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Species diversity of Dacine fruit flies (Diptera: Tephritidae: Dacinae: Dacini) in Tripura, N.E. India

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Abstract
The present study was conducted from May, 2015 to May, 2017 to identify the Dacine fruit fly species present in Tripura, N.E. India. Para-pheromone traps (cue-lure and methyl-eugenol) and food bait traps were used to catch the Dacine fruit flies. Twenty species of Dacine fruit flies have been recorded form this North-Eastern state of India. Among these, 11 species are new records for the state and 6 species, namely *Bactrocera nigrifacia*, *B. rubigina*, *B. tuberculata*, *B. bogorensis*, *B. vulta* and *B. apicalis*) are new records for India. Taxonomic keys and coloured photo graphs for identification of these fruit flies are provided.

Keywords: Fruit fly, Tephritidae, Dacini, *Bactrocera*, *Dacus*, Tripura, North East India, New records.

1. Introduction
With about 4,500 species, fruit flies (Tephritidae) represent one of the largest families of Diptera [5]. Among the species reported worldwide, 325 species of fruit flies are known to occur in the Indian subcontinent, of which 243 in 79 genera are from India alone under four subfamilies, namely Dacinae, Phytalmiinae, Tephritinae and Trypetinae [1, 30]. The Dacini is a very large group of tephritid fruit flies, with over 800 described species, chiefly in the genera *Bactrocera* and *Dacus*. Of these, at least 80 are known to infest commercial and/or edible host fruits and fleshy vegetables, causing direct damage to fruit and frequently resulting in trade restrictions [17]. Other species are non economic since they breed on wild vegetations but certainly play important role in maintaining ecological balance.
About 60 species of Dacine fruit flies have been recorded from India so far [5, 7, 8, 21, 24, 25]. 18 species of Dacines were reported from Andaman and Nicobar Islands [24, 25]. Drew & Raghu [7] reported 21 species of dacines from the Western Ghats of India. Prabhakar *et al.* [23] recorded 13 species of Dacine fruit flies from north western Himalaya of India. 54 species of Dacines are reported from peninsular India (Kerala, Tamil Nadu, Andhra Pradesh, Karnataka, Maharashtra, Orissa and Madhya Pradesh) and also Andaman and Nicobar Islands [5]. North-East India is one of the mega bio-diversity hotspots of the world, which comprises of eight states including Tripura. Nevertheless, limited works have been done so far to identify Dacine fruit flies in North East India. Nair *et al.* [21] studied the species composition of Dacine fruit flies associated with cucurbits in Tripura and recently reported 9 species of Dacine fruit flies, namely *Bactrocera dorsalis*, *B. cucurbitae*, *B. tau*, *B. diversa*, *B. caudata*, *B. hochii*, *B. cilifera*, *B. latifrons* and *Dacus longicornis* from this state of which two species, namely *B. hochii* and *B. cilifera* were new country records for India. Earlier, eight species of Dacine fruit flies namely *B. dorsalis*, *B. cucurbitae*, *B. tau*, *B. scutellaris*, *B. diversa*, *B. zonata*, *B. minax* and *B. caudata* were reported from other states of North-Eastern India by other workers [3-5, 8, 11, 12].
In the present course of study an attempt has been made to identify the Dacine fruit fly species, including the non-economic ones, present in Tripura. Identification keys have been prepared and coloured photographs of body parts of fruit flies have been provided for accurate identification of all the fruit fly species of genus *Bactrocera* and *Dacus* occurring in this state.

2. Materials and Methods
2.1. Study area
The present study was carried out from May, 2015 to May, 2017 in farm areas of College of Agriculture, Tripura (Lembucherra, West Tripura District, Tripura). The college farm areas are

comprised of fruit trees, seasonal commercial vegetables (cruciferous, cucurbitaceous, solanaceous, leguminous, etc.), cereals, pulses, oil seeds, flowering plants and rich flora of naturally occurring wild vegetations.

2.2. Collection of specimens

Adult fruit flies were collected by following two methods modified after Ukey *et al.* [27] and Verghese *et al.* [29].

i) Para-pheromone traps: Traps baited with para pheromone lures (Cue-lure [4-(pacetoxyphenyl)- 2-butanone] and methyl-eugenol [4-allyl-1, 2-dimethoxy benzenecarboxylate]) (Metcalf) [20] were installed at ten sites for catching male fruit flies from the fields. At each site, two traps, separately baited with two lures, at a distance of 10 meters were hung about 1.5 meters above the ground. Cached flies were brought to the laboratory at every seven days intervals for identification. Since some species are not attracted to the above mentioned lures, another trapping method by using food bait was also implemented.

ii) Food bait trap: Both male and female fruit flies of different species were collected by using food baits constituted of molasses and/or over ripe banana (100 g per litre of water). 10 traps at a distance of 10 meters were installed about 1.5 meters above the ground. The food bait traps were installed for seven days once in a month.

2.3. Identification of Fruit flies:

The adult flies collected at regular intervals throughout the study period by the above mentioned methods were identified to species level based on morphological characters using the keys of Drew & Raghu [7] and Leblanc *et al.* [15], and also by studying full description of species from Drew & Romig [8].

3. Results and Discussion

Fruit fly species recorded during the present study in Tripura are represented in Table-1. Twenty species of Dacine fruit flies *viz*., *Bactrocera* (*Bactrocera*) *dorsalis* (Hendel), *B.* (*Bactrocera*) *zonata* (Saunders), *B.* (*Bactrocera*) *latifrons* (Hendel), *B.* (*Bactrocera*) *correcta* (Bezzi), *B.* (*Bactrocera*) *nigrifacia (*Zhang, Ji & Chen), *B.* (*Bactrocera*) *rubigina* (Wang & Zhao), *B.* (*Bactrocera*) *nigrofemoralis* (White and Tsuruta), *B.* (*Bactrocera*) *tuberculata* (Bezzi), *B.* (*Daculus*) *digressa* (Radhakrishnan), *B.* (*Sinodacus*) *bogorensis* (Hardy), *B.* (*Sinodacus*) *hochii* (Zia), *B.* (*Hemigymnodacus*) *diversa* (Coquillett), *B.* (*Zeugodacus*) *caudata* (Fabricius), *B.* (*Zeugodacus*) *cucurbitae* (Coquillett), *B.* (*Zeugodacus*) *tau* (Walker), *B.* (*Zeugodacus*) *vulta* (Hardy), *B.* (*Parasinodacus*) *incisa* (Walker), *B.* (*Parasinodacus*) *cilifera* (Hendel), *B.* (*Asiadacus*) *apicalis* (de Meijere), and *Dacus* (*Callantra*) *longicornis* (Wiedemann) have been recorded from Tripura. Out of these, 11 species are new records from Tripura and 6 species are new country records for India. Specimens of recorded fruit fly species were deposited at Zoological Survey of India, Kolkata.

Notes on the fruit flies recorded for the first time in Tripura during the present study

Bactrocera (*Bactrocera*) *correcta* (Bezzi) [Fig. 5; 25; 45; 65]: It occurs in India, Pakistan, Nepal, Bhutan, Myanmar, Sri Lanka, China, Thailand, Malaysia, Vietnam [8] and Bangladesh [15]. Within India, it was recorded from Bihar, Gujarat, Haryana, Himachal Pradesh, Karnataka, Kerala, Madhya Pradesh, Maharashtra, Punjab, Tamil Nadu [5]. It infests wide range of edible and wild fruits [2, 26]. It is a significant pest species in some parts of its geographic distribution [10]. But during the present study, a very small number of male flies were attracted to Methyl eugenol traps. The occurrence of this species is new record from Tripura.

B. (*Bactrocera*) *nigrifacia* (Zhang, Ji & Chen) [Fig. 14; 34; 54; 74]: It is present in China, Thailand [8] and Bangladesh [15]. Members in family Verbenaceae, Capparaceae, Cucurbitaceae and Euphorbiaceae are infested by this species [8]. Males were caught in cue lure traps and the species is recorded for the first time from India.

B. (Bactrocera) nigrofemoralis (White & Tsuruta)[Fig. 15; 35; 55; 75]: It is distributed in India, Sri Lanka, Bhutan, Pakistan [8] and Bangladesh [14]. Within India, it was recorded from Karnataka, Kerala, Tamil Nadu, Himachal Pradesh [5, 22]. Host plants of this species include Pomelo, mamey sapote [28]. A small number of males have been caught in cue lure traps during the present study. This is the new record from Tripura.

B. (*Bactrocera*) *rubigina* (Wang & Zhao)[Fig. 16; 36; 56; 76]: It is present in China, Bhutan, Thailand and Vietnam [8] and Bangladesh[16]. *Litsea verticillata* (Lauraceae) was recorded as the host plant of this species [18]. Large number of males has been caught in cue lure traps and the species is recorded for the first time from India.

B. (*Bactrocera*) *tuberculata* (Bezzi)[Fig. 18; 38; 58; 78]: It is distributed in Myanmar, Bhutan, China, Thailand, Vietnam [8] and Bangladesh [15]. It was recorded from plant families namely, Anacardiaceae, Caricaceae, Euphorbiaceae, Lecythidaceae, Myrtaceae, Polygalaceae, Rosaceae and Sapotaceae [2]. Male flies of this species have been caught in methyl eugenol traps and the species is recorded for the first time from India.

B. (*Bactrocera*) *zonata* (Saunders) [Fig. 20; 40; 60; 80]: Common species on the Indian subcontinent, that also occurs, though less commonly observed, in Thailand and Vietnam [16]. Within India, it is distributed in Andhra Pradesh, Assam, Bihar, Delhi, Gujarat, Haryana, Himachal Pradesh, Karnataka, Kerala, Madhya Pradesh, Maharashtra, Punjab, Tamil Nadu, Uttaranchal, Uttar Pradesh, West Bengal [5]. It is a polyphagous pest and infests a wide range of wild and edible fruits [2, 26, 28]. During the present study male flies were attracted to Methyl eugenol traps and this is the new record for Tripura.

B. (*Daculus*) *digressa* (Radhakrishnan) [Fig. 7; 27; 47; 67]: It has been recorded only from India [5] and Bangladesh[16]. Within India, it was recorded from Karnataka and Tamil Nadu [5]. Host plant recorded in India is *Alangium salviifolium* (L.f.) Wangerin [5]. A very small number of male flies were attracted to cue lure traps and its presence in Tripura is recorded for the first time during the present study.

B. (*Sinodacus*) *bogorensis* (Hardy)[Fig. 2; 22; 42; 62]: It has been reported only from Indonesia [8] and Bangladesh[16]. It has no known host record. A small number of males have been caught in cue lure traps and the species is recorded for the first time from India.

B. (*Zeugodacus*) *vulta* (Hardy) [Fig. 19; 39; 59; 79]: It is present in Thailand, Caina, Laos, Bhutan, Malaysia, Indonesia, Philippines, Vietnam [8]. It is a non-economic fruit fly species with no known host record. Very small number of adults was caught in cue lure trap. This species is recorded for the first time from India.

B. (*Asiadacus*) *apicalis* (de Meijere) [Fig. 1; 21; 41, 61]: It is present in Indonesia, Brunei, China, Malaysia, Thailand, Vietnam [8]. It has been recorded to infest flowers of *Trichosanthes wawraei* (Family-Cucurbitaceae) [2]. A small number of males have been caught in cue lure traps and the

species is recorded for the first time from India.

B. (*Parasinodacus*) *incisa* (Walker) [Fig. 11; 31; 51; 71]: It is distributed in Myanmar, China, India, Malaysia, Thailand, Vietnam [8]. Within India, it was reported only from Andaman and Nicobar Islands [5]. It has no known host record. Very small number of adults was caught in cue lure trap and the presence of this species in Tripura is recorded for the first time.

Key to the Dacine fruit fly species recorded in Tripura

1. Larger fly with wasp like petiolate abdomen, abdominal tergum I longer than broad and abdominal tergites fused (Fig. 73); broad dark fuscous wing costal band overlapping vein R_{4+5} and becoming darker at apex (Fig.53); males attracted to cue-lure ..... *Dacus longicornis*
   Comparatively smaller fly, abdominal tergum I broader than long and abdominal tergites not fused; wing costal band confluent with vein R_{2+3} or at most overlapping vein R_{2+3} … 2
2. Scutum with medial post sutural yellow vitta present 3
   Scutum with medial post sutural yellow vitta absent 10
3. Wing costal band confluent with vein R_{2+3} and ending at apex of this vein; a large dark fuscous spot at the apex of wing (Fig.41); scutum predominantly red-brown (Fig.21); males attracted to cue-lure ..... *Bactrocera apicalis*
   Wing costal band not ending at apex of vein R_{2+3} 4
4. Wing with infuscations around r-m and dm-cu cross veins and with a distinct spot at the apex of costal band (Fig.46); scutum predominantly red-brown (Fig.26); males attracted to cue-lure ..... *Bactrocera cucurbitae*
   Wing without infuscations around r-m and dm-cu cross veins… 5
5. Face fulvous with a broad transverse black band (Fig.10); scutum red-brown with very short medial post sutural yellow vitta (Fig.30); lateral post sutural yellow vittae absent or very reduced; prescutellar setae absent; one pair of scutellar setae present; an enlarged circular dark fuscous spot present at apex of wing costal band (Fig.50); males attracted to cue-lure ..... *Bactrocera hochii*
   Prescutellar setae present; well developed medial and lateral post sutural yellow vittae present; apex of wing costal band not so greatly expanded 6
6. Face fulvous with a pair of circular to oval black spots (Fig.17); wing costal band overlapping vein R_{2+3} and expanded into an apical spot (Fig.57); scutum black with large areas of red-brown (Fig.37); two pair of scutellar setae present; males attracted to cue-lure ..... *Bactrocera tau*
   Face fulvous with or without a transverse black band or face is entirely dark fuscous to black; scutum colour black; costal band of uniform width through out or at most slightly expanded at the apex 7
7. Face fulvous with or without a transverse black band 8
   Face entirely dark fuscous to black 9
8. Face entirely fulvous in male (Fig.8) but fulvous with transverse black band in female; scutellum with one pair (rarely two pairs in male) of scutellar setae; each of abdominal terga III –V with a black 'T' pattern (in males, the 'T' pattern is prominent on abdominal targa III and IV); male abdomen without pecten (Fig.68); males weakly attracted to methyl eugenol ..... *Bactrocera diversa*
   Face fulvous with a transverse black band in both sexes (Fig.3); scutellum with two pairs of scutellar setae; male abdomen with pecten and a black 'T' pattern (Fig.63); males attracted to cue-lure ..... *Bactrocera caudata*
9. Face entirely black (Fig.2); wing costal band confluent with vein R_{2+3} and widening at the apex of R_{4+5}(Fig.42); femora with extensive black markings; males attracted to cue-lure ..... *Bactrocera bogorensis*
   Face entirely dark fuscous to black(Fig.19); wing costal band over lapping vein R_{2+3} and of uniform width(Fig.59); all femora fulvous; males attracted to cue-lure ..... *Bactrocera vulta*
10. Costal band not interrupted before reaching its apex 11
    Costal band interrupted or drastically narrowed before reaching its apex 17
11. All femora with extensive dark fuscous or black markings, abdominal terga III-V predominantly dark fuscous or black 12
    All femora and abdomen mostly pale coloured 14
12. A yellow spot anterior to notopleural suture present(Fig.31); face fulvous with a pair of transverse black bands(Fig.11); scutum mostly black; abdominal terga III-V dark fuscous to dull black(Fig.71); prescutellar setae absent; males attracted to cue-lure ..... *Bactrocera incisa*
    Yellow spot anterior to notopleural suture absent; prescutellar setae present; face mostly black; abdomen predominantly black 13
13. Lateral postsutural yellow vittae ending at or just behind intra-alar setae; (Fig.34); male attracted to cue-lure ..... *Bactrocera nigrifacia*
    Lateral postsutural yellow vittae ending long before intra-alar setae(Fig.35); male attracted to cue-lure ..... *Bactrocera nigrofemoralis*
14. Anterior supra-alar setae and prescutellar setae absent; scutum orange-brown(Fig.27); abdomen predominantly orange-brown with a narrow dark 'T' pattern (Fig.67); males attracted to cue-lure ..... *Bactrocera digressa*
    Anterior supra-alar setae and prescutellar setae present 15
15. Wing costal band confluent with vein R_{2+3} and not expanded apically (Fig.49); scutum entirely black or black with variable orange-brown patterns or entirely orange-brown; abdominal terga III-V with a black 'T' pattern (Fig.69); males attracted to methyl-eugenol ..... *Bactrocera dorsalis*
16. Wing costal band overlapping R_{2+3} 16
    Wing costal band overlapping R_{2+3} and expanding

apically into a small spot (Fig.52), Scutum mostly black; abdomen orange-brown, without a black 'T' pattern (Fig.72); males not attracted to methyl eugenol or cue-lure ..... *Bactrocera latifrons*

Scutum uniformly red-brown or with a lanceolate pattern (Fig.36); abdomen red-brown with a 'T' pattern (Fig.76); males attracted to cue-lure ..... *Bactrocera rubigina*

17. Scutum red-brown (Fig.40); abdomen red-brown (Fig.80); males attracted to methyl-eugenol ..... *Bactrocera zonata*

    Scutum predominantly or entirely black; abdomen predominantly red-brown or black 18

18. Abdomen red-brown; abdominal terga III-V with a dark 'T' pattern (Fig.65); males attracted to methyl-eugenol.... *Bactrocera correcta*

    Abdominal terga III-V black 19

19. Face fulvous with a pair of large circular black spots (Fig.18); legs entirely fulvous; males attracted to methyl-eugenol ..... *Bactrocera tuberculata*

    Face fulvous with a pair of transverse black bands (Fig.4); fore femora black and mid and hind femora fulvous basally and black apically; males attracted to cue-lure ..... *Bactrocera cilifera*

Table 1: List of Dacine Fruit fly species recorded in Tripura.

S. No.	Species	Collection method	Sex of species collected and studied	Number of specimens
1	*Bactrocera* (*Bactrocera*) *dorsalis* (Hendel)	Methyl eugenol, food bait	Male and female	9839
2	*B.* (*Bactrocera*) *zonata* (Saunders)*	Methyl eugenol	Male	262
3	*B.* (*Bactrocera*) *latifrons* (Hendel)	Food bait	Male and female	47
4	*B.* (*Hemigymnodacus*) *diversa* (Coquillett)	Methyl eugenol, food bait	Male and female	656
5	*B.* (*Bactrocera*) *correcta* (Bezzi)*	Methyl eugenol	Male	38
6	*B.* (*Bactrocera*) *nigrifacia (*Zhang, Ji & Chen)*#	Cue lure	Male	79
7	*B.* (*Bactrocera*) *rubigina* (Wang & Zhao)*#	Cue lure	Male	8729
8	*B.* (*Bactrocera*) *nigrofemoralis* (White and Tsuruta)*	Cue lure	Male	13
9	*B.* (*Bactrocera*) *tuberculata* (Bezzi)*#	Methyl eugenol	Male	167
10	*B.* (*Daculus*) *digressa* (Radhakrishnan)*	Cue lure	Male	10
11	*B.* (*Sinodacus*) *bogorensis* (Hardy)*#	Cue lure	Male	22
12	*B.* (*Sinodacus*) *hochii* (Zia)	Cue-lure	Male	88
13	*B.* (*Zeugodacus*) *caudata* (Fabricius)	Cue-lure	Male	1033
14	*B.* (*Zeugodacus*) *cucurbitae* (Coquillett)	Cue-lure, food bait.	Male and female	6940
15	*B.* (*Zeugodacus*) *tau* (Walker)	Cue-lure, food bait.	Male and female	7930
16	*B.* (*Parasinodacus*) *cilifera* (Hendel)	Cue-lure, food bait.	Male and female	35
17	*B.* (*Zeugodacus*) *vulta* (Hardy)*#	Cue lure	Male	4
18	*B.* (*Parasinodacus*) *incisa* (Walker)*	Cue lure	Male	6
19	*B.* (*Asiadacus*) *apicalis* (de Meijere)*#	Cue lure	Male	25
20	*Dacus* (*Callantra*) *longicornis* (Wiedemann)	Cue-lure	Male	373

* New record from Tripura, # New record from India

Plate 1: Heads of Dacines showing frons: 1, *B. apicalis*, 2, *B. bogorensis*, 3, *B. caudata*, 4, *B. cilifera*, 5, *B. correcta*, 6, *B. cucurbitae*, 7, *B. digressa*, 8, *B. diversa*, 9, *B. dorsalis*, 10, *B. hochii*, 11, *B. incisa*, 12, *B. latifrons*, 13, *D. longicornis*, 14, *B. nigrifacia*, 15, *B. nigrofemoralis*, 16, *B. rubigina*, 17, *B. tau*, 18, *B. tuberculata*, 19, *B. vulta*, 20, *B. zonata*.

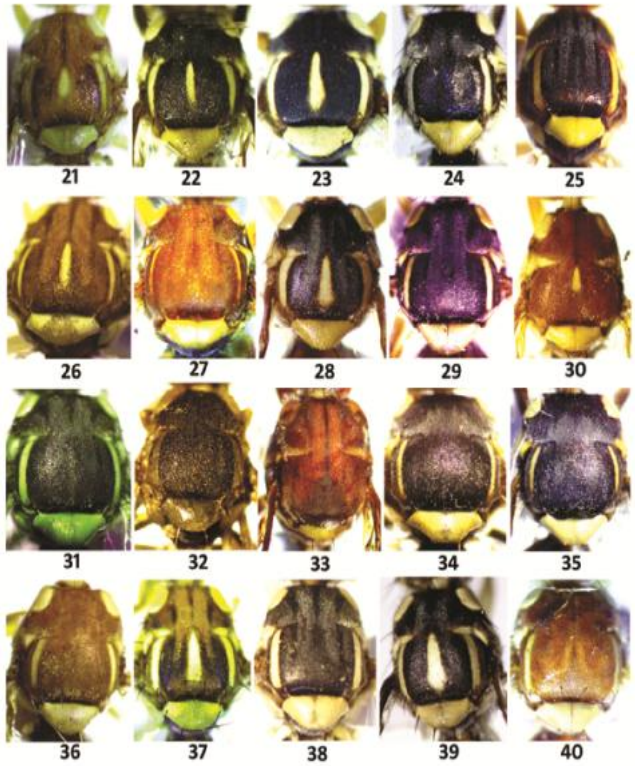

Plate 2: Thorax of Dacines: 21, *B. apicalis*, 22, *B. bogorensis*, 23, *B. caudata*, 24, *B. cilifera*, 25, *B. correcta*, 26, *B. cucurbitae*, 27, *B. digressa*, 28, *B. diversa*, 29, *B. dorsalis*, 30, *B. hochii*, 31, *B. incisa*, 32, *B. latifrons*, 33, *D. longicornis*, 34, *B. nigrifacia*, 35, *B. nigrofemoralis*, 36, *B. rubigina*, 37, *B. tau*, 38, *B. tuberculata*, 39, *B. vulta*, 40, *B. zonata*

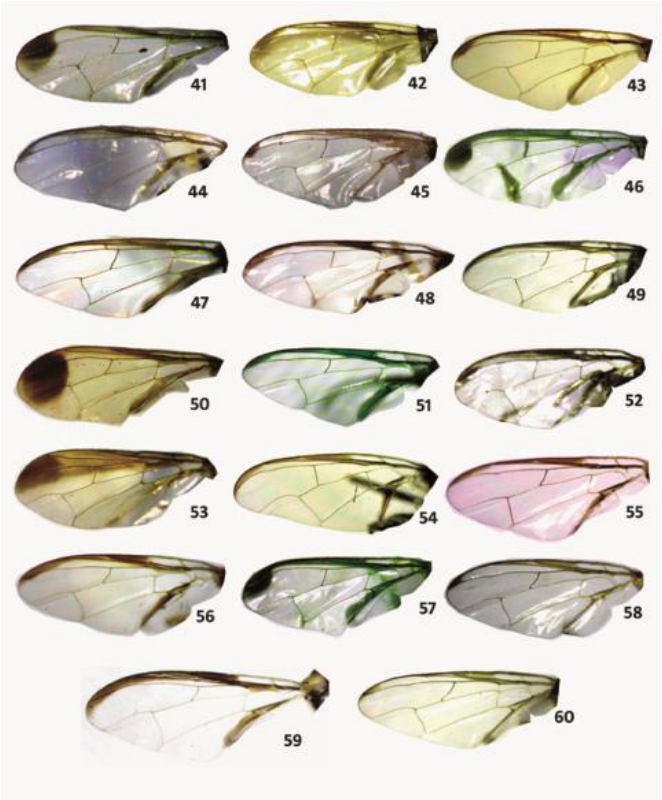

Plate 3: Wings of Dacines: 41, *B. apicalis*, 42, *B. bogorensis*, 43, *B. caudata*, 44, *B. cilifera*, 45, *B. correcta*, 46, *B. cucurbitae*, 47, *B. digressa*, 48, *B. diversa*, 49, *B. dorsalis*, 50, *B. hochii*, 51, *B. incisa*, 52, *B. latifrons*, 53, *D. longicornis*, 54, *B. nigrifacia*, 55, *B. nigrofemoralis*, 56, *B. rubigina*, 57, *B. tau*, 58, *B. tuberculata*, 59, *B. vulta*, 60, *B. zonata*.

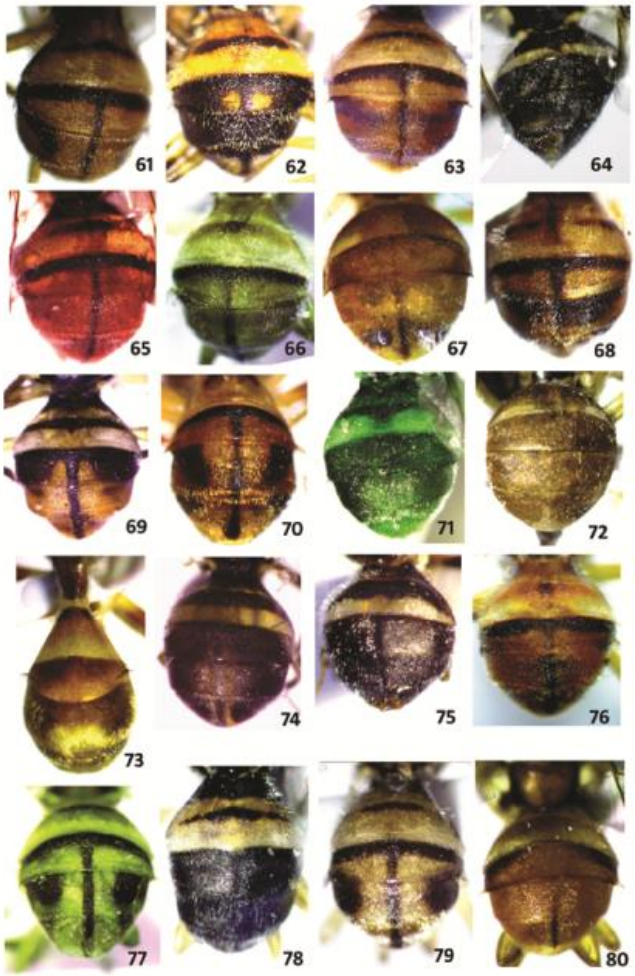

Plate 4: Abdomens of Dacines: 61, *B. apicalis*, 62, *B. bogorensis*, 63, *B. caudata*, 64, *B. cilifera*, 65, *B. correcta*, 66, *B. cucurbitae*, 67, *B. digressa*, 68, *B. diversa*, 69, *B. dorsalis*, 70, *B. hochii*, 71, *B. incisa*, 72, *B. latifrons*, 73, *D. longicornis*, 74, *B. nigrifacia*, 75, *B. nigrofemoralis*, 76, *B. rubigina*, 77, *B. tau*, 78, *B. tuberculata*, 79, *B. vulta*, 80, *B. zonata*.

4. Conclusion

Out of 20 species of Dacine fruit flies recorded during the present study, 11 species of Dacine fruit flies, namely *B. zonata*, *B. correcta*, *B. nigrifacia*, *B. rubigina*, *B. nigrofemoralis*, *B. tuberculata*, *B. digressa*, *B. bogorensis*, *B. vulta*, *B. incisa* and *B. apicalis* have been recorded for the first time from Tripura. Among these, 6 species, namely *B. nigrifacia*, *B. rubigina*, *B. tuberculata*, *B. bogorensis*, *B. vulta*, and *B. apicalis* are new country records from India.

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