A Hidden Threat in Production and Its Sustainable Management on Mango Fruit Fly Bactrocera dorsalis (Hendel), (Diptera: Tephritidae)

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ABSTRACT

Mango fruit flies are hidden but highly destructive pest that threatens profitable and sustainable mango production in India and other tropical countries. Among the different species, *Bactrocera dorsalis* is the most damaging due to its rapid multiplication, wide host range, and severe fruit infestation. The pest causes internal fruit damage, premature fruit drop, rotting, and significant reduction in market and export quality, leading to economic losses ranging from 20–80% under favourable conditions. Because the larvae feed inside the fruit, early detection is often difficult. This article highlights the distribution, identification, life cycle, symptoms, and economic importance of mango fruit flies. It also emphasizes Integrated Pest Management (IPM) as the most effective and environmentally safe strategy for control. Important practices include orchard sanitation, destruction of fallen fruits, deep ploughing, fruit bagging, methyl eugenol traps, protein bait sprays, conservation of natural enemies, and need-based application of selective insecticides such as spinosd. The article further discusses the possible influence of climate change on fruit fly outbreaks and the role of emerging technologies such as smart trapping systems, AI-based monitoring, and drone-

assisted surveillance. Adoption of farmer-friendly IPM practices can reduce pesticide dependence, improve fruit quality, protect the environment, and enhance the export competitiveness of mango growers.

INTRODUCTION:

Mango (*Mangifera indica* L.), popularly known as the **"King of Fruits,"** is one of the most important fruit crops cultivated in tropical and subtropical regions of the world. India is the largest producer of mango, contributing nearly half of the global production. Mango is valued not only for its delicious taste and nutritional quality but also for its significant contribution to farmers' income, employment generation, and export earnings. However, several insect pests reduce mango productivity, among which the **mango fruit fly** is considered one of the most destructive pests.

Species such as *Bactrocera dorsalis*, *Bactrocera correcta*, and *Bactrocera zonata* infest developing and ripening fruits, causing direct damage through oviposition and larval feeding and indirect losses through fruit rotting and quarantine restrictions **(Dhillon *et al*., 2005; Roy *et al*., 2021)**. Yield losses in mango due to fruit flies may range from 20% to 80% depending on season, cultivar, and management practices **(Nair *et al*., 2022).** Sustainable management integrating monitoring, male annihilation, sanitation, and need-based insecticide application is therefore essential for profitable mango production.

Fruit fly infestation can cause severe losses by damaging fruits before harvest and reducing their market and export value. Therefore, understanding its biology, damage symptoms, and integrated management practices is essential for sustainable mango cultivation.

Distribution

Mango fruit flies are widely distributed throughout tropical and subtropical regions of Asia, Africa, Australia, and the Pacific Islands. In India, they occur in almost all mango-growing states, including Uttar Pradesh, Andhra Pradesh, Telangana, Karnataka, Tamil Nadu, Maharashtra, Gujarat, Bihar, Odisha, West Bengal, and Kerala. Warm temperatures and high humidity during the fruiting season create ideal conditions for rapid multiplication of fruit fly populations.

Important Species

Several fruit fly species infest mango, but the most economically important are:

- ***Bactrocera dorsalis*** (Oriental fruit fly) – the most destructive species
- ***Bactrocera correcta***
- ***Bactrocera zonata***

Among these, *Bactrocera dorsalis* causes the highest economic losses due to its wide host range, high reproductive capacity, and rapid population growth.

Identification

Adult

Adult fruit flies are medium-sized insects measuring about 6–8 mm in length. They possess a brown to dark brown body with distinct yellow markings on the thorax. Their transparent wings bear characteristic dark bands, making identification easier. The abdomen is elongated with alternating black and yellow patterns. Females possess a sharp ovipositor at the end of the abdomen for laying eggs inside fruits.

Egg

Eggs are creamy white, elongated, and cylindrical, measuring approximately 1 mm in length. They are deposited beneath the fruit skin in small groups.

Larva (Maggot)

The larva is creamy white, legless, cylindrical, and tapered towards the head. It feeds on the fruit pulp and passes through three larval instars.

Pupa

After completing larval development, mature maggots leave the fruit and pupate in the soil at a depth of 2–5 cm. The pupa is brown, oval-shaped, and enclosed in a hard puparium.

Life Cycle

Fruit flies undergo complete metamorphosis consisting of egg, larva, pupa, and adult stages. Females puncture the fruit skin with their ovipositor and lay eggs in clusters beneath the epidermis. Eggs hatch within 1–2 days under warm conditions. The maggots feed on fruit pulp for about 7–12 days, creating galleries and promoting secondary microbial infection. Mature larvae leave the fruit and pupate in the soil at a depth of 2–5 cm. The pupal period generally lasts 8–12 days, and adults emerge and become sexually active within 8–15 days depending on temperature and humidity **(Fletcher, 1987; Vargas *et al*., 2020).** Adult males are strongly attracted to methyl eugenol, whereas females are attracted to host fruit volatiles and proteinaceous food sources.

Nature of Damage

Damage begins when female fruit flies puncture young or mature fruits for egg laying. The puncture marks appear as tiny dark spots on the fruit surface. After hatching, maggots feed inside the fruit pulp, creating tunnels and cavities. As feeding progresses, fruits become soft and begin to rot due to secondary bacterial and fungal infections. Infested fruits often fall prematurely, while harvested fruits rapidly deteriorate during transportation and storage. Severe infestations significantly reduce fruit quality, market price, and export acceptability.

Symptoms of Infestation

Farmers can identify fruit fly damage through the following symptoms:

- Small puncture marks on the fruit surface.
- Oozing of sap or gummy exudates from puncture sites.
- Softening of fruit tissues.
- Premature fruit drop.
- Internal rotting of fruit pulp.
- Presence of creamy white maggots inside fruits.
- Foul smell from heavily infested fruits.

Integrated Pest Management (IPM)

Effective management of mango fruit fly requires an integrated approach combining cultural, mechanical, biological, and chemical methods.

1. **Orchard Sanitation:** Regular orchard sanitation is the first and most important step. Fallen and infested fruits should be collected every week and destroyed by deep burial or solarization in sealed plastic bags. This practice breaks the life cycle by preventing larvae from entering the soil for pupation.
2. **Soil Management:** Deep ploughing beneath the tree canopy after harvest exposes pupae to sunlight, predators, and

desiccation, thereby reducing adult emergence.

3. **Fruit Bagging:** Individual fruits may be covered with paper or cloth bags approximately 40–50 days after fruit set. Fruit bagging acts as a physical barrier preventing females from laying eggs while also improving fruit appearance.

4. **Methyl Eugenol Traps:** Methyl eugenol is a powerful male lure for B. dorsalis and related species and forms the basis

of the male annihilation technique (MAT). Traps baited with methyl eugenol combined with an insecticide such as malathion or spinosad effectively reduce male populations and help in monitoring seasonal abundance. Installation of 10–20 traps per hectare is commonly recommended in commercial mango orchards, with lures replaced every 4–6 weeks **(IAEA, 2022).** Field studies have shown significant reduction in fruit infestation when MAT is combined with orchard sanitation and protein bait sprays **(Jang & Light, 2021; Saha *et al*., 2023).**

Methyl eugenol traps are highly effective for attracting and killing male fruit flies. Installing **15–20 traps per hectare** before fruit maturation helps reduce the breeding population considerably. Regular replacement of lure and insecticide ensures maximum trap efficiency.

5. **Protein Bait Spray:** Protein bait mixed with a recommended insecticide attracts adult flies searching for food. Spot spraying on tree trunks or foliage reduces adult populations while minimizing pesticide use over the entire orchard.

6. **Biological Control:** Natural enemies help suppress fruit fly populations.

Important parasitoids include:

- *Fopiusarisanus*
- *Diachasmimorphalongicaudata*
- *Psyttaliafletcheri*

Conservation of these beneficial insects through reduced indiscriminate pesticide use strengthens natural biological control.

7. **Chemical Control:** Chemical control should be used judiciously and integrated with non-chemical measures. Cover sprays directed against adults before fruit ripening are more effective than attempts to control larvae inside fruits. Protein bait sprays containing spinosad have gained importance because of their lower impact on natural enemies and reduced residue risk. Insecticides such as spinosad 45 SC, malathion 50 EC, deltamethrin 2.8 EC, and lambda-cyhalothrin 5 EC have shown effectiveness against adult fruit flies when applied at recommended doses **(Nair *et al*., 2022; Hasyim *et al*., 2021).** Repeated use of a single insecticide should be avoided to delay resistance development.

Climate Change and Fruit Fly

Climate change is expected to increase the severity of fruit fly infestations. Rising temperatures accelerate insect development, increase the number of generations per year, and extend the breeding season. Irregular rainfall and increased humidity further favor survival and multiplication. Continuous

monitoring and adoption of climate-smart pest management practices are therefore becoming increasingly important.

Emerging Technologies

Modern technologies are providing new opportunities for fruit fly management.

These include:

- Sterile Insect Technique (SIT)
- Smart pheromone-based trapping systems
- Artificial intelligence (AI)-assisted pest monitoring
- Mobile applications for pest surveillance
- Drone-assisted orchard monitoring
- Digital decision-support systems for farmers

These technologies can enhance early detection and reduce reliance on chemical pesticides.

Farmer-Friendly Tips

- Install methyl eugenol traps before fruit maturity.
- Collect and destroy fallen fruits every week.
- Practice deep ploughing after harvest.
- Avoid leaving damaged fruits in the orchard.
- Harvest fruits at the proper maturity stage.
- Use fruit bagging wherever feasible.
- Monitor orchards regularly for early detection.
- Follow Integrated Pest Management (IPM) practices.
- Use only recommended pesticides and observe waiting periods.
- Encourage natural enemies by minimizing unnecessary pesticide sprays.

CONCLUSION:

Mango fruit fly remains one of the most serious constraints to profitable mango production. It's concealed feeding habit, rapid multiplication, and wide host range make management challenging. However, adoption of Integrated Pest Management practices including orchard sanitation, methyl eugenol trapping, fruit bagging, biological control, and judicious pesticide use can substantially reduce fruit fly damage while protecting the environment and ensuring food safety. Creating awareness among farmers through training and extension programs will be vital for sustainable mango production and improved export competitiveness.

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