iii) Subgen. ***Leptoxyda*** Macq.

61. *D. persicus* Hendel[1]

C. SUBFAMILY CERATITIDINAE

XI. Gen. ***ACROCERATITIS*** Hendel

62. *A. ceratitina* (Bezzi)[1]
63. *A. separata* (Bezzi)[1]
64. *A. tenmalaica* Hancock & Drew[1]
65 *A. tomentosa* Hardy[1]

XII. Gen. ***ANOPLOMUS*** Bezzi

66. *A. flexuosus* Bezzi

XIII. Gen. ***CALLISTOMYIA*** Bezzi

67. *C. klugii* Wied.
68. *C. pavonina* Bezzi

XIV. Gen. ***CARPOPHTHORELLA*** Hendel

69. *C. scutellomaculata* Hering

XV. Gen. ***CERATITOIDES*** Hendel

70. *C. maai* (Chen)[1]
71. *C. laqueatus* (End.)[1]
72. *C. sikhimensis* Hancock[1]

XVI. Gen. ***CHAETELLIPSIS*** Bezzi

73. *C. dispilota* Hardy[1]
74. *C. paradoxa* Bezzi[1]

XVII. Gen ***CYRTOSTOLA*** Hancock & Drew

75. *C. limbata* (Hendel)[1]

XVIII. Gen. ***GALBIFASCIA*** Hardy

76. *G. sexpunctata* Hardy[1]

XIX. Gen. ***GASTROZONA*** Bezzi

77. *G. balioptera* Hardy
78. *G. fasciventris* (Macq.)[1]
79. *G. montana* Bezzi[1]
80. *G. proterva* Hering

XX. Gen. ***PARAXARNUTA*** Hardy

81. *P. extorris* (Hering)[1]
82. *P. spiralis* (Munro)

XXI. Gen. ***PHAEOSPILA*** Bezzi

83. *P. varipes* Bezzi

XXII. Gen. ***PHAEOSPILODES*** Hering

84. *P. bambusae* Hering[1]

XXIII. Gen. ***PROANOPLOMUS*** Shiraki

85. *P. nigroscutellatus* Shiraki[1]
86. *P. vittatus* Hardy
87. *P. yunnanensis* Shiraki[1]

XXIV. Gen. ***TAENIOSTOLA*** Bezzi

88. *T. vittigera* Bezzi[1]

XXV. Gen. ***XANTHORRACHIS*** Bezzi

89 *X. annandalei* Bezzi
90. *X. assamensis* Hardy

D. SUBFAMILY TRYPETINAE

Tribe Adramini

XXVI. Gen. ***ADRAMA*** Walker

91. *A. austeni* Hendel
92. *A. determinata* (Walk.)[1]

XXVII. Gen. ***EUPHRANTA*** Loew

(i) Subgen. ***Euphranta*** Loew

93. *E. macularis* (Wied.)

(ii) Subgen. ***Rhacochlaena*** Loew

94. *E. cassiae* (Munro)[1]
95. *E. crux* (Fab.)
96. *E. dissoluta* Bezzi
97. *E. lemniscata* (End.)
98. *E. nigripeda* (Bezzi)

XXVIII. Gen. ***ICHNEUMONOSOMA*** de Meijere

99. *I. imitans* (de Meij.)

XXIX. Gen. ***INDOPHRANTA*** Agarwal & Kapoor

100. *I. humerata* Agarwal & Kapoor

XXX. Gen. ***MERACANTHOMYIA*** Hendel

101. *M. intermedia* Hardy
102. *M. kotiensis* Kapoor
103. *M. maculipennis* (Macq.)

XXXI. Gen. ***PELMATOPS*** Enderlein

104. *P. ichneumoneus* Westwood

Tribe Carpomyini

Subtribe Carpomyina

XXXII. Gen. ***CARPOMYA*** Costa

105. *C. vesuviana* Costa[1]
106. *C. pardalina* (Bigot)[1]

XXXIII. Gen. ***RHAGOLETIS*** Loew

107. *R. bezzianum*[2] Hendel

Subtribe Chetostomatina

XXXIV. Gen. ***ANOMOIA*** Walker

108. *A. immsi* (Bezzi)
109. *A. mirabilis* (Seguy)

XXXV. Gen. ***CHETOSTOMA*** Rondani

110. *C. completa* Kapoor & Agarwal[1]
111. *C. sarolensis* Agarwal & Kapoor

XXXVI. Gen. ***MYOLEJA*** Rondani

112. *M. alboscutellata* Wulp
113. *M. fossata* (Fab.)

Subtribe Trypetina

XXXVII. Gen. ***ACIDIELLA*** Hendel

114. *A. angustifrons (Hendel)*
115. *A. contraria* (Walk.)
116. *A. discalis* (Brunetti)
117. *A. erythraspis* (Bezzi)
118. *A. rioxaeformis* (Bezzi)

XXXVIII. Gen. ***ACIDIOSTIGMA*** Hendel

119. *A. apicalis* (Bezzi)

XXXIX. Gen. ***CHENACIDIELLA*** Skiraki

120. *C. bangaloriensis* Kapoor & Agarwal

XL. Gen. ***HEMILEA*** Loew

121. *H. cnidella* Munro
122. *H. praestans* Bezzi

XLI. Gen. ***PHILOPHYLLA*** Rondani

123. *P. freidbergi* Han
124. *P. flavofemorata* Han

XLII. Gen. ***TRYPETA*** Meigen

125. *T. buddha* Hering
126. *T. indica* (Hendel)

XLIII. Gen. ***VIDALIA*** Rob.-Desv.

127. *V. ceratophora* Bezzi
128. *V. cervicornis* Brunetti[1]
129. *V. fletcheri* Munro
130. *V. himalayensis* (Bezzi)
131. *V. impressifrons* Rob.-Desv.
132. *V. melanonotum* Brunetti
133. *V. triceratops* Bezzi
134. *V. trigenata* Munro

Tribe Xarnutini

XLIV. Gen. *XARNUTA* Walker

135. *X. leucotela* Walk

E. SUBFAMILY TEPHRITINAE

Tribe Cecidocharini

XLV. Gen. ***PROCECIDOCHARES*** Hendel

136. *P. utilis*[3] Stone[1]

Tribe Eutretini

XLVI. Gen. ***DICTYOTRYPETA*** Hendel

137. *D. longiseta*[2] Hering

Tribe Myopitini

XLVII. Gen. ***UROPHORA*** Rob.-Desv.

138. *U. stylata* (Fab.)

Tribe Noeetini

XLVIII. Gen. ***ENSINA*** Rob.- Desv.

139. *E. sonchi* Rob.- Desv.[1]

XLIX. Gen. ***PARATEPHRITIS*** Shiraki

140. *P. abstracta* Munro

Tribe Schistopterini

L. Gen. ***RHABDOCHAETA*** de Meijere

141. *R. asteria* Hendel[1]
142. *R. bakeri* Bezzi
143. *R. gladifera* Hering

Tribe Tephrellini

Subtribe Platensinina

LI. Gen. ***ELAPHROMYIA*** Bigot

144. *E. pterocallaeformis* (Bezzi)

LII. Gen. ***PLATENSINA*** Enderlein

145. *P. acrostacta* (Wied.)[1]
146. *P. amplipennis* (Walk.)
147. *P. fulvifacies* Hering
148. *P. tetrica* Hering
149. *P. zodiacalis* (Bezzi)[1]

LIII. Gen. ***PLIOMELAENA*** Bezzi

150. *P. quadrimaculata* Agarwal & Kapoor
151. *P. udhampurensis* Agarwal & Kapoor
152. *P. zonogastra* (Bezzi)

LIV. Gen. ***METASPHENISCA*** Hendel

153. *M. bifaria* (Munro)[1]
154. *M. reinhardi* (Wied.)

LV. Gen. ***OXYACIURA*** Hendel

155. *O. monochaeta* (Bezzi)
156. *O. xanthotricha* (Bezzi)

LVI. Gen. ***SPHAENISCUS*** Becker

157. *S. atilius* (Walk.)[1]
158. *S. quadrincisus* Wied.

LVII. Gen. ***TEPHRACIURA*** Hering

159. *T. basimacula* (Bezzi)
160. *T. pachmarica* Agarwal & Kapoor

LVIII. Gen. ***TEPHRELLA*** Bezzi

161. *T. decipiens* Bezzi
162. *T. variegata* Radhakrishnan[1]

Tribe Tephritini

***Campiglossa* group**

LIX. Gen. ***CAMPIGLOSSA*** Rondani

163. *C. cribellata* Bezzi
164. *C. gemma* Hering
165. *C. iracunda* Hering
166. *C. kumaonensis* Agarwal & Kapoor
167. *C. lyncea* (Bezzi)
168. *C. absinthii* Fab.

LX. Gen. ***DIOXYNA*** Frey
169. *D. sororcula* (Wied.)[1]

LXI. Gen ***MESOCLANIS*** Munro
170. *M. campiglossina* Hering

LXII. Gen. ***SCEDELLA*** Munro
171. *S. spiloptera* Bezzi

***Spathulina* group**

LXIII. Gen. ***SPATHULINA*** Rondani
172. *S. acroleuca* (Schiner)

***Sphenella* group**

LXIV. Gen ***SPHENELLA*** Rob.-Desv.
173. *S. sinensis* Schiner

***Tephritis* group**

LXV. Gen. ***ACANTHIOPHILUS*** Becker
174. *A. helianthi* (Rossi)[1]
175. *A. lugubris* Hering

LXVI. Gen. ***ACTINOPTERA*** Rondani
176. *A. brahma* (Schiner)
177. *A. carignaniensis* Kapoor & Grewal
178. *A. formosana* Shiraki
179. *A. montana* (de Meij.)

LXVII. Gen. ***TEPHRITIS*** Latreille
180. *T. atocoptera* Agarwal & Kapoor
181. *T. darjeelingensis* Agarwal *et al.*
182. *T. ludhianensis* Agarwal & Kapoor
183. *T. mixta* (Walk.)

LXVIII. Gen. ***TRUPANEA*** Schrank
184. *T. amoena* Frauenfeld[1]
185. *T. antiqua* (Walk.)
186. *T. asteria* (Schiner)
187. *T. aucta* Bezzi
188. *T. augur* Frauenfeld[1]
189. *T. cosmia* Schiner
190. *T. inaequabilis* Hering
191. *T. keralensis* Agarwal *et al.*
192. *T. pentadactyla* Senior-White
193. *T. proavita* Hering
194. *T. pteralis* Agarwal *et al.*
195. *T. sirhindiensis* Agarwal & Kapoor
196. *T. stellata* (Fuessly)[1]

Tribe Terellini

LXIX. Gen. ***CRASPEDOXANTHA*** Bezzi
197. *C. indica* Zaka-ur-Rab.
198. *C. octopunctata* Bezzi[1]

LXX. Gen. ***TERELLIA*** Rob.- Desv.
199. *T. tribulicola* Senior-White

Tribe Xyphosini

LXXI. Gen. ***ICTERICODES*** Hering
200. *I. cashmerensis* (Hendel)[2]

---

[1]Species with complete or incomplete host plant record.
[2]Doubtful occurrence.
[3]Doubtful generic placement.