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Research Article

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# Distribution, Damage Severity and Management of Dacine Fruit Flies in Nepal: A Review

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## Abstract

Fruit flies are economically significant pests in horticultural crops. The diversity of dacine fruit fly species (Family: Tephritidae; Sub-family: Dacinae; Tribe: Dacini) varies depending on location, season, crop, and variety. This review explores various aspects of fruit fly management in fruits and vegetables, including their distribution across regions, districts and crops with reference to published articles, theses, proceedings and reports in Nepal. The most commonly reported genera in Nepal are *Bactrocera, Zeugodacus*, and *Dacus. Z. cucurbitae* (Coq.) and *Z. tau* (Walker) are reported major pests in cucurbits, while *B. minax* (Enderlein) reported in sweet oranges. Across these three genera, 28 fruit fly species have been reported in 31 districts (27 in the hills and 4 in the Terai). Seventeen species were reported in Kaski district, while more than 10 species reported in Chitwan, Nawalparasi, Sindhuli, Tanahun, and Kathmandu. Average damage to cucurbit crops ranged from 26-51%, with a maximum of 74% damage reported in sweet oranges. Due to the oligophagous and polyphagous nature of these species, controlling them with a localized management method is challenging in Nepal, where farmers cultivate multiple crops. Integrated management practices, including cultural, botanical, chemical pesticides, and cue-lure traps, are recommended for cucurbits, while a community-level area-wide control program is advised for sweet orange orchards.

**Keywords :** Cucurbit, diversity, location, monitoring, tephritidae

## Introduction:

Fruit flies (tribe: Dacini; sub-family: Dacinae; family: Tephritidae; order: Diptera) are economically important pests in fruits and vegetables. In the family Tephritidae, more than 500 genera and over 5,000 species have been recognized worldwide (Scolari et al., 2021), of which nearly 932 species belong to the tribe Dacini (Doorenweerd et al., 2018). Leblanc et al. (2019) documented the presence of 26 dacine fruit fly species while Sapkota et al. (2024) reported 27 species, including

*D. (Callentra) nepalensis* (Hardy 1964), in Nepal. Most of the dacine fruit flies are oligophagous and polyphagous in nature, adoptive to a wide range of climates, and possess high dispersal capacity. Adhikari et al. (2020) ranked the crops damaged by fruit flies as cucurbitaceous vegetables (79%), tree fruits (14%) and solanaceous vegetables (6%) based on cases registered at plant clinics.

The diversity of dacine fruit fly species varies with respect to location, season, crop, and variety, and their preference also differ depending on crop growth stages. These pests cause significant devastation to both the production and trade of fresh cucurbits; however, their preference and the extent of damage may vary with fruit fly species and host crop (Prabhakar et al., 2007). The most commonly reported genera of dacine fruit flies in Nepal include *Bactrocera, Zeugodacus* and *Dacus* in fruits and vegetables. *Z. cucurbitae* (Coquillett) and *Z. tau* (Walker) are major pests in cucurbits (Shrestha, 2023; Nair et al., 2017; Sawai et al., 2019), while *B. minax* (Enderlein) is commonly reported in sweet orange orchards (Adhikari and Joshi, 2018). These species have been reported across Nepal, from the east to west and from the terai to the mid-hills. The extent of yield-loss due to fruit flies in cucurbits ranges from 30–100%, depending upon host species, locality and the season (Dhillon et al., 2005). Various management measures, such as pheromone trap, cultural practices, chemical and botanicals controls are commonly used either individually or in combination. This manuscript reviews the available information on dacine fruit fly species to explore potential management strategies for these pests in fruits and vegetables in the context of Nepal.

### *Geographical distribution of fruit fly species*

The crop damage due to fruit fly has been reported from many districts of terai and mid-hills (up to 1500 masl) regions in Nepal. However, the species of dacine fruit fly so far reported in 31 districts is presented in Figure 1 and Table 1.

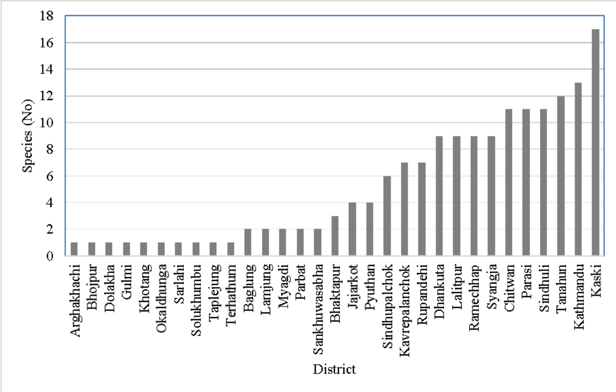


**Figure 1:** Number of dacine fruit fly species reported in field and/or monitoring experiments in different districts of Nepal (1964-2023).

Dacine fruit flies are distributed in most of the districts of terai and mid-hills, however, the presence of at least one fruit fly species reported from 31 districts (Figure 1). Of the 31 districts, only four districts are in terai and 27 districts in lower to mid-hills regions. Maximum number of fruit fly species (17) was reported from Kaski district while more than 10 species were reported from other five districts (Chitwan, Nawalparasi, Sindhuli, Tanahun and Kathmandu).

**Table 1:** Geographical distribution of dacine fruit fly species reported in field and/or monitoring experiments in different districts of Nepal (1964-2023)

| SN | Fruit fly species | Distribution (Districts) | | References | Attractant & pest status[@] |
|---|---|---|---|---|---|
| | | Low-hill to mid-hill | Terai | | |
| 1. | *Dacus (Callantra) nepalensis* (Hardy 1964) | Sankhuwasabha | | Hardy (1964), Museum (2023), Potentially synonym of *D. polistiformis* (Leblanc et al., 2019) | NR, NP |
| 2. | *Bactrocera dorsalis* (Hendel 1912) | Baglung, Dhankuta, Jajarkot, Kaski, Kathmandu, Kavrepalanchok, Lalitpur, Myagdi, Parbat, Pyuthan, Ramechhap, Sindhuli, Sindhupalchok, Syangja, Tanahun | Chitwan, Nawalparasi, Rupandehi | Pradhan (1970), Pandey et al. (1995), Khatri and Sthapit (1997), Joshi and Manandhar (2001), Shrestha (2006), Gyawali (2006), Sharma et.al. (2015), Gautam et al. (2015), PPD (2016), Bhandari et al. (2017a), Adhikari and Joshi (2018), Acharya and Adhikari (2019), Leblanc et al. (2019), Bhusal et al. (2020), Chiluwal et al. (2022), Pandey (2022), Basnet (2022), Gupta and Regmi (2022), Shrestha (2023), Karki et al. (2023), Parajuli et al. (2023), Acharya et al. (2024) | ME, Zn, PP |

| SN | Fruit fly species | Distribution (Districts) | | References | Attractant & pest status@ |
|---|---|---|---|---|---|
| | | Low-hill to mid-hill | Terai | | |
| 3. | *Zeugodacus caudatus* (Fabricius 1805) | Bhaktapur, Kathmandu | Chitwan, Nawalparasi | Kapoor et al. (1979), Gautam et al. (2015), Maharjan et al. (2015), Leblanc et al. (2019) | CL, OP |
| 4. | *Zeugodacus scutellaris* (Bezzi 1913) | Bhaktapur, Dhankuta, Jajarkot, Kaski, Kathmandu, Kavrepalanchok, Lalitpur, Ramechhap, Sindhuli, Sindhupalchok, Syangja, Tanahun | | Kapoor et al. (1979), Joshi and Manandhar (2001), Shrestha (2006), Gyawali (2006), Ito (2011), Sharma et al. (2015), Maharjan et al. (2015), Gautam et al. (2015), PPD (2016), Bhandari et al. (2017a), Adhikari and Joshi (2018), Acharya and Adhikari (2019), Leblanc et al. (2019), Bhusal et al. (2020), Chiluwal et al. (2022), Shrestha (2023), Karki et al. (2023), Parajuli et al. (2023), Acharya et al. (2024) | CL, OP |
| 5. | *Zeugodacus cucurbitae* (Coquillett 1899) | Bhaktapur, Dhankuta, Kaski, Kathmandu, Kavrepalanchok Lalitpur, Lamjung, Pyuthan, Ramechhap, Sindhuli, Sindhupalchok, Syangja | Chitwan, Nawalparas, Rupandehi, Sarlahi | Pradhan (1970), Pandey et al. (1995), Pradhan (1976), Manjunathan (1997), Jaiswal et al. (1997), Khatri and Sthapit (1997), Gautam et al. (1998), Joshi and Manandhar (2001), Shrestha (2006), Gyawali (2006), Sapkota (2008), Sharma et al. (2015), Maharjan et al. (2015), Gautam et al. (2015), PPD (2016), Bhandari et al. (2017a), Adhikari and Joshi (2018), Acharya and Adhikari (2019), Leblanc et al. (2019), Pokhrel (2019), Bhusal et al. (2020), Gautam et al. (2021), Subedi et al. (2021), Chiluwal et al. (2022), Gupta and Regmi (2022), Basnet (2022), Pandey (2022), Gupta and Regmi (2022), Gosai and Adhikari (2022), Shrestha (2023), Karki et al. (2023), Acharya et al. (2024) | CL, Zn , PP |
| 6. | *Zeugodacus diversus* (Coquillett 1904) | Kaski, Kathmandu, Tanahun | Chitwan | Joshi and Manandhar (2001), Leblanc et al. (2019), Chiluwal et al. (2022) | weak ME, OP |
| 7. | *Bactrocera zonata* (Saunders 1842) | Dhankuta, Kaski, Kathmandu, Kavrepalanchok, Lalitpur, Pyuthan, Ramechhap, Sindhuli, Sindhupalchok, Syangja | Chitwan, Nawalparasi Rupandehi | Khatri and Sthapit (1997), Joshi and Manandhar (2001), Shrestha (2006), Gyawali (2006), Sharma et al. (2015), Gautam et al. (2015), PPD (2016), Bhandari et al. (2017a), Adhikari and Joshi (2018), Acharya and Adhikari (2019), Leblanc et al. (2019), Bhusal et al. (2020), Chiluwal et al. (2022), Gupta and Regmi (2022), Shrestha (2023), Karki et al. (2023), Acharya et al. (2024) | ME, PP |

| SN | Fruit fly species | Distribution (Districts) | | References | Attractant & pest status@ |
|---|---|---|---|---|---|
| | | Low-hill to mid-hill | Terai | | |
| 8. | *Zeugodacus tau* (Walker 1849) | Dhankuta, Jajarkot, Kaski, Kathmandu, Kavrepalanchok, Lalitpur, Pyuthan, Ramechhap, Sindhuli, Sindhupalchok, Syangja | Chitwan, Nawalparasi Rupandehi | Khatri and Sthapit (1997), Joshi and Manandhar (2001), Shrestha (2006), Gyawali (2006), Sapkota (2008), Sharma et al. (2015), Gautam et al. (2015), PPD (2016), Bhandari et al. (2017a), Adhikari and Joshi (2018), Acharya and Adhikari (2019), Leblanc et al. (2019), Bhusal et al. (2020), Sharma et al. (2020), Chiluwal et al. (2022), Basnet (2022), Pandey (2022), Shrestha (2023), Karki et al. (2023), Parajuli et al. (2023), Acharya et al. (2024) | CL, PP |
| 9. | *Zeugodacus yoshimotoi* (Hardy 1973) | Dhankuta, Kaski, Kathmandu, Kavrepalanchok, Lalitpur, Sindhuli, Syangja, Tanahun | | Shrestha (2006), Gyawali (2006), Ito (2011), PPD (2016) , Bhandari et al. (2017a), Leblanc et al. (2019) | CL, NP |
| 10. | *Bactrocera minax*# (Enderlein 1920) | Arghakhachi, Baglung, Bhojpur, Dhankuta, Dolakha, Gulmi, Kavrepalanchok, Khotang, Lamjung, Myagdi, Okaldhunga, Parwat, Ramechhap, Sankhuwasabha, Sindhuli, Sindhupalchok, Solukhumbu, Syangja, Taplejung, Terhathum | | Joshi and Manandhar (2001), NCRP (2006), Bajracharya (2010), NCRP (2012), PPD (2016), Bhandari et al. (2017a), Adhikari and Joshi (2018), Adhikari et al. (2022), Karki et al. (2023), Acharya et al. (2024) | No lure, weak ME, OP |
| 11. | *Bactrocera correcta* (Bezzi 1916) | Kaski, Kathmandu, Ramechhap | | Gautam et al. (2015), Chiluwal et al. (2022), Karki et al. (2023) | ME, PP |
| 12. | *Bactrocera latifrons* (Hendel 1915) | Lalitpur | | Tiwari (2016) | Lati-lure, OP |
| 13. | *Bactrocera atrifacies* (Perkins 1938) | Dhankuta, Lalitpur | | Tiwari (2016), Bhandari et al. (2017a) | CL, NP |
| 14. | *Dacus ciliatus* Loew 1862 | Lalitpur | | Gautam et al. (2015), Tiwari (2016) | NR |
| 15. | *Bactrocera nigrofemoralis* White & Tsuruta 2001 | Jajarkot, Kaski, Ramechhap, Sindhuli, Syangja | | PPD (2016), Tiwari (2016), Karki et al. (2023), Parajuli et al. (2023) | CL, NP |
| 16. | *Bactrocera tuberculata* (Bezzi 1916) | Dhankuta, Kaski, Kathmandu, Sindhuli, Tanahun | Nawalparasi | Tiwari (2016), Bhandari et al. (2017a), Leblanc et al. (2019), Bhusal et al. (2020) | ME, PP |
| 17 | *Dacus longicornis* (Wiedemann 1830) | Kaski, Sindhuli, Syangja | Nawalparasi | PPD (2016), Adhikari and Joshi (2018), Leblanc et al. (2019), Bhusal et al. (2020) | CL, OP |

| SN | Fruit fly species | Distribution (Districts) | | References | Attractant & pest status@ |
|---|---|---|---|---|---|
| | | Low-hill to mid-hill | Terai | | |
| 18. | *Bactrocera abbreviata* (Hardy, 1974) | Kaski, Kathamndu, Tanahun | Chitwan | Leblanc et al. (2019) | Zn, NP |
| 19. | *Bactrocera aethriobasis* (Hardy,1973) | | Nawalparasi | Leblanc et al. (2019) | ME, NP |
| 20. | *Bactrocera digressa* Radhakrishnan 1999 | Kaski, Tanahun | Chitwan, Nawalparasi | Leblanc et al. (2019) | CL, Zn,NP |
| 21. | *Bactrocera nigrifacia* Zhang, Ji and Chen 2011 | Kaski, Kathmandu, Tanahun | Chitwan, Nawalparasi, Rupandehi | Leblanc et al. (2019) | CL, NP |
| 22. | *Bactrocera rubigina* (Wang and Zhao 1989) | Kaski, Kathmandu, Tahanun | Chitwan, Rupandehi | Leblanc et al. (2019) | CL, Zn, NP |
| 23. | *Bactrocera syzygii* White and Tsuruta 2001 | Tanahun | Chitwan | Leblanc et al. (2019) | Zn, NP |
| 24. | *Zeugodacus duplicatus* (Bezzi, 1916) | | Rupandehi | Leblanc et al. (2019). | NR, NP |
| 25. | *Dacus feijeni* White 1998 | Tanahun | | Leblanc et al. (2019) | CL, NP |
| 26. | *Dacus maculipterus* Drew and Hancock 1998 | Kaski | | Leblanc et al. (2019) | NR, NP |
| 27. | *Dacus trimacula* Wang 1990 | Kaski, Tanahun | | Leblanc et al. (2019) | CL, Zn, NP |
| 28. | *Dacus sphaeroidalis* (Bezzi, 1916) | Ramechhap | | Karki et al. (2023) | CL, NP |

#earlier reported as *B.?tsuneonis* Miyaka (Joshi and Manandhar, 2001); @Adopted from Doorenweerd et al. (2018) and Vasuda and Agarwal (2019)

CN: Common Name; NR: Non-Recorded; NP: Non-pest; CL: Cue-lure; ME: Methyl Eugenol, Zn: Zingerone, OP: Oligophagous, PP: Polyphagous.

### *Host diversity and damage severity*

The maggots of dacine fruit fly feed directly inside fruits, flowers and stems, and indirect damage is caused by secondary infections. Generally, females prefer to lay their eggs in soft, tender fruit tissues by piercing them with their ovipositor, which often goes unnoticed until the fruit is matured, leading to post-harvest losses. Upon close observation, a watery fluid can be seen oozing from the puncture during egg-laying. These punctures can serve as entry points for pathogens, leading to secondary infections and further decay of the fruits. In Nepal, the most serious damage has been caused by species of the genera *Zeugodacus, Bactrocera,* and *Dacus,* especially *Z. cucurbitae* and *Z. tau* in cucurbit crops, *B. minax* in sweet oranges, and *Dacus* spp. in various fruit crops (Sapkota et al., 2010; Adhikari and Joshi, 2018; Lablanc et al., 2019). Adhikari and Joshi (2024) also reported *B. latifrons* causing significant damage to solanaceous crops. Experimental research on damage assessment of *Z. cucurbitae*, *B. minax,* and fruit flies irrespective to the species is shown in Table 2. Although the researchers report damage caused by

**Table 2:** Host diversity and damage severity of dacine fruit flies in Nepal irrespective to growing seasons and cultivars.

| Genus or Species | Family and plant type | Crop | Damage reported due to fruit fly (%) | |
|---|---|---|---|---|
| | | | Mean±sd | References |
| *Zeugodacus cucurbitae* (Coquillett)) | Cucurbitaceae Fruits | Squash | 51±5 | 45-58 (Jaiswal et al., 1997); 54 (Sapkota et al., 2010); 47-51 (Simkhada, 2015); 48 (Gosai and Adhikari, 2022) |
| | | Pumpkin | 44 | 29-59 (Pradhan, 1976) |
| | | Bitter gourd | 44±18 | 25-40 (Pradhan, 1976); 42-68 (GC, 2001) |
| | | Bottle gourd | 43±14 | 27-49 (Pradhan, 1976); 54 (Gautam et al., 2021) |
| | | Cucumber | 26±10 | 19-22 (Pradhan, 1976); 29-42 (Maharjan et al., 2015); 16 (Subedi et al., 2021) |
| | | Sponge gourd | 26 | 26 (Pradhan, 1976) |
| Fruit flies | Cucurbitaceae Fruits | Squash | 45±26 | 25-34 (Shrestha, 2023); 44-90 (Basnet,2022); 20-58 (Pandey, 2022) |
| *Bactrocera minax* (Enderlein) | Rutaceae Fruits | Sweet orange | 74±25 | 97 (NCRP, 2012); 60 (NCRP, 2018); 100 (Acharya and Adhikari, 2019); 41-73 (Adhikari et al., 2020) |

Note: sd: standard deviation

the cucurbit fruit fly or melon fly, the damage is often recorded without specifying the species. In the case of sweet oranges, all reported damage has been attributed to *B. minax* (Adhikari and Joshi, 2018). Joshi (2019) noted the spread of *B. minax* from the eastern mid-hills to the central mid-hills and further into the western mid-hill citrus orchards in Nepal.

The most damage severity was reported in sweet orange i.e. 74% while the most damaged cucurbit crop was reported in squash (45-51%) followed by bitter gourd (44%) and pumpkin (44%) (Table 2).

### *Management practices*

In Nepal, farmers mostly follow local area management techniques to suppress pests rather than eradicate them. A combination of para-pheromone lures/traps, sanitation, and cultural measures is commonly practiced alongside other management techniques to keep pest populations below the economic threshold. Other reported management practices include fruit bagging, pest exclusion nets, variety selection, botanical pesticides, local baits, protein baits, insecticides, etc. (Table 3). A community-level, area-wide control program has also been initiated in citrus orchards.

There is inconsistency in management practices since the recommendations are based on a single season's crop and specific locations only (Table 3). The Nepalese farming system often integrates fruits and vegetables in home gardens and even in commercial farms. Due to the oligophagous and polyphagous nature of the pest, management is quite difficult as they can complete their life cycle on alternative hosts. For sweet oranges, Bhandari et al. (2017b) reported that locally prepared baits (beer supernatant and debris plus honey and spinosad) were effective against *B. minax*, while Acharya and Adhikari (2019) observed nearly 100% loss in orchards treated with the same bait. In the case of cucurbits, botanical pesticides (e.g., 'Jholmal' and neem extract) combined with para-pheromone traps (1 trap/40 m²) were found to be more effective than chemical pesticides (Sapkota et al., 2010). Recent studies also indicated that spinosad 45 SC was more effective than other insecticides in controlling fruit fly populations in the field (Pandey, 2022; Shrestha, 2023). Sapkota et al. (2009) recommended integrating cultural practices (early planting and deep ploughing), field sanitation, the use of botanical pesticide 'Jholmal', and cue-lure traps as the best alternatives to control fruit fly populations in cucurbit fields. Similarly, Adhikari et al. (2020) reported that the community-level area-wide control program (AWCP) is the most effective method for controlling *B. minax* infestations in sweet orange orchards.

## Conclusion:

Fruit flies have caused significant economic losses due to fruit damage and reduced yields in cucurbits and fruit crops. Occurrence of fruit flies and their damage (without identification of species) is commonly realized across the terai and mid-hill districts of Nepal. This review figures 28 fruit fly species damaging crops in 31 districts, with the number of species varying between the mid-hills and terai regions. Researchers have focused on integrated local management practices in cucurbits without identifying the damage causing species. In sweet oranges, *B. minax* was identified as the damaging species, and community-level area-wide management practices have been initiated. Since fruit fly species are mostly

**Table 3:** Management practices to control dacine fruit flies in Nepal irrespective to season of growing and cultivars

| Fruit fly | Crop | Recommended management practices |
|---|---|---|
| *Zeugodacus cucurbitae* (Coquillett) | Squash | • Some degree of varietal tolerance so varietal selection suggested (Jaiswal et al., 1997)<br>• Cue lure traps (10 drops cue-lure and malathion 50 EC) which was recharged every month (Gautam et al., 1998)<br>• Every three days interval sprays of 'Jholmal' from flowering to harvest along with cue-lure traps (1/40m$^2$) (Sapkota et al., 2010)<br>• Weekly spray of 'Jholmal' (1:6 water) (Simkhada, 2015)<br>• Three spray of neem leaf extract (1:5 water) at 10 days interval from 40 days after transplanting (Gosai and Adhikari, 2022) |
| | Bitter gourd | • Cue-lure traps recharge at weekly interval (GC, 2001)<br>• Fruit bagging with cloth bag within a day of anthesis (Pokhrel, 2019) |
| | Bottle gourd | • Three sprays of spinosad 45 SC 200 ml/ha/spray (Gautam et al., 2021) |
| | Cucumber | • Infestation differs with variety so variety selection suggested (Maharjan et al., 2015)<br>• Net house with black plastic mulch (Subedi et al., 2021) |
| *Bactrocera minax* (Enderlein) | Sweet orange | • Cover spray of systemic insecticide during their ovipositional period (Bajrachary et al., 2010)<br>• Locally prepared bait i.e. Beer supernatant and debris (1:1) plus honey(5 g/L) when used in Mc Phail traps and in spot spray in combination with the insecticide spinosad (Bhandari et al., 2017b)<br>• GREAT® fruit fly bait and sprays of spinosad 48 SC 0.025 ml/L at weekly interval (Acharya and Adhikari, 2019)<br>• Area wide control program using GREAT® fruit fly bait (25% protein hydrolysate and 0.1% abamectin) under leaf spot application at weekly interval from May to July (Adhikari et al., 2020) |
| Fruit flies# | Squash | • Spinosad 45 SC 0.4-1 ml/L after 50% flowering at weekly interval with cue-lure trap (Pandey, 2022; Basnet 2022; Shrestha, 2023) |

Note: #management reported irrespective to fruit fly species.

oligophagous and polyphagous in nature, controlling them with a single or localized management approach is challenging in Nepal, where farmers grow multiple crops. Therefore, research should focus on identifying the damage causing species and understanding their biology to develop effective management strategies.

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## Declaration of conflict of interest and ethical approval:

The authors declare no conflicts of interest regarding the publication of this manuscript.

## References:

Acharya, P., Acharya, N., Bhusal, K., Lamsal, B., Pradhan, R., Pandey, S., Lamsal, M.P. & Shrestha, J. (2024). Efficacy of home-made and commercial trapping baits for the management of fruit flies in mandarin orchards. *International Journal of Horticulture, 14* (3), 121-128. DOI: https://doi.org/10.5376/ijh.2024.14.0014

Acharya, U.K. & Adhikari, D. (2019). Chinese citrus fly (*Bactrocera minax)* management in mid-hills of Nepal. *The Journal of Agriculture and Environment*, *20*, 47-56. DOI: https://doi.org/10.3126 / nh.v14i1.30161

Adhikari, D. & Joshi S.L. (2018). Occurrences and field identities of fruit flies in sweet orange (*C. sinensis*) orchards in Sindhuli, Nepal. *Journal of Natural History Museum, 30*, 47-54.

Adhikari, D. & Joshi S.L. (2024). Solanaceous fruit fly *(Bactrocera latifrons)* [in Nepali]. Plant Quarantine and Pesticide Management Center, Lalitpur, Nepal. 2 p.

Adhikari, D., Joshi, S.L., Thapa, R.B., Pandit, V. & Sharma, D.R. (2020). Fruit fly management in Nepal: A case from plant clinic. *Journal of Biological*

*Control, 34*(1), 8-14. DOI: https://doi.org/10.18311/jbc/2020/22833

Adhikari, D., Thapa, R.B., Joshi S.L., Du, J.J. & Tiwari, S. (2022). Biology and management of Chinese citrus fly, *B. minax* (Enderlein) (Diptera: Tephritidae). *Journal of Agriculture and Forestry University, 5*, 1-13.

Adhikari, D., Thapa, R.B., Joshi, S.L., Liang, X.H. & Du, J.J. (2020). Area-wide control program of Chinese citrus fly *B. minax* (Enderlein) in Sindhuli, Nepal. *American Journal of Agricultural and Biological Sciences*, *15*, 1-7. DOI: https://doi.org/10.3844 / ajabssp.2020.1.7

Bajracharya, A.S.R. (2010). *Management of Chinese fruit fly B. minax with cover spray in sweet orange orchard*. Annual Technical Report 2065-66, Agriculture Research Station, Pakhribas, Nepal. pp. 73-74.

Basnet, S. (2022). *Bio-rational management and identification of fruit fly species in squash at Kirtipur, Kathmandu, Nepal* [Unpublished master thesis]. Postgraduate Program, IAAS, Tribhuvan University, Nepal. 54 p.

Bhandari, K., Ansari, A.R., Joshi S.L., Subedi, H.P. & Thakur, M.K. (2017a). Fruit fly (Diptera Tephritidae) diversity in citrus fruits in eastern hills of Nepal. *Proceedings of the 9th National Horticulture Workshop, May 31-June 1, 2017, Kathmandu*. Nepal Agricultural Research Council. pp. 50-62.

Bhandari, K., Ansari, A.R., Joshi S.L., Subedi, H.P. & Thakur, M.K. (2017b). Efficacy study of protein baits against *B. minax* and their potential use in spot sprays in eastern hills of Nepal. *Proceedings of the 9th National Horticulture Workshop, May 31-June 1, 2017, Kathmandu*. Nepal Agricultural Research Council. pp. 42-49.

Bhusal, N.R., Kafle, K., Bhattarai, S.S. & Adhikari, D. (2020). Monitoring of fruit flies (Diptera:Tephritidae) on cucurbit vegetables in Sindhuli, Nepal. *Journal of Plant Protection Society, 6*, 178-191.

Chiluwal, K., Shrestha, E., Devkota, S., Shrestha, K., Sigdel, S., Khanal, A., Basnet, R.B., Upadhyay, B. & Aryal, L.N. (2022). Identification of cucurbit fruit flies and their relative attractiveness to different cues and releasers. *Nepal Journal of Science and Technology, 21*, 45-56. DOI: https://doi.org/10.3126/njst.v21i1.49911

Dhillon, M., Singh, R., Naresh, J., & Sharma, H. (2005). The melon fruit fly, *B. cucurbitae:* A review of its biology and management. *Journal of Insect Science, 5,* 1-16.

Doorenweerd, C., Leblanc, L., Norrbom, A.L., San Jose, M., & Rubinoff, D. (2018). A global checklist of the 932 fruit fly species in the tribe Dacini (Diptera, Tephritidae). *ZooKeys, 730*, 19-56. DOI: https://doi.org/10.3897

Gautam, M., Poudel, S., Dhungana, N. & Bhusal, N. (2021). Comparative efficacy of different insecticides against cucurbit fruit fly (*B. cucurbitae)* on bottle gourd in Sarlahi district, Nepal. *International Journal of Natural Resource Ecology and Management, 6*(2), 27-37. DOI: https://doi.org/10.11648/j.ijnrem.20210602.11

Gautam, R., Gurung, T., Ghimire, S., Jaiswal, J. & Pandey, R. (1998). Adoption and impact of integrated management of melon fruit fly (*B. cucurbitae*) at farm level in western hills of Nepal. *LARC Seminar Paper 98/11,* 8.

Gautam, R., Singh, S. & Kumar, R. (2015). *Management of important fruit flies with focus on their identification–Technical Manual*. Westville Publishing House, India. 72 p.

GC, Y.D. (2001). Performance of bitter gourd varieties to cucurbit fruit fly in Chitwan condition. *Journal of Institute of Agriculture and Animal Science*, *21-22*, 251-252.

Gosai, S. & Adhikari, C. (2022). Bio-efficacy of different plant extracts against melon fruit fly *Z. cucurbitae* (Coq.) in zucchini, Bharatpur, Nepal. *Journal of Plant Protection Society, 7*, 11-23.

Gupta, A. & Regmi, R. (2022). Efficacy of different homemade and commercial baits in monitoring of fruit flies at Maranthana, Pyuthan, Nepal. *Malaysian Journal of Sustainable Agriculture*, *6*(2*)*, 94-102. DOI:https://doi.org/10.26480/mjsa.02.2022.101.109

Gyawali, B.K. (2006). Effect of composite lures on fruit flies (*Bactrocera* spp.). *Proceeding of a National Workshop on Integrated Pest Management,* August 25-26, DoA, Lalitpur. Plant Protection Society, Nepal. pp. 64-71.

Hardy, D.E. (1964). Diptera from Nepal, the fruit flies (Diptera: Tephritidae). In D. Elmo Hardy and M. T. James (Eds.). The fruit flies (Diptera: Tephritidae) and the blow flies (Diptera: Calliphoridae). London: Trustees of the British Museum (Natural History), *15*(6), 145-179.

Ito, S. (2011). Die bohrfliegen aus nordost-Nepal (Diptera, Tephritidae). *ESAKIA*, *51*, 1-45.

Jaiswal, J., Gurung, T., GC, Y.D. & Pandey, R. (1997). Findings of melon fruit fly control survey and its integrated management. *LARC Working Paper 97*. P. 12.

Joshi, S.L. & Manandhar, D. (2001). *Reference insects* *of Nepal.* Entomology Division, NARC, Lalitpur, Nepal. 122 p.

Joshi, S.L. (2019, June 13). *Bactrocera minax (Enderlein) (Diptera:Tephritidae) and its invasion in Nepal* [Conference session]. Prime Minister Agriculture Modernization Project, Lalitpur, Nepal.

Kapoor, V.C., Malla, Y.K. & Ghosh, K. (1979). On a collection of fruit flies (Diptera: Tephritidae) from Kathmandu Valley, Nepal. *Oriental Insects, 13*(1-2), 81-85. DOI: https://doi.org/10.1080/00305316.1979.10433545

Karki, B., Thapa, R.B., Adhikari, D., Gautam, B. & Shedai, A. (2023). Farmer's survey and monitoring of fruit flies (Diptera: Tephritidae) in citrus orchards of Ramechhap district, Nepal. *Journal of Plant Protection Society, 8*, 38-48.

Khatri, N. & Sthapit, A. (1997). *Reference Insects of Nepal.* Entomology Division, NARC, Lalipur, Nepal. 279 p.

Leblanc, L., Bhandari, B.P., Aryal, L.N. & Bista, S. (2019). New country records and annotated checklist of the dacine fruit flies (Diptera: Tephritidae: Dacini) of Nepal. *Proceedings of the Hawaiian Entomological Society, 51*, 39-46.

Maharjan, R., Regmi, R. & Poudel, K. (2015). Monitoring and varietal screening cucurbit fruit fly, *B. cucurbitae* Coq. (Diptera: Tephritidae) on cucumber in Bhaktapur and Kathmandu, Nepal. *International Journal of Applied Sciences and Biotechnology*, *3*, 714-720. DOI: 10.3126/ijasbt. v3i4.13988

Manjunathan, T. (1997). A report on the integrated pest management consultancy for LARC. *LARC Occasional Paper 97*.

Nair, N., Thangjam, B., Bhattacharjee, T. & Debnath, M. (2017). Species composition of dacine fruit flies (Diptera: Tephritidae: Dacinae: Dacini) associated with cucurbits in Tripura, a north-eastern state of India. *Journal of Entomology and Zoology Studies*, *5*, 330-335.

NCRP. (2006). *Annual Report*. National Citrus Research Program, Paripatle, Dhankuta, Nepal. pp. 18-20.

NCRP. (2012). *Annual report.* National Citrus Research Program, Paripatle, Dhankuta, Nepal. pp. 21-22.

NCRP. (2018). *Annual report.* National Citrus Research Program, Paripatle, Dhankuta, Nepal. pp. 47-48.

Pandey P. (2022). *Identification of fruit fly species and its management in squash in Rupandehi district* [Unpublished master thesis]. Postgraduate Program, IAAS, Tribhuvan University, Nepal. 47 p.

Pandey, R.P., Gurung T.B. & Adhikari B. (1995). Monitoring studies of chaffer beetle (*Phyllophaga* sp.) melon fruit fly (*Dacus cucurbitae)* and fruit fly (*D. dorsalis)* on citrus 1993 and 1994. RARC Working Paper No. 95/56.

Parajuli, A., Timilsina, R.H., Paudel, B., Karki N., Upadhya K.P., Basnet, P. & Adhikari, D. (2023). Monitoring of fruit fly in mandarin orchards of Jajarkot, Nepal: A mixed- method approach. *Fundamental and Applied Agriculture, 8*(1&2), 447–457. DOI:https://doi.org/10.5455/faa.142870

Plant Protection Directorate (PPD). (2016). Fruit fly species identification training. *PPD Bulletin, 27*, 2.

Pokhrel, S. (2019). Fruit bagging with cloth bag: An eco-friendly and cost-effective management method of cucurbit's fruit fly (*B. cucurbitae*) on bitter gourd in Kathmandu, Nepal. *Journal of Agriculture and Forestry University*, *3*, 49-56.

Prabhakar, C., Sood, P., Mehta, P. & Chaudhary, A. (2007). Fruit fly, *B. scutellaris (*Bezzi): A potential threat to cucurbit cultivation under low and mid-hills of Himachal Pradesh. *Pest Management and Economic Zoology, 15*, 181-185.

Pradhan R.B. (1970). Studies on the bionomics of *Dacus* spp. and life cycle of *Dacus dorsalis* Hendel (Trypetidae: Diptera) under different conditions of temperature and humidity. *Nepalese Journal of Agriculture, 5*, 1-14.

Pradhan, R.B. (1976). Relative susceptibilities of some vegetables grown in Kathmandu Valley to *Dacus cucurbitae* Coq. *Nepalese Journal of Agriculture, 12*, 67-75.

Sapkota, R. (2008). *Damage assessment and management of cucurbit fruit fly (B. cucurbitae) in squash during spring-summer season in Lamjung district, Nepal* [Master thesis unpublished]. Postgraduate Program, IAAS, Tribhuvan University, Nepal. 108 p.

Sapkota, R., Dahal, K.C. & Thapa, R.B. (2010). Damage assessment and management of cucurbit fruit flies in spring-summer squash. *Journal of Entomology and Nematology*, *2*(1), 7-12.

Sapkota, R., Thapa, R.B., GC, Y.D., Sharma, M. & Dahal, K. (2009). Farmers' survey and field management of cucurbit fruit fly (*B. cucurbitae*) in squash at Lamjung, Nepal. *Journal of Institute of Agriculture and Animal Science*, *30*, 93-96.

Sapkota, R., Dahal, K.C., KC, G., Bajracharya, A.R. & Thapa, R.B. (2024). Fruit flies (Diptera: Tephritidae: Dacinae: Dacini) species diversity in Nepal: A review. *SAARC Journal of Agriculture, 22*(1), 1-15.

Sawai, H., Godase, S., Narangalkar, A. & Navik, O. (2019). Population fluctuation of fruit flies in cucurbit ecosystem. *Journal of Entomological Research*, *43*, 149-152. DOI:10.5958/0974-4576.2019.00029.X

Scolari, F., Valerio, F., Benelli, G., Papadopoulos, N. T. & Vaníˇcková, L. (2021). Tephritid fruit fly semiochemicals: current knowledge and future perspectives. *Insects, 12*, 408.

Sharma, D. R., Adhikari, D. & Tiwari, D. B. (2015). Fruit fly surveillance in Nepal. *Agricultural and Biological Sciences Journal*, *1*(3), 121-125.

Shrestha M. (2023). *Diversity and eco-friendly management of fruit fly species in summer squash field, Sindhupalchok, Nepal* [Master thesis unpublished]. Postgraduate Program, Institute of Agriculture and Animal Science, Tribhuvan University, Nepal. 77p.

Shrestha, K. (2006). Surveillance of fruit fly in fruits. *Proceedings of a National Workshop on Integrated Pest Management*, August 25-26, DoA, Lalitpur. Plant Protection Society, Nepal. pp. 81-85.

Simkhada, R. (2015). Performance of botanicals and impact of pheromone traps for managing fruit fly (*B. cucurbitae*) in summer squash. *Agriculture Development Journal*, *11*, 2091-0746.

Subedi, K., Regmi, R., Thapa, R.B. & Tiwari, S. (2021). Evaluation of net house and mulching effect on cucurbit fruit fly (*B. cucurbitae* Coq.) on cucumber. *Journal of Agriculture and Food Research, 3,* 100103. DOI:https://doi.org/10.1016/j.jafr.2021.100103

Tiwari, D.B. (2016). Fruit fly and their management. *Plant Protection Bulletin*, *25,* 7-8.

Vasudha, A. & Agarwal, M. (2019). Management of dacine fruit flies (Tephritidae: Dacinae: Dacini) in horticultural ecosystems: A review. *Journal of Entomology and Zoology Studies*, *7*, 33-42.