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Biology, Morphometrics and Field Behaviour of Mango Fruit Borer, *Citripestis eutraphera* (Meyrick) in Gujarat (India)

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ABSTRACT

The biology, morphometrics and field behaviour of mango fruit borer, *Citripestis eutraphera* (Meyrick), has been studied at Navsari Agricultural University, Navsari, Gujarat (India) during 2022. Field observations and laboratory studies revealed that adult females laid an average of 41.15 ± 7.22 white coloured eggs on upper 1/3 portion of fruit along the periphery at junction of peduncle and fruit which turned red after 1-2 days. The incubation period averaged 2.48 ± 0.50 days. Larva passed through five instars over a period of 13.4 ± 0.81 days. Dark brown to black colour fully grown larvae mostly pupated in soil, with pupal period of 7.6 ± 0.86 days. The longevity of female and male adult was 8.04 ± 0.88 days and 3.96 ± 0.73 days with total life span of 36.04 ± 1.83 days and 31.92 ± 1.95 days, respectively. The sex ratio of male as to female was 1: 1.53. The pre-oviposition, oviposition and post-oviposition periods were 2.8 ± 0.81 days, 2.24 ± 0.77 days and 2.16 ± 0.68 days, respectively. Newly emerged larvae scraped the fruit's skin and peduncle while late instars bored through fruit pulp and soft seed/kernel due to which fruit rotting and dropping was observed. A maximum thirteen larvae per fruit were observed during infestation. The present study on biology, morphometric and field behaviour of *C. eutraphera* helps in developing effective and sustainable pest management practices, including integrated pest management (IPM), which minimizes reliance on chemical pesticides.

Keywords: Mango Fruit Borer, life cycle, fecundity, oviposition, reproductive parameter, longevity.

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INTRODUCTION

Mango, *Mangifera indica* L. (Family: Anacardiaceae), is a tropical and subtropical fruit known as "National Fruit of India," "King of Fruits," "Fruit of the Gods," and "Apple of the Tropic," The states of Andhra Pradesh, Uttar Pradesh, Karnataka, Bihar, Gujarat and Maharashtra are major mango producers of the country. In Gujarat, Valsad, Navsari, Gir Somnath, Junagadh, Kutch and Surat are the major mango producing districts. Valsad and Navsari are major mango producing districts of South Gujarat having sub-tropical climate with moderately high humidity. In mango, about 492 species of insects, 17 species of mites and 26 species of nematodes have been reported from all over the world. Of these, 188 species have been reported from India (Tandon & Verghese, 1985) but only a handful are of major importance which includes hopper, thrips, mealy bug, stem borer, fruit flies and stone weevil. In Gujarat, total thirty-one insect-pests damaging mango in nursery including twelve leaf eating caterpillars or defoliator, three shoot damaging insect pests *viz*., Shoot borer, stem miner, and shoot midge; thirteen sucking insect-pests *viz*., mango hoppers, thrips, plant hopper, leaf gall midges, mealybugs and scales; three leaf defoliating beetles and weevils (Khimani & Chavan, 2025).

Some of the minor pests were also found to become major pests as a result of the changes in the environment. Insect are impacted by uncertainties related to various aspects of climate change, including small-scale climate variability such as temperature increase, increase in atmospheric CO_2, changing precipitation patterns, relative humidity, and other factors (Skendzic, Zovko, Zivkovic, Lesic, & Lemic, 2021). Prior to recent time, minor or secondary pests such as scales, thrips, mites, leaf webbers, stem borers, fruit borers, *etc*., are considered to be a threat (Jayanthi, Verghese, Shashank, & Kempraj, 2014). The mango fruit borer, *Citripestis eutraphera* (Meyrick), (Lepidoptera: Pyralidae) originally confined to the Andaman Islands, is a recent invasion in mainland India. *C. eutraphera*, a species of snout moth was described by Meyrick in 1933 and geographically distributed in Java, Indonesia, India and Northern Territory in Australia. However, in India the only official record of *C. eutraphera* is from Andaman Islands (Bhumannavar, 1991) and this is the first record from the mainland, indicating the geographical spread within the country. Mango fruit borer, *C. eutraphera* which was originally described from Java, is a significant borer of mango fruits in South and South-East Asia and some parts of Australia (Anderson & Tran-Nguyen, 2012).

The most recent classical example of intra-national invasion of insect pests from the Andaman and Nicobar Islands to mainland India is the mango fruit borer, *C. eutraphera* and it was probably restricted to the Islands for almost two decades, till 2014, when it was reported by Jayanthi et al. (2014) from South India on *M. indica*, a cultivated mango. They first time reported the occurrence of *C. eutraphera* causing extensive damage to immature fruits of mango in Karnataka and Tamil Nadu (Soumya, Verghese , Shashank, & Kempraj, 2016). The infestation of *C. eutraphera* was recently reported for the first time in Gujarat, where it caused significant damage (Bana, Sharma, & Sharma, 2018). This species recently invaded and spread to mainland India and infested mango in Karnataka, Tamil Nadu, Kerala, Gujarat, parts of Maharashtra and Odisha (Krull & Basedow, 2006; Krull, 2004; Jayanthi et al*.,* 2014; Hiremath, Amritha, & Prathapan,

2017; Singh & Kaur, 2014; Sunitha, Sujatha, & Rao, 2020) and recently in Punjab (Singh, Shashank, Singh, & Kaur, 2021). Infestation level increased from 2.5 to 10.8 per cent to the fruits, starting from marble stage to maturity stage size, was observed during 2015 to 2019 in Punjab (Singh et al., 2021). It also infested seedlings and grafts of cashew, *A. occidentale* in Kerala (Jacob, Veena, & Bhumannavar, 2004; Hiremath et al., 2017; Kori Nagaraj, Ramegowda, Aswathanarayana Reddy, Narabenchi, & Vishuvardhana, 2020; Kori Nagaraj, Aswathanarayana Reddy, Subramanyam, & Ramegowda, 2022). In South Gujarat, during last three year the average seasonal infestation level ranged from 3.50 (2021-22) to 6.45 per cent (2023-24) with the average peak infestation level of 7.20 to 12.40 per cent coincided with marble fruiting stage (Anonymous, 2022; 2023 and 2024). Mango-growing pockets in the South-Western parts of Gujarat, as well as parts of Kerala and Tamil Nadu will remain moderately to highly suitable for *C. eutraphera* distribution in 2050 and 2070 (Choudhary, Mali, Fand & Das, 2019). Concerned with the threat caused by *C. eutraphera* in Gujarat, the present study on its biology was carried out.

MATERIALS AND METHODS

The biology of mango fruit borer was studied at Department of Entomology, N.M. College of Agriculture, NAU, Navsari (20.9241^0 N Latitude and 72.9079^0 E Longitude) during March - May, 2022 (Fig. 1). The initial culture was obtained by collecting infested fruits from mango plantation at Instructional Farm, NAU, Navsari. Each fruit was dissected in laboratory to collect the larvae and further reared in the laboratory. Each larva was kept individually in plastic bottle (4.5 cm diameter X 6 cm height). Marble sized fruit cuttings having soft kernel were provided to the larvae as a food until pupation. This food was changed once after a day. After completion of third instar, a fine soil was layered in the plastic bottle (4.5 cm diameter X 6 cm height) for pupation. Pupae were removed carefully from the soil and kept separately in plastic vials until the emergence of adults. The biology was carried out at room temperature of 24.4 to 29.0 °C and relative humidity of 53.30 to 65.00 per cent.

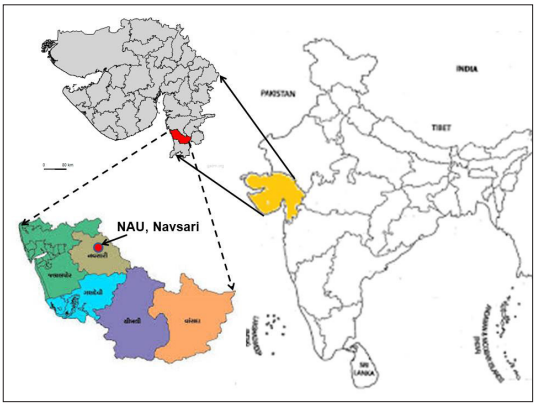

Figure 1. Map of the study sites.

Newly emerged male and female adults (3:1) were released into glass jars (20.0 cm height X 16.0 cm diameter) and fresh leaves and fruits of mango were placed inside for resting and mating. A cotton swab dipped in five per cent sugar solution was also placed in rearing jar as a food to the moths. The open end of glass jars was covered with fine muslin cloth, secured in a position with the help of the rubber band. These jars were kept under constant watch up to mating. After mating individual mated pair of male and female adults (n= 10 pairs) was placed in the wooden cages (75 cm height X 45 cm width X 45 cm length) for further oviposition. The small branches containing mango fruits with peduncle or stalk and leaves were also provided for egg laying. The leaves and fruits were replaced with fresh one every third day and the egg laid on fruits were removed from the jar and used for further studies.

Comprehensive observations were made across various life stages. Eggs, larvae and pupa were examined for their morphological characteristics. A total of (n=20) freshly laid eggs were individually observed for morphological characters. Incubation period and hatching percentage were also recorded. Different instars of larvae, their feeding behaviour and developmental periods were also noted. A total of (n=20) newly hatched neonate larvae were individually transferred to each Petri dish. of size of 8.5 cm diameter and 1.2 cm height. Mature larvae along with infested leaves were kept in plastic containers moist soil to confirm the site of pupation. Pre-pupal and pupal stages were monitored to determine developmental periods and sites of pupation. Adults were analyzed for sexual dimorphism and nature of damage. Sex ratios were also calculated. The morphological characteristics of various life stages were thoroughly examined using a stereo microscope equipped with the ScopeTek DCM130E microscope-camera and Scope Photo software. Reproductive parameters such as pre-oviposition, oviposition, and post-oviposition periods were recorded to understand the egg-laying behaviour of female adults. Fecundity was determined by daily egg counts until the death of female adults. Longevity and total life cycle durations of adult weevils were also recorded.

Statistical analysis: Data of duration of all the stages, their measurements, and fecundity of *C. eutraphera* were presented as mean ± SD.

RESULTS AND DISCUSSION

Egg: Oviposition took place during night and eggs were laid singly (Fig. 2c) or in groups (Fig. 2d). Adult female of *C. eutraphera* mostly preferred rough areas and upper 1/3 portion of the fruit for egg laying on both, fresh as well as damaged fruits (rough surface generated due to the scrapping the skin of fruit by mango thrips and early larval instars of *C. eutraphera*) (Fig. 2e). Maximum eggs were observed along the periphery at junction of peduncle and fruit which were found stuck with the surface (Fig. 2b, h), stalk or peduncle (Fig. 2a), middle and lower part of the fruit was the least preferred site for egg laying (Fig. 2c). Eggs were also observed on network of silken threads prepared by larva of *C. eutraphera* on already damaged fruits by *C. eutraphera* but they did not stuck with the fruit surface (Fig. 2g). In rare cases overlapping of

eggs was also observed during oviposition (Fig. 2f). No eggs were found on leaves. Parental care of eggs was observed wherein female protected the eggs from biotic and abiotic factors by ovipositing eggs under the dried sepals at periphery of junction of peduncle and fruits (Fig. 2h).

These findings are in line with earlier workers, Jacob et al. (2004), Anderson & Tran-Nguyen (2012), Jayanthi et al. (2014) and Soumya, et al. (2017) wherein they reported eggs laid on rough surface of the fruit and on the pedicels in its life span. Given the limited information on the biology of *C. eutraphera*, present investigation draws confirmation of data from studies on other fruit borer species. According to Sujatha & Zehruddin (2006), the stalk of inflorescence and fruit are most preferred site for oviposition by red banded caterpillar, *Deanolis albizonalis* (Hampson). Moreover, the female moth of lima bean pod borer, *Etiellla* sp. also laid eggs singly or in batches near the peduncle of fruit (Parmar, Patel, Parmar, & Gajre, 2021). These findings are more or less similar with the present findings of mango fruit borer, *C. eutraphera.* Information about parental care of eggs of *C. eutraphera* is scanty. However, using a theoretical evolutionary framework, we hypothesized that parental care behaviour of *C. eutraphera* over egg developmental rate can represent a significant benefit of care. Female adults of *C. eutraphera* adjust the egg laying site in its life-history in response to expected offspring mortality, which in turn might increase overall offspring survival, and ultimately, fitness of both adults and offsprings.

The freshly laid eggs of *C. eutraphera* were white and turned red (Fig. 2d, i) after 1-2 days before hatching. Three to four hours before hatching of the egg, the embryo in the chorion developed into brown head capsule which could be seen through translucent chorion. At the time of egg hatching, the larva cut the chorion and wriggled out from the egg. Empty chorion was snow white in colour and remained stuck to the fruit surface. All the eggs which are laid and stuck with the different portion of fruit surfaces were flattened in shape and less than 1mm in size. Whereas, the eggs laid on network of silken threads prepared by the larva of *C. eutraphera* on already damaged fruits are oval in shape and are not stuck with the fruit surface (Fig. 2g). The egg length ranged from 0.64 to 0.70 mm, averaging 0.68 ± 0.02 mm, while their breadth ranged from 0.45 to 0.53 mm, averaging 0.48 ± 0.02 mm. According to Anderson and Tran-Nguyen (2012), Jayanthi et al. (2014) and Kori Nagaraj et al. (2020) eggs of *C. eutraphera* were flattened, less than 1mm in size and white in colour when laid but later change in red. These findings are in conformity with present findings.

The information on actual length and breadth of eggs of *C. eutraphera* on mango is scanty. Sujatha & Zehruddin (2006) noted the average length and breadth of eggs of red banded caterpillar; *D. albizonalis* 0.67 mm and 0.56 mm, respectively. Similarly, according to Parmar et al. (2021), the eggs of *Etiellla* sp. was oval in shape, pale yellowish or dirty white in colour which changed dark yellowish prior to hatching and average length and breadth of egg was 0.63 ± 0.03 mm and 0.39 ± 0.03 mm, respectively. Thus, past workers findings in relation to size of eggs of other fruit borer species were more or less agreement with present fruit borer, *C. eutraphera.*

The incubation period ranged from 2 to 3 days, averaging 2.48 ± 0.50 days (Table 2). The present results are also in line with Anderson and Tran-Nguyen (2012) who reported 2-3 days incubation period of *C. eutraphera* on mango. Similarly, incubation period was recorded as 2.34 ± 0.52 days on cashew by Kori Nagaraj et al. (2020). The hatching percentage of eggs of *C. eutraphera* ranged from 50.00 to 93.33 per cent (average 70.55 ± 13.24%) (Table 2). The present findings could not be compared, as there is no information available pertaining to this aspect.

Figure 2. Eggs of *C. eutraphera*: a) Eggs of on peduncle of fruit; b) Eggs laid along the periphery at junction of peduncle; c) Eggs of on middle portion of fruits; d) Eggs laid in group; e) Eggs laid at rough areas (generated by thrips damage) of the fruit; f) Overlapping of eggs; g) Eggs laid on network of silken threads prepared by the larva of *C. eutraphera* on already damaged fruits; h) eggs laid within the concave structure of dried sepals attached with peduncle; i) microscopic view of the egg.

Larva: Larva of *C. eutraphera* moults four times and thus, passed through five instars (Fig. 3) and succeeding instar took relatively more time for their development than the preceding instar. Number of larval instars of *C. eutraphera* has not been specially investigated so far. Moreover, Parmar et al. (2021) revealed that mango fruit borer, *Etiella* sp. had five larval instars. The larvae of the succeeding instar took relatively more time for their development than the preceding instar in the period of study.

The newly hatched larva was pale pink with dark brown to black coloured head and found sluggish which became active after some times (Fig. 3b to f). Similar observation reported by Jayanthi et al. (2014). The length of first instar larva ranged from 0.84 to

0.91 mm, averaging 0.89 ± 0.02 mm, and the breadth ranged from 0.16 to 0.19 mm, averaging 0.17 ± 0.01 mm (Table 1). The duration of first instar larvae was one to two days, with an average of 1.2 ± 0.40 days (Table 2). The second instar larva was brown to black in color with a light brown head (Fig. 3c) with few scattered hairs across the body. Length ranged from 2.95 to 3.40 mm, averaging 3.15 ± 0.14 mm, while their width ranged from 0.50 to 0.72 mm, averaging of 0.62 ± 0.06 mm. The total lifespan of second instar larva ranged from two to three days, with an average of 2.24 ± 0.43 days. The third instar larva was dark brown to black in color with brownish head covered with scattered hairs (Fig. 3d). The segmentation was clearly visible. The length of third instar larva ranged from 5.56 to 7.10 mm, with an average of 6.22 ± 0.33 mm. The breadth ranged from 1.30 to 1.64 mm with an average of 1.47 ± 0.07 mm (Table 1). Moreover, larval duration was with an average of 3.12 ± 0.33 days (Table 2).

Table 1. Measurements of life stages of mango fruit borer *C. eutraphera*.

Sr.No.	Particular	Measurements (mm)					
		Length			Width		
		Min.	Max.	Mean ± SD	Min.	Max.	Mean ± SD
1	Egg	0.64	0.70	0.68 ± 0.02	0.45	0.53	0.48 ± 0.02
2	Larva						
	First instar	0.84	0.91	0.89 ± 0.02	0.16	0.19	0.17 ± 0.01
	Second instar	2.95	3.40	3.15 ± 0.14	0.50	0.72	0.62 ± 0.06
	Third instar	5.56	7.10	6.22 ± 0.33	1.30	1.64	1.47 ± 0.07
	Fourth instar	10.07	13.30	12.14 ± 0.86	1.79	2.01	1.87 ± 0.06
	Fifth instar	19.45	24.00	21.7 ± 0.98	2.54	3.00	2.81 ± 0.14
3	Pre-pupa	8.25	10.75	9.55 ± 0.89	2.00	2.50	2.29 ± 0.11
4	Earthen cocoon	10.00	13.75	12.21 ± 1.13	5.00	6.50	5.75 ± 0.59
5	Pupa	4.07	4.52	4.39 ± 0.11	1.53	1.75	1.62 ± 0.06
	Male Pupa	8.15	8.80	8.44 ± 0.18	2.05	2.35	2.24 ± 0.08
	Female Pupa	8.85	9.80	9.29 ± 1.89	2.40	2.65	2.51 ± 0.09
6	Adult						
	Male	8.02	12.00	10.00 ± 1.09	18.58	23.45	20.00 ± 1.20
	Female	12.25	16.50	13.52 ± 1.03	20.85	27.05	24.00 ± 1.65

Min.- Minimum; Max.- maximum; SD- Standard deviation.

The fourth instar larva of *C. eutraphera* was similar in general appearance and colour to third instar larva, except the larger size (Fig. 3e). The length measured from 10.07 to 13.30 mm, averaging 12.14 ± 0.86 mm and that of width varied from 1.79 to 2.01 mm averaging 1.87 ± 0.06 mm (Table 1). The duration of fourth instar larva varied from 3 to 5 days with an average of 3.68 ± 0.62 days (Table 2).The fifth instar or full grown larva had metallic dark brown colour head and ranged in coloration from dark brown to black (Fig. 3f). Segmentation was also clearly visible as in case of 4th instar. The body was covered with scattered long hairs and was clearly visible with the naked eye. Long hairs were present on either side of each segment in the dorso-lateral area of body. The larva was more active and had an ability to move fast (forward and backward) by light contact. Defence mechanism was also observed. The length of fifth instar larva ranged from 19.45 to 24.00 mm, with an average of 21.70 ± 0.98 mm, and their breadth ranged from 2.54 to 3.00 mm, with an average of 2.81 ± 0.14 mm

(Table 1). Larva in their fifth instar lived for an average of 3.16 ± 0.37 days, ranging from 3 to 4 days. Information on measurement of each instar was scarce. Singh et al. (2021) recorded fully mature larvae black in colour. Krull & Basedow (2006) noted 20 mm length of full grown larva. Present findings in accordance with earlier workers. The entire larval period of *C. eutraphera* ranged from 12 to 15 days, with an average of 13.4 ± 0.81 days (Table 2). According to Krull & Basedow (2006) the total larval life span of *C. eutraphera* was 12 to 15 days. Similarly, average total larval period of 16.82 ± 1.22 days was reported by Kori Nagaraj et al. (2020) in cashew nut. The findings of earlier workers are more or less in line with the present finding.

Table 2. Details of life cycle of *C. eutraphera*.

Sr. No.	Particulars	Period (Days)		
		Min.	Max.	Av. ± SD
1	Incubation period	2	3	2.48 ± 0.50
2	Larval Period			
	1st instar	1	2	1.20 ± 0.40
	2nd instar	2	3	2.24 ± 0.43
	3rd instar	3	4	3.12 ± 0.33
	4th instar	3	5	3.68 ± 0.62
	5th instar	3	4	3.16 ± 0.37
3	Pre pupal period	2	3	2.24 ± 0.43
4	Pupal Period	8	12	10.00 ± 1.08
5	Adult Period			
	Pre oviposition	2	4	2.80 ± 0.81
	Oviposition	1	3	2.24 ± 0.77
	Post oviposition	1	3	2.16 ± 0.68
6	Longevity			
	Female	7	10	8.04 ± 0.88
	Male	3	5	3.96 ± 0.73
7	Total life cycle			
	Female	32	40	36.04 ± 1.83
	Male	28	35	31.92 ± 1.95
8	Depth of pupation (cm)	1.50	2.60	1.98 ± 0.33
9	Hatching Per cent of eggs (%)	12.00	20.00	15.95 ± 2.37
10	Sex ratio (M:F)	1:1.17	1:1.86	1: 1.53
11	Fecundity (Nos.)	50.0	93.33	70.55 ± 13.24

Pre-pupa: The fully grown larva became sluggish, the body contracted, and its colour turned greenish black (Fig. 3g). When the feeding stopped, the larva started digging into the moist soil in search of a favourable site for pupation in the plastic container. The time for searching suitable site for pupation ranged from 12 to 20 min. averaging 15.95 ± 2.37 min. (Table 2). All the mature larvae made pupal chamber in earthen cocoon in moist soil adjacent to the fruit up to depth ranged from 1.50 to 2.60 cm with an average of 1.98 ± 0.33 cm (N=20). In field condition, normally larvae build their chambers immediately upon finding a preferable site, where there was a shallow pit, a soil gap, or a clod of soil. If these preferable sites were not found, larvae had to burrow into the soil from a flat surface. The larvae used their mandibles to move towards soil particles. At the same time, they spun silk and used saliva to glue the soil particles together until only a small opening remained in the chamber. The larvae

then turned around to orient toward the opening to complete the chamber. This pupal behaviour is unknown and has not been reported by any workers.

Sometimes larva also found to pupate within the fallen fruit. In case of immature infested dropped fruit, mature larva had tendency to come out from the fruit and hide under the fruit attached with ground surface by webbing and pre-pupate. The pre-pupal period varied from 2 to 3 days with an average of 2.24 ± 0.43 days (Table 2). The pre-pupa ranged in length from 8.25 to 10.75 mm, with an average of 9.55 ± 0.89 mm and in breadth from 2.00 to 2.50 mm, with an average of 2.29 ± 0.11 mm (Table 1). No information is available on the measurement and behavior of pre-pupa.

Pupa: An obtect type of pupa was observed. The length of earthen cocoon (Fig. 3h) ranged from 10.00 to 13.75 mm, with an average of 12.21 ± 1.13 mm. While, the breadth ranged from 5.00 to 6.50 mm with average of 5.75 ± 0.59 mm (Table 1). The duration of pupal stage (earthen cocoon) varied from 7 to 10 days, averaging 7.6 ± 0.86 days (Table 2). In laboratory condition when soil was not provided for pupation, dark brown pupa (Fig. 3i) was also formed instead of earthen cocoon. The average length of pupa was 9.29 ± 1.89 mm, averaging 8.85 to 9.80 mm. The average breadth of pupa was 2.51 ± 0.09 mm with a range of 2.40 to 2.65 mm. In case of brown colored pupa, the pupal period ranged from 8 to 12 days with an average 10 ± 1.08 days, while that of an earthen cocoon, ranged from 7 to 10 days with an average 7.6 ± 0.86 days (Table 2).

According to Jayanthi et al. (2014) pupation of *C. eutraphera* took place inside the soil. Larvae pupate either in soil or in fallen fruit, and the pupal stage completed approximately in 14 days (Jacob et al., 2004; Anderson & Tran-Nguyen, 2012). Whereas Kori Nagaraj et al. (2020) noted the pupal period of 7.19 ± 0.86 days on cashew nut. The observation made in the present study in relation to the site of pupation and pupal period was in conformity with the past workers.

Adult: The adult is a medium-sized moth with a wingspan of 20 mm (Fig. 3k). The fore-wings were grey without any specific markings, whereas the hind wings were transparent with hairs. Both hind wings and forewings were metallic grey in colour (Fig. 3k, l). In comparison to female moths, males were smaller in size. Similarly, abdomen of male moth was also found smaller than female. Adult wings overlapped during the resting stage (Fig. 3j). The length of adult female was ranged from 12.25 to 16.50 (average of 13.52 ± 1.03 mm), and its wing span ranged from 20.85 to 27.05 mm, averaging 24.00 ± 1.65 mm. Similarly, length and wing span of adult male ranged from 8.02 to 12.00 mm and 18.58 to 23.45 mm with average of 10.00 ± 1.09 mm and 18.58 to 23.45 mm, respectively (Table 1). Very little information is available on adult measurements. According to Jacob et al. (2004) the adult had a wingspan of 20 mm, which is more or less in line with present findings.

Anderson & Tran-Nguyen (2012) described the forewing of *C. eutraphera* as ground colour yellowish-grey, veins black scaled, ante-medium band non-existent, post-median band pale yellowish-grey, fuscous interspersed with creamy white scales, with rusty red, cream, black fringe. Hind wing was ground colour dirty white with black scaling along veins, anal area less black veined scales but with long dark, white hairs. The adult moths have dark brown forewings and pale white to grey hind

wings (Jayanthi et al., 2014). The present findings pertaining to colour of adult of *C. eutraphera* was comparable with past workers findings. The sex ratio of male as to female varied from 1: 1.17 to 1: 1.86 with an average of 1: 1.53 (Table 2).

Figure 3. Life cycle of *C. eutraphera*: a) Egg, b) I instar larva, c) II instar larva, d) III instar larva, e) IV instar larva, f) V instar larva, g) Pre-pupa, h) Earthen cocoon, i) Pupa, j) Adult in resting position, k) Male adult, l) Female adult.

Reproductive parameters: The pre-oviposition, oviposition and post-oviposition period of *C. eutraphera* varied from 2 to 4 days (average 2.8 ± 0.81 days), 1 to 3 days (2.24 ± 0.77 days) and 1 to 3 days (2.16 ± 0.68 days), respectively (Table 2). The information on reproductive parameters is scanty.

Fecundity: The egg laying capacity of laboratory reared female moth varied from 33 to 57 eggs with an average of 41.15 ± 7.22 eggs (Table 2). According to Jacob et

al. (2004) and Soumya et al. (2016), the female moth laid 125 to 450 eggs on rough areas of the fruits and pedicels in its life span of about a week. Present findings disagreed with these as very less egg laying was observed during present study which could be attributed due to the variations in the location and climatic conditions. The reproductive behaviour and habitat selection of *C. eutraphera* have not been specially investigated so far.

Longevity: The longevity of female and male varied from 7 to 10 days and 3 to 5 days with an average of 8.04 ± 0.88 days and 3.96 ± 0.73 days, respectively (Table 2). The present findings are more or less in confirmation with Kori Nagaraj et al. (2020), who reported that male and female moths of *C. eutraphera* had adult longevity of 7.46 ± 0.59 and 8.91 ± 0.65 days, respectively.

Total Life Cycle: The total life cycle of female and male adults (Fig. 3a to j) ranged from 32 to 40 days 28 to 35 days with an average of 36.04 ± 1.83 days and 31.92 ± 1.95 days, respectively (Table 2). According to Parmar et al. (2021), the whole life cycle of *Etiella* sp. was 22 to 31 days, with an average of 26.62 ± 2.57 days for males and 25 to 33 days with an average of 28.90 ± 2.11 days for females. The present findings are more or less in agreement with the findings of Soumya et al. (2016), who reported that *C. eutraphera* took at least one month to complete each generation.

Nature of Damage: The fruit's skin was scraped by newly emerged larvae (Fig. 4b), and later instars bored holes in the fruit to feed on the pulp to reach the soft seed/ kernel (Fig. 4e). In infested fruits, bored holes filled with frass (Fig. 4h) and adjacent fruits of mango were often found blackened around the bored area (Fig. 4i). During marble to egg stage, early instar larva also started feeding on the peduncle resulted in premature dropping of fruits (Fig. 4l). Mostly larva enters the fruit by boring on the upper 2/3 portion of fruit especially near peduncle (Fig. 4b). Fruit entry from basal region was found rarely. However, in case of jointed fruit (two or more fruits) which were damaged on single panicle, larva made entry by tunnelling along the jointed parts of the fruit ((Fig. 4i). Severe infestation was observed during April and May, when the fruits were around the size of a marble or a lime (Fig. 4b).

It was seen that, up to lime size of fruit, the larvae also fed on the soft seeds led to the shedding of the fruits (Fig. 4j, k). However, mangoes attacked in mature and fully-grown stages remained on the tree, but the number of fruits damaged in mature stage was less than at lime size stage of mango. When seed becomes hard, only the flesh was eaten without any dropping of fruits. The sap stain from bore hole made by the larvae (Fig. 4g). The larva created irregular galleries in the kernel and completely devoured it. The kernel lost the germination. The exit hole allows ants, beetles, and occasionally microorganisms to enter the fruits. Furthermore, the damage caused longitudinal cracks in the fruits, which encouraged fruit flies to lay their eggs there (Fig. 4f). Therefore, the damage caused by *C. eutraphera* in mango caused a total loss of fruit quality, loss of kernel germination, and also made the fruit unfit for consumption. More or less similar type of damage was reported by Krull & Basedow (2006); Singh et al. (2021); Reddy, Gundappa, & Chakravarthy (2018) and Jayanthi et al. (2014).

It was also noted that, maximum eight larvae per fruit with an average of 4.0 larvae per fruit was observed at egg stage, when single fruit was infested by *C. eutraphera*. Similarly, maximum nine larvae per fruit with an average of 4.7 larvae per fruit were observed at egg stage when adjacent couple of fruits was infested. Likewise, maximum thirteen larvae per fruit with an average of 7.4 larvae per fruit were observed at mature stage when adjacent multiple fruits were infested.

Figure 4. Nature of Damage by *C. eutraphera*: a) Damage at sorghum grain stage; b) Pea stage; c) (Fruit screen scraped by early instar larva); Marble stage; d) Egg stage; e) Mature stage; f) Cracking of fruits due to infstation; g) Sap stain running from bore hole; h) Entry hole plugged with excreta; i) Damage at jointed fruits; j & k) Larva feed on the soft kernal of mangoj; l) mature fruits dropped due to infestation.

Complex of two fruit borer species *viz*., *C. eutraphera* and *Conogethes punctiferalis* (Guenee) (Lepidoptera: Crambidae) was observed in South Gujarat. Based on

the mean larval population of both the species from pea stage to mature stage, maximum composition of *C. eutraphera* (95.66 % and 94.82 %) was observed than *C. punctiferalis* (4.34 % & 5.18 %), respectively (Chaudhari, 2023). Both the fruit borer species preferred pulp and seed. Larva of C. *punctiferalis* directly bored into the fruit along the any side of fruit. But, larva of *C. eutraphera* mostly enters the fruit by boring on the upper 2/3 portion of fruit especially near peduncle. In most instances, larvae damage the peduncle of the fruit after hatching, leading to pre-mature fruit dropping.

The present studies on life cycle and behavior of *C. eutraphera* will found crucial for its effective management because we could reach its targeted interventions, like exploiting vulnerabilities during specific life stages, disrupting mating or feeding, movement and dispersal habits or leading to more sustainable and efficient pest control. Besides, in future by studying its population dynamic in relation weather parameters we could understand how this pest respond to environmental factors which will helps in predicting pest outbreaks and timing control measures.

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REFERENCES

Anderson, S. L. & Tran-Nguyen. (2012). Mango fruit borer (*Citripestis eutraphera*).Updated on 11/30/2021, 3:16:26 PM..http://www.padil.gov.au

Anonymous (2022). Agresco Report Submitted to 19th Plant Protection Sub-Committee (PPSC) of Navsari Agricultural University, Navsari, Gujarat, India.

Anonymous (2023). Agresco Report Submitted to 20th Plant Protection Sub-Committee (PPSC) of Navsari Agricultural University, Navsari, Gujarat, India.

Anonymous (2024). Agresco Report Submitted to 21th Plant Protection Sub-Committee (PPSC) of Navsari Agricultural University, Navsari, Gujarat, India.

Bana, J. K., Sharma, H., & Sharma, D. K. (2018). Mango fruit borer, *Citripestis eutraphera* (Meyrick), in South Gujarat: Need for domestic quarantine. *Indian Journal of Entomology*, 80(3), 654-657.

Bhumannavar, B. S. (1991). Record of *Citripestis eutraphera* Meyrick (Pyralidae: Lepidoptera) on *Mangifera andamanica* in India. *Journal of Bombay Natural History Society*. 88(2), 299.

Chaudhari, A. (2023). Studies on mango fruit borer, *Citripestis eutraphera* (Meyrick) (Lepidoptera: Pyralidae): Thesis submitted to the Navsari Agricultural University, Navsari, Gujarat in partial fulfillment of the requirements for the award of Degree of M.Sc.

Choudhary, J., Mali, S. S., Fand, B. B., & Das, B. (2019). Predicting the invasion potential of indigenous restricted mango fruit borer, *Citripestis eutraphera* (Lepidoptera: Pyralidae) in India based on Max Ent modelling. *Current Science,* 116(4), 25.

Hiremath, S. R., Amritha, S., & Prathapan, K. D. (2017). First report of the mango fruit borer, *Citripestis eutraphera* (Meyrick) (Lepidoptera: Pyralidae) as a seedling borer of cashew, *Anacardium occidentale* L. (Anacardiaceae). *Journal of Lepidopterists Society*, 71(2), 115-116.

Jacob, T. K., Veena, K., & Bhumannavar, B. S. (2004): Insect pests of cashew in the Andaman Islands. *Cashew,* 18(4), 25-28.

Jayanthi, K. P., Verghese, A., Shashank, P. R., & Kempraj, V. (2014). Spread of indigenous restricted fruit borer, *Citripestis eutraphera* (Meyrick) (Lepidoptera: Pyralidae) in mango: time for domestic quarantine regulatory reforms. *Pest Management in Horticultural Ecosystem*, 20, 227-230.

Khimani, V. M. & Chavan, S.M. (2025). Insect pest diversity on mango in the nursery under humid tropics of Gujarat, India. *Pest Management in Horticulturaal Ecosystem*, 30(2):303-311.

Kori Nagaraj, G., Ramegowda, K., Aswathanarayana Reddy, N., Narabenchi, G., & Vishuvardhana, B. (2020). Studies on apple and nut borer, *Citripestis eutraphera* Meyrick (Lepidoptera: Pyralidae) in cashew. In: XVII AZRA International Conference on Frontier Research in Applied Zoology and Insect Pest management Strategies: A way forward for Food and Nutritional from 12-14th, February, 2020 at UAS, Raichur, Karnataka, Pp 82-83.

Kori Nagaraj, N., Aswathanarayana Reddy, N., Subramanyam, B., & Ramegowda, G. K. (2022). Report of incidence of mango fruit borer, *Citripestis eutraphera* (Meyrick) (Lepidoptera: Pyralidae) as apple and nut borer in cashew, *Anacardium occidentale* L. (Anacardiaceae) in maidan parts of Karnataka, India. *Insect Environment,* 25(1), 29-33.

Krull, S. & Basedow, T. (2006). Studies on the biology of *Deanolis sublimbalis* (Snellen) (Lepidoptera, Pyralidae) and its natural enemies on mango in Papua New Guinea. *Institute of Phytopathology and Applied Zoology*, 4(25), 225-228.

Krull, S. M. (2004). Studies on the mango-ecosystem in Papua New Guinea with special reference to the ecology of *Deanolis sublimbalis* Snellen (Lepidoptera: Pyralidae) and to the biological control of *Ceroplastes rubens* Maskell (Homoptera:Coccidae).*Thesis Ph.D*., Justus-Liebig Universitat Gieben, 190 p (2004).

Parmar, S., Patel, Z. P., Parmar, S., & Gajre, N. (2021). Studies on biology and morphometrics of fruit borer, *Etiella* sp. (Lepidoptera: Pyralidae) on mango under laboratory conditions. *International Journal of Chemical Studies*, 8(6), 2017-2021.

Reddy, P. V., Gundappa, B., & Chakravarthy, A. K. (2018). "*Pests of mango*", Omkar, New Delhi, pp. 415-440.

Singh, S. & Kaur, G. (2014). Diversity of pestiferous borers of mango. *Indian Journal of Applied Entomology,* 28(2),125-127.

Singh, S., Shashank, P., Singh, V., & Kaur, R. (2021). Occurrence of indigenously restricted fruit borer, *Citripestis eutraphera* on mango in Punjab and its damage potential**.** *Indian Journal of Plant Protection,* 49(1), 9-13.

Skendzic, S., Zovko, M., Zivkovi´c, I.P., Lesi´c, V., Lemi´c, D. (2021).The Impact of Climate Change on Agricultural Insect Pests. *Insects*, 12, 440. https://doi.org/10.3390/ insects12050440

Soumya, B. R., Verghese, A., & Jayanthi, P. K. (2017). Diversity and economic status of Lepidopteran insect-pest on two major varieties of mango. *Journal of Entomology and Zoological Studies*, 5, 838-843.

Soumya, K. P., Verghese, A., Shashank, P. R., & Kempraj, V. (2016). Spread of indigenous restricted fruit borer, *Citripestis eutraphera* (Meyrick) (Lepidoptera: Pyralidae) in mango: time for domestic quarantine regulatory reforms. *Pest Management in Horticultural Ecosystem*, 20, 227-230.

Sujatha, A. & Zaheruddeen, S. (2006). Studies on morphometrics of mango fruit borer, *Deanalis albizonalis* (Hampson). *Journal of Applied and Zoological Research*, 17(2), 131-137.

Sunitha, P., Sujatha, A., & Rao, J. (2020). Diversity and potentiality of lepidopteraus borer pests on mango and sapota in Andhra Pradesh. *Journal of Applied and Zoological Research,* 31(2), 137-148.

Tandon, P. L. & Verghese, A. (1985). *World list of insect, mite and other pests of mango*. Technical Document, Vol. 5, Indian Institute of Horticultural Research, Bengaluru, Karnataka, 22 pp.