Pest Management in Horticultural Ecosystems
Vol. 32, No.1 pp 87-92 (2026)
DOI Number : 10.5958/0974-4541.2026.00010.X

Biology of melon fruit fly, *Zeugodacus cucurbitae* (Coquillett), reared on different fruit-based semi-synthetic diets

AMARAPU AJAY BABU[1], G. S. PANDURANGA[1*], RAJASRI MANDALI[2] and K. VISWANATH[3]

[1]Department of Entomology, S.V. Agricultural College, Acharya N.G. Ranga Agricultural University, Tirupati 517 502, Andhra Pradesh, India
[2]Department of Entomology, ANGRAU-Advanced PG Centre, Guntur 522 034, Andhra Pradesh, India
[3]ANGRAU-Regional Agricultural Research Station, Tirupati 517 502, Andhra Pradesh, India

***E-mail:** gs.panduranga@angrau.ac.in

ABSTRACT: Biology of melon fruit fly, *Zeugodacus cucurbitae* (Coquillett) were studied by rearing maggots on four fruit-based semi-synthetic diets prepared from pumpkin (FSD-I), ridge gourd (FSD-II), bitter gourd (FSD-III) and bottle gourd (FSD-IV), along with a standard artificial diet, under laboratory conditions of 25±2°C and 75±5% RH. Larval and pupal development were fastest on FSD-I and FSD-IV (7.25 days larval duration; 8.00–8.50 days pupal period), whereas FSD-III recorded the longest developmental period (9.00 and 9.25 days, respectively). Pupal recovery (77.00%) and pupal weight (1.50 g/100 pupae) were highest on FSD-I, followed by FSD-IV (72.75% and 1.45 g/100 pupae). Adult emergence (83.00%) and flying ability (79.75%) were significantly superior on FSD-I, with a female-biased sex ratio (1:1.16) and the highest fecundity (35.75 eggs/female) and egg hatch (72.50%).

Keywords: biology; fruit-based semi-synthetic diet; *Zeugodacus cucurbitae*

INTRODUCTION

India is one of the leading nations in fruit and vegetable production, with cucurbitaceous vegetables forming an integral part of the horticultural economy owing to their adaptability to diverse agro-climatic conditions and their contribution to farmers' income. In Andhra Pradesh alone, cucurbits are cultivated over 0.028 million hectares with an annual production of 1.328 million metric tonnes (Indiastat, 2025). Cultivation of these crops, however, is severely constrained by the melon fruit fly, *Zeugodacus cucurbitae* (Coquillett) (Diptera: Tephritidae), one of the most economically important tephritid pests attacking more than 81 host plants across 19 families, of which 28 are cucurbits (De Meyer *et al*., 2015). Gravid female flies oviposit inside developing fruits, and the emerging maggots feed internally on the pulp, rendering the fruit unmarketable and often causing complete crop loss under heavy infestation, with yield losses ranging from 30 to 70 per cent depending on season and cultivar (Dhillon *et al*., 2005). Since maggots develop and feed concealed within the fruit, they remain largely inaccessible to contact insecticides (Sohrab *et al*., 2018), and heavy reliance on broad-spectrum insecticides for their management has resulted in resistance development, pesticide residues in produce and leads to disruption of natural enemy populations. An integrated approach is required for fruit fly management, as a first step, a sound understanding of the pest's biology and development on different hosts, since such baseline information underpins the design of rearing systems, sterile insect technique (SIT) programmes and other components of integrated pest management (Radhika *et al*., 2023). Semi-synthetic and artificial diets are indispensable for continuous laboratory rearing of tephritid fruit flies for taxonomic, physiological and applied research, since natural host fruits are difficult to standardize, prone to microbial spoilage and cumbersome to handle at scale (Kirti *et al*., 2018; Cohen, 2015). Although fruit-based semi-synthetic diets incorporating pumpkin have earlier been reported to support satisfactory rearing of *Z. cucurbitae* (Panduranga *et al*., 2018; Kirti *et al*., 2018; Muthulakshmi *et al*., 2021; Abhishek *et al*., 2022), comparative information on the performance of other commonly available cucurbit fruits, *viz*., ridge gourd, bitter gourd and bottle gourd, as diet, alongside the standard artificial diet, remains limited. The present study was therefore undertaken to evaluate and compare the biological performance of *Z. cucurbitae* reared on pumpkin, ridge gourd, bitter gourd and bottle gourd fruit-based semi-synthetic diets against the standard artificial diet (control), with a view to identifying a suitable, cost-effective diet for laboratory mass rearing of this pest.

MATERIALS AND METHODS

Location and rearing of culture

The study was carried out at the Insectary, Department of Entomology, S.V. Agricultural College, Acharya N.G. Ranga Agricultural University (ANGRAU), Tirupati, Andhra Pradesh, during 2025–26. Melon fruit fly-infested cucurbits collected from farmers' fields and the college Horticulture Garden were used to initiate and maintain the laboratory culture at 25±2°C and 75±5% RH. Third instar maggots emerging from infested fruits pupated in sterilized sand provided in rearing trays, and the harvested pupae were held in adult emergence cages (30 × 30 × 30 cm) provisioned with sugar and yeast hydrolysate (3:1) as adult diet and water-soaked cotton swabs. After a pre-oviposition period of 12 days, males and females of the same age were mated in oviposition cages, and eggs were collected on ovipositional devices placed in the cages for 24 h on alternate days.

Preparation of experimental diets

Four fruit-based semi-synthetic diets (FSD) were prepared using pumpkin (FSD-I), ridge gourd (FSD-II), bitter gourd (FSD-III) and bottle gourd (FSD-IV) by using respective host-fruit. Ripened fruits were sliced and ground into a fine semi-solid pulp, for 1000g of respective fruit pulp 15g yeast extract powder (protein source) and the antimicrobial agents sodium benzoate (1.3g) and methyl paraben (1.8g) were added and thoroughly blended (Panduranga *et al*., 2018; Abhishek *et al*., 2022). The standard artificial diet consisted of brewer's yeast, sugar, citric acid and wheat germ oil in distilled water, along with sodium benzoate and methyl paraben at lower concentrations (0.11 g each). Each diet (250 g) was dispensed in 200 mm petri plates and inoculated with 500 eggs; the standard artificial diet was similarly inoculated at 500 eggs per 250 mL. Each treatment was replicated four times in a completely randomized design (CRD), and inoculated plates were held over 5 cm of sterilized sand for pupation at 25±2°C, 65±5% RH and a photoperiod of 12:12 (L:D) h.

Biological parameters of melon fruit fly

Larval duration, pupal recovery, pupal weight, pupal period, adult emergence, adult flying ability, sex ratio, adult longevity, fecundity and F1 egg hatch were recorded following standard procedures (Abhishek *et al*., 2022). Pupal recovery and adult flying ability were computed as percentages of the eggs inoculated and pupae provided for emergence, respectively; adult flying ability was assessed using a talcum powder-coated PVC pipe (20 cm × 8.5 cm) placed over Petri dish. Fecundity and egg hatch were recorded from twelve-day-old paired adults confined in oviposition cages over a two-week period.

Recording of biological parameters

Larval duration was determined by recording the interval between egg hatching and initiation of pupation and was expressed in days. Pupal recovery was worked out by dividing the total number of pupae obtained by the initial number of larvae inoculated on the diet and expressed as a percentage. Pupal period was recorded as the time interval between pupal formation and adult emergence and expressed in days.

Pupae harvested from different treatments were placed in a glass Petri dish and kept inside an adult emergence cage (30 × 30 × 30 cm) provisioned with sugar and yeast hydrolysate in 3:1 ratio. Observations were recorded daily, and after complete cessation of emergence (up to five days), the number of adults emerged was computed and expressed as a percentage of the initial number of pupae.

Adult flying ability was assessed by randomly collecting fifty pupae from each diet and placing them in a glass Petri dish. A black PVC pipe (20 cm in length and 8.5 cm in diameter), coated on the inside with talcum powder, was placed over the dish within an adult rearing cage. Flying ability was calculated based on the number of flies that flew out through the pipe, expressed as a percentage of the total number of emerged adults.

Sexing of the emerged flies was done based on the presence or absence of the ovipositor, and sex ratio was expressed as the ratio of males to females. Adult longevity was recorded by confining freshly emerged flies to adult rearing cages (30 × 30 × 30 cm) provisioned with sugar and yeast hydrolysate (3:1). Cages were monitored daily for mortality, and the average longevity of adults was expressed in days.

Table 1: Biological parameters of melon fruit fly, *Z. cucurbitae* reared on fruit based semi synthetic diets and standard artificial diet

Parameters	FSD-I	FSD-II	FSD-III	FSD-IV	Standard Artificial Diet	ANOVA
Larval duration (days) **	7.25[a] (2.78±0.02)	8.25 [ab] (2.96±0.02)	9.00[b] (3.08±0.02)	7.25[a] (2.78±0.02)	8.00[ab] (2.92±0.02)	F=8.144; df=4,11; P<0.01
Pupal recovery (%) *	77.00[a] (61.35±0.26)	71.50[b] (57.74±0.26)	63.50[c] (52.69±0.26)	72.75[b] (58.54±0.26)	72.00[b] (58.06±0.26)	F=28.888; df=4,11; P<0.01
Pupal weight (g/100 Pupae) **	1.50[a] (1.42±0.00)	1.40[c] (1.38±0.00)	1.37[c] (1.37±0.00)	1.45 [b] (1.39±0.00)	1.46[ab] (1.40±0.00)	F=23.17; df=4,11; P<0.01
Pupal period (days) **	8.00[a] (2.92±0.01)	8.75 [ab] (3.04±0.01)	9.25 [b] (3.12±0.01)	8.50[ab] (3.00±0.01)	8.50[ab] (3.00±0.01)	F=4.970; df=4,11; P<0.01
Adult emergence (%) *	83.00[a] (65.66±0.18)	73.00[c] (58.70±0.18)	71.00[c] (57.42±0.18)	78.50 [b] (62.39±0.18)	73.75[c] (59.19±0.18)	F=68.811; df=4,11; P<0.01
Sex ratio (♂:♀)	1:1.16	1:1.06	1:1.08	1:1.10	1:1.10	-
Adult fliers (%) *	79.75[a] (63.29±0.25)	66.50[c] (54.64±0.25)	64.00[c] (53.13±0.25)	72.50[b] (58.38±0.25)	70.50[b] (57.11±0.25)	F=53.484; df=4,11; P<0.01
Adult longevity (days) **	45.00[a] (6.75±0.02)	37.00[cd] (6.12±0.02)	35.25[d] (5.98±0.02)	41.00[b] (6.44±0.02)	39.00[bc] (6.28±0.02)	F=31.456; df=4,11; P<0.01
Fecundity (eggs/female) ***	35.75[a] (1.57±0.00)	27.25 [b] (1.45±0.00)	24.00 [c] (1.40±0.00)	32.25[a] (1.52±0.00)	28.50[b] (1.47±0.00)	F=35.135; df=4,11; P<0.01
F1 Egg hatch (%) *	72.50[a] (58.38±0.26)	54.25[c] (47.44±0.26)	53.00[c] (46.72±0.26)	69.75[ab] (56.65±0.26)	67.50[b] (55.25±0.26)	F=91.839; df=4,11; P<0.01

Where; FSD-I: Pumpkin fruit based Semi-synthetic diet; FSD-II: Ridge gourd fruit based Semi-synthetic diet; FSD-III: Bitter gourd fruit based Semi-synthetic diet and FSD-IV: Bottle gourd fruit based Semi-synthetic diet.

Within a row means followed by the same letter are not significantly different (α=0.05), Tukey test, SPSS-20.

Figures in the parenthesis are transformed values ± standard error (m). *Arc sine transformation, **Square root transformation, ***Logarithmic transformation

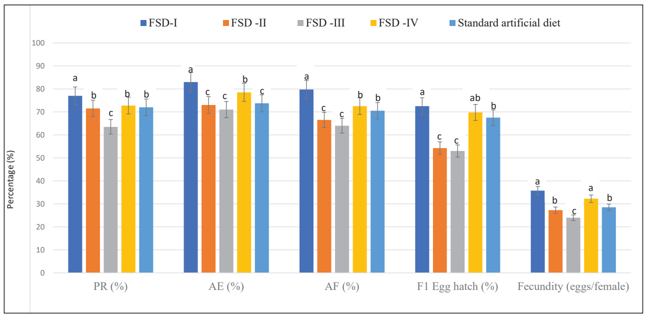

Fig. 1. Biological parameters of melon fruit fly *Z. cucurbitae* reared on fruit based semi synthetic diets and standard artificial diet
Where, PR-pupal recovery, AE-adult emergence, AF-adult fliers, FSD-I: Pumpkin fruit based Semi-synthetic diet, FSD-II: Ridge gourd fruit based Semi-synthetic diet, FSD-III: Bitter gourd fruit based Semi-synthetic diet and FSD-IV: Bottle gourd fruit based Semi-synthetic diet.

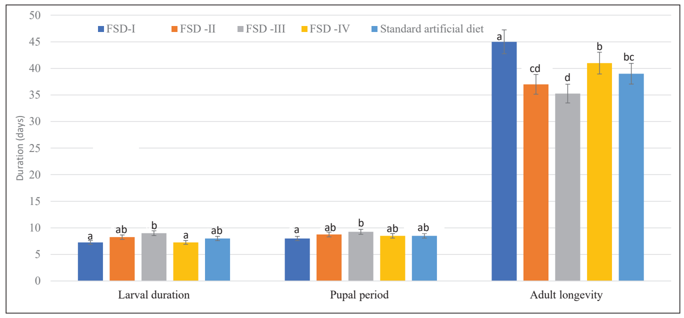

Fig. 2. Biological parameters of melon fruit fly *Z. cucurbitae* reared on fruit based semi synthetic diets and standard artificial diet
Where FSD-I: Pumpkin fruit based Semi-synthetic diet; FSD-II: Ridge gourd fruit based Semi-synthetic diet; FSD-III: Bitter gourd fruit based Semi-synthetic diet and FSD-IV: Bottle gourd fruit based Semi-synthetic diet.

For recording fecundity, equal numbers of 12-day old male and female adult flies were confined to oviposition cages (30 × 30 × 30 cm). Small Petri plates (9 cm diameter) containing the respective fruit-based semi-synthetic diet, covered with parafilm, were provided as ovipositional devices.

Statistical analysis

Data on biological parameters (mean of four replications) were subjected to analysis of variance (ANOVA), and treatment means were compared using Tukey's Honestly Significant Difference (HSD) test at α = 0.05 using SPSS-20.

RESULTS AND DISCUSSION

Biological parameters of *Z. cucurbitae* reared on fruit-based semi-synthetic diets and standard artificial diet

Biological parameters of *Z. cucurbitae* reared on the four fruit-based semi-synthetic diets and the standard artificial diet are presented in Table 1.

Total larval duration ranged from 7.25 to 9.00 days across diets. The shortest duration (7.25 days) was recorded on FSD-I and FSD-IV, and the longest (9.00 days) on FSD-III; FSD-II and the standard artificial diet were intermediate (8.00–8.25 days). All four host fruits used in the semi-synthetic diets belong to the same family Cucurbitaceae, but differ in their carbohydrate, protein and moisture content; diets that provided a more balanced nutrient profile supported faster larval development (Nestel and Nemny-Lavy, 2007). These results agree closely with Muthulakshmi *et al.* (2021), who reported a larval duration of 7.60 days on a pumpkin-based diet, and Abhishek *et al.* (2022), who recorded 8.00 days on the standard artificial diet.

Pupal recovery was significantly higher on FSD-I (77.00%) than on the remaining diets, followed by FSD-IV (72.75%), the standard artificial diet (72.00%) and FSD-II (71.50%); recovery was lowest on FSD-III (63.50%). Pupal weight followed a similar trend, being highest on FSD-I (1.50 g/100 pupae) and lowest on FSD-III (1.37 g/100 pupae), meeting the pre-irradiation pupal-weight benchmark of 1.5–1.68 g/100 pupae recommended for sterile insect technique programmes (FAO/IAEA/USDA, 2019). This indicates that FSD-I supplied adequate digestible protein, carbohydrate and micronutrients for larval growth and successful pupation (Sharp *et al.*, 1983), consistent with the findings of Muthulakshmi *et al.* (2021) and Abhishek *et al.* (2022), who reported 71.12–72.32% pupal recovery on pumpkin-based diets, and Panduranga *et al.* (2018), who obtained 83.20% pupal recovery on a pumpkin-based diet.

Pupal period was shortest on FSD-I (8.00 days) and longest on FSD-III (9.25 days), these findings are in line with Pradhan *et al.* (2020), who reported pupal periods of 8.56 and 8.70 days on pumpkin and bottle gourd, respectively, and shorter than the 6.95 days reported by Chaudhary *et al.* (2025) on cucumber.

Adult emergence and flying ability were highest on FSD-I (83.00% and 79.75%, respectively), followed by FSD-IV (78.50% and 72.50%). The lowest values were recorded on FSD-III (71.00% emergence, 64.00% flying ability), which was statistically on par with FSD-II and the standard artificial diet. These results are consistent with Kirti *et al.* (2018), who reported 80.50% adult emergence and 74.36% flying ability on a pumpkin-based semi synthetic diet. and Abhishek *et al.* (2022), who reported 83.50% adult emergence with a sex ratio of 1:1.11 on a fruit-based semi-synthetic diet.

The sex ratio was skewed in favour of females on all diets, most strongly on FSD-I (1:1.16), followed by FSD-IV and the standard artificial diet, which recorded an identical ratio of 1:1.10; the least skewed ratios were obtained on FSD-II (1:1.06) and FSD-III (1:1.08). Adult longevity followed the same pattern, being highest on FSD-I (45.00 days) and lowest on FSD-III (35.25 days), which is on par with findings of Mir *et al.* (2014), who recorded an adult longevity of 48.56 days on cucumber, and Pradhan *et al.* (2020), who reported 41.00–44.00 days on pumpkin and bottle gourd.

Fecundity and F1 egg hatch were also highest on FSD-I (35.75 eggs/female; 72.50% egg hatch), followed by FSD-IV (32.25 eggs/female; 69.75% egg hatch), and lowest on FSD-III (24.00 eggs/female; 53.00% egg hatch). These values fall within the range reported by Kirti *et al.* (2018) and Panduranga *et al.* (2018) of 28.00–32.00 eggs/female with 68.10–71.80% egg hatch, and are in agreement with Abhishek *et al.* (2022), who reported 77.34% egg hatch on a fruit-based semi-synthetic diet. Adequate protein and fatty-acid content in FSD-I, FSD-IV and the standard artificial diet appears to have supported greater reproductive output relative to the remaining diets

Among all biological parameters studied the pumpkin fruit-based semi-synthetic diet (FSD-I) resulted promising results, bottle gourd-based semi synthetic diet (FSD-IV) as the next best diet; performance on the standard artificial diet was intermediate between FSD-II and FSD-IV and superior to FSD-III. Incorporation of yeast extract as a supplementary protein and fatty acid source into the pumpkin and bottle gourd substrates appears to compensate for any nutritional gaps in the natural fruit matrix, converting it into superior larval growth, pupal quality and adult reproductive fitness. These two fruit substrates therefore offer practical, low-cost alternatives to synthetic bulking agents for laboratory colonization and mass rearing of *Z. cucurbitae*, while avoiding the handling and disposal difficulties associated with unmodified natural host fruits.

CONCLUSION

Pumpkin fruit-based semi-synthetic diet (FSD-I) supported the fastest larval and pupal development, highest pupal recovery and weight, adult emergence, flying ability, fecundity and egg hatch, and produced the largest life stages of *Z. cucurbitae*, followed closely by the bottle gourd-based diet (FSD-IV). Bitter gourd-based diet (FSD-III) was the least suitable substrate across all parameters. The standard artificial diet performed at a level intermediate between the fruit-based diets. Pumpkin and bottle gourd fruit based semi synthetic diets are therefore recommended as suitable, low-cost, and easily manageable alternatives to natural host fruits for laboratory mass rearing of melon fruit fly, including for programmes requiring large numbers of quality insects such as the sterile insect technique.

ACKNOWLEDGEMENT

The authors are thankful to the Acharya N.G. Ranga Agricultural University, Guntur and the Indian Council of Agricultural Research, New Delhi, for the facilities and financial assistance provided during the course of this investigation.

AUTHORS CONTRIBUTION

AAB and GSP: conceptualization, designing and implementation of the experiments, data collection and manuscript preparation; RM and KV: planning, supervision, formal analysis and manuscript finalisation.

CONFLICT OF INTEREST

The authors declare that they have no conflict of interest with respect to the content of this article.

REFERENCES

Abhishek, B. M., Panduranga, G. S., Venkateswarlu, N. C., Srilatha, V. and Ramanamurthy, B. 2022. Semi-synthetic fruit-based diets for mass rearing of melon fly, *Zeugodacus cucurbitae* (Coquillett). *Rubrica,* **9**: 55–60.

Bhowmik, P., Devi, L. L., Chatterjee, M. and Mandal, D. 2014. Seasonal bionomics of melon fly, *Bactrocera cucurbitae* Coquillett on bottle gourd in laboratory condition. *The Ecoscan*, **8**(2): 157–162.

Chaudhary, K. V., Patel, S. R. and Kumar, A. 2025. Biology of melon fruit fly *Bactrocera cucurbitae* (Coquillett) on cucumber. *Indian Journal of Entomology*, **87**(2): 417–420.

Cohen, A. C. 2015. Insect Diets: Science and Technology. 2nd Edition. CRC Press, Boca Raton, Florida, USA. 473 pp.

De Meyer, M., Delatte, H., Mwatawala, M., Quilici, S., Jean-Francois, V. and Virgilio, M. 2015. A review of the current knowledge on *Zeugodacus* *cucurbitae* (Coquillett) (Diptera: Tephritidae) in Africa, with a list of species included in Zeugodacus. *ZooKeys,* **540**: 539–577.

Desai, S., Jakhar, B. L., Patel, R. K. and Dalvaniya, D. G. 2018. Biology of melon fly, *Bactrocera cucurbitae* (Coquillett) on sponge gourd. *Indian Journal of Entomology,* **80**(3): 834–839.

Dhillon, M. K., Singh, R., Naresh, J. S. and Sharma, H.C. 2005. The melon fruit fly, *Bactrocera cucurbitae:* A review of its biology and management. *Journal of Insect Science*, **5**: 40–56.

FAO/IAEA/USDA. 2019. Product quality control for sterile mass-reared and released tephritid fruit flies. Version 7.0. International Atomic Energy Agency, Vienna, Austria. 148 pp.

Kirti, S., Panduranga, G. S. and Sharma, R. K. 2018. A fruit-based diet for mass rearing melon fly *Bactrocera cucurbitae* (Diptera: Tephritidae, *Indian Journal of Entomology*, **80**(4): 1596–1600.

Mir, S. H., Dar, S. A., Mir, G. M. and Ahmad, S. B. 2014. Biology of *Bactrocera cucurbitae* (Diptera: Tephritidae) on cucumber. *Florida Entomologist*, **97**(2): 753–758.

Muthulakshmi, B. C., Panduranga, G. S., Rajesh, A., Karthik Reddy, P. and Ramana Murthy, B. 2021. Studies on life history parameters of melon fruit fly *Zeugodacus cucurbitae* (Coquillett) reared on fruit-based diets. *Andhra Pradesh Journal of Agricultural Sciences.*

Nestel, D. and Nemny-Lavy, E. 2007. Nutrient balance in medfly, *Ceratitis capitata*, larval diets affect the ability of the developing insect to incorporate lipid and protein reserves. *The Netherlands Entomological Society*, **126**: 53–60.

Panduranga, G. S., Sharma, K. and Sharma, R. K. 2018. Evaluation of liquid artificial diets for mass rearing of *Bactrocera cucurbitae* (Coq.). *Indian Journal of Biochemistry and Biophysics*, **55**: 125–131.

Pradhan, Y., Gupta, M. K., Kumar, C. N. and Longkumer, I. Y. 2020. Biology and biometrics of melon fly, *Bactrocera cucurbitae* Coquillett (Diptera: Tephritidae) on some cucurbitaceous crops. *Journal of Entomology and Zoology Studies*, **8**(5): 2263–2267.

Radhika, Bantewad, S. D., Sonkamble, M. M. and Udavant, R. N. 2023. Morphometric study of melon fruit fly *Bactrocera cucurbitae* (Coq.) on host bitter gourd. *The Pharma Innovation Journal*, **12**(4): 702–706.

Sharp, J. L., Boller, E. F. and Chambers, D. L. 1983. Selection for flight propensity of laboratory and wild strains of *Anastrepha suspensa* and *Ceratitis capitata* (Diptera: Tephritidae). *Journal of Economic Entomology,* **76**(2): 302–305.

Sohrab, Prasad, C. S. and Hasan, W. 2018. Study on the biology and life cycle of cucurbit fruit fly, *Bactrocera cucurbitae* (Coquillett). *Journal of Pharmacognosy and Phytochemistry*, **SP1**: 223–226.

Verghese, A., Madhura, H.S., Kamala Jayanthi, P.D. and Stonehouse, J.M. 2002. Fruit flies of economic significance in India, with special reference to *Bactrocera dorsalis* (Hendel). Proceedings of 16th International Fruit Fly Symposium, pp. 317–324. https://www.indiastat.com/data/agriculture.2024-25.

MS Received: 05 March 2026
MS Acceptance: 25 April 2026