The Pharma Innovation Journal 2023; 12(12): 3757-3762

www.ThePharmaJournal.com

The Pharma Innovation

ISSN (E): 2277-7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2023; 12(12): 3757-3762

www.thepharmajournal.com
Received: 11-10-2023
Accepted: 23-11-2023

MB Zala
Assistant Research Scientist, Agricultural Research Station, Anand Agricultural University, Sansoli, Gujarat, India

TM Bharpoda
Retd. Professor, Department of Agricultural Entomology, B. A. College of Agriculture, Anand Agricultural University, Anand, Gujarat, India

Corresponding Author:
MB Zala
Assistant Research Scientist, Agricultural Research Station, Anand Agricultural University, Sansoli, Gujarat, India

Biology of mango leaf gall midge, *Procontarinia matteiana* Kieffer & Cecconi (Diptera: Cecidomyiidae)

MB Zala and TM Bharpoda

Abstract
The biology of leaf gall midge, *Procontarinia matteiana* Kieffer & Cecconi on mango was studied in the laboratory of Department of Agricultural Entomology, B. A. College of Agriculture, AAU, Anand during March-April, 2018. The female of *P. matteiana* laid watery yellow coloured eggs on mango leaf with average incubation period of 2.25 + 0.35 days. The first instar maggots were white in colour whereas second and third instar maggots were yellow in colour. The first, second and third instar maggots period was 1.10±0.21, 2.10±0.39 and 3.20±0.67 days, respectively with total maggot period of 6.40±1.05 days. The pupae were yellow in colour, having average pupal period as 6.15±0.82 days. Pupation completed inside the galls. Male gall flies were comparatively smaller than female. The average pre-oviposition, oviposition and post-oviposition periods were 1.00±0.24, 1.20 + 0.35 and 1.05 + 0.16 days, respectively. The longevity of male and female was 2.70±0.42 and 4.30±0.39 days, respectively. The average fecundity of female fly was 8.20±0.92 eggs. The average longevity of the adult male and female were 2.30±0.35 and 3.60±0.37 days, respectively. The total life period of male and female adult of *P. matteiana* was 15.80±0.79 and 18.80±1.23 days, respectively. The average sex ratio (male: female) of *P. matteiana* was found 1: 0.84.

Keywords: Biology, leaf gall midge, *Procontarinia matteiana*, mango

Introduction
Mango is a "National fruit of India" because of delicious taste, besides delicious taste, excellent flavour and attractive fragrance. A 100 g serving of raw mango has 65 calories and about half the vitamin C found in oranges. Mangoes are thought to help stop bleeding, to strengthen the heart and to benefit the brain. Fresh mangoes and mango pulp are the important items of argil-exports. The mango kernel contains 8-10 percent good quality fat, which can be used for soap and also as a substitute for cola in confectionery. The mango is also used to make the processed products like candy, relishes, pickles, beverages and many more. Insect pest problems are increasing fast because of rapid change in the agro-ecosystems, advancement of modern agricultural practices. More than 400 insect pests have been listed attacking this king fruit (Srivastava, 2000) [16]. Out of these, about two dozen insect pests severely damage different parts of mango tree.

The infestation of mango gall midge, *Procontarinia matteiana* Kieffer & Cecconi (Cecidomyiidae: Diptera) has steadily increased year after years in mango orchards due to changes in environment, cropping system, cultivation of susceptible varieties etc. About 26 species of insects produces galls on various plant parts of mango tree. Most of the mango gall inducing species belong to genus *Procontarinia* (Cecidomyiidae: Diptera) (Boucek, 1986) [5]. Mango gall midge is a common gall midge on mango found in India (Askari and Radjabi, 2003) [2]. In India, the infestation of gall midge found on mango throughout the year, prominently during vegetative and fruit maturity period *i.e.* September and April (Kaushik *et al.*, 2012) [10]. Two peaks of gall midge incidence were observed by Zala and Bharpoda (2022) [19] during March/April and September/October. It remains active throughout the year showing initiation of gall formation in new flush leading to defoliation of affected leaves and reduction of photosynthesis. A serious outbreak of mango gall midge might be resulted in reduction of fruit yield (Augustyn *et al.*, 2013) [3]. Considering the above facts, the laboratory study on the biology of leaf gall midge, *P. matteiana* on mango was carried out.

Materials and Methods
Rearing Technique: Large numbers of gall midge infested mango twigs were collected from the Horticulture Farm of B. A. College of Agriculture, AAU, Anand to maintain the mass culture for the study of biology.

The galls present on the leaves were observed critically under the microscope by inserting pointer inside the gall. Numbers of maggots were observed carefully inside the galls and galls were round marked with the marker pen. Such galls with maggot were cut in square and kept in the Petri dish on wet cotton wool to keep leaf fresh and turgid for a longer period. The galls were observed daily till the formation of pupa. The pupae so collected were kept in Petri dish containing moist cotton wool for the adult emergence (Jadhav *et al*., 2013) [8].

The newly emerged adult flies were sorted into male and female based on their external morphological characters (the male and female can be distinguished by size and presence of numerous hairs at the tip of male abdomen and presence of ovipositor at the tip of female abdomen). The uninfested twigs of mango cv. Kesar were collected from the field and brought to laboratory to prepare oviposition cage. The portion of fresh twigs were wrapped with cotton wool and inserted in conical flask containing water to keep twig fresh and turgid for longer period. Large number of such a flask were prepared for mass rearing of mango gall midge in the laboratory. Such five pairs of conical flask were kept in wooden cage. Honey solution (5%) was provided in a fresh sponge twice in a day as a food for adults (Jadhav *et al*., 2013) [8].

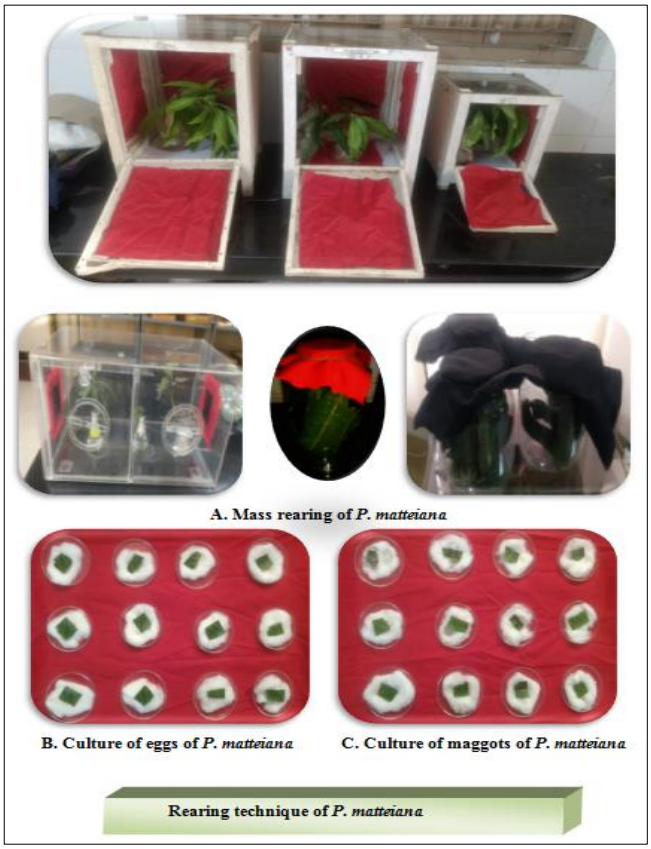

Fig 1: Rearing technique of P. matteiana

Egg

The freshly laid eggs were kept on the slide with the help of camel hair brush. The eggs were examined under the microscope to study their colour, shape and size. For measuring length and breadth, the fresh eggs were transferred on the slide with the help of fine camel hair brush and measured under compound microscope *i.e.* Magnus-Pro microscope.

To study the incubation period and hatching percentage, 25 eggs were kept separately inside the cut portion of leaves with gall in Petri dish on wet cotton wool to keep leaf fresh and turgid for a longer period. Eggs were observed daily in morning and evening till hatching. The eggs were considered as hatched when tiny maggots came out from the eggs. Hatching percentage was calculated on the basis of number of eggs hatched, out of total number of eggs kept under observations.

Maggot

Newly emerged maggots were reared individually inside the cut portion of leaves with gall in Petri dish on wet cotton wool to keep leaf fresh and turgid for a longer period of time. The developing maggots were transferred to fresh square cut portion of leaf with gall in morning till the completion of maggot's development. Petri dishes were also changed daily to maintain the sanitation. Observations were recorded on number of instars and duration of each instar till pupation. The measurement (length and width) of each instar was recorded under the compound microscope *i.e.* Magnus-Pro microscope.

Pupa

A stage, when full grown maggot ceased its feeding and become inactive was considered as pupal stage. Pupae were collected and kept inside the cut portion of leaves with gall in Petri dish which contain the moist cotton wool. The pupae were observed for their colour, shape and size under the microscope. The length and breadth were also measured.

Adult

The newly emerged adults were killed using insect killing bottle. They were mounted on triangle, dried and preserved with wing expanded. Such preserved adults were observed under the microscope to study their colour, shape, size, appearance and sex differences. Measurements of the adults were also taken.

Sex Ratio

To study the sex ratio; laboratory reared adults were observed for the sex, the ratio was calculated by separating the male and female on the basis of their morphological characters (the male and female can be distinguished by size and presence of numerous hairs at the tip of male abdomen and presence of ovipositor at the tip of female abdomen).

Pre-oviposition, Oviposition, Post-oviposition Periods, Fecundity and Longevity

To study the pre-oviposition, oviposition and post-oviposition periods; freshly emerged male and female adults were paired and released in wooden cage covered with red cloth as described under rearing technique.

A period between the emergence of female flies and commencing the egg laying was considered as pre-oviposition period. Period between starting of egg laying and ceasing of egg laying by female was noted as oviposition period. While, period between ceasing of egg laying to the death of female was considered as post-oviposition period. The number of eggs laid by each female was recorded daily till the ceasing of egg laying and average fecundity was calculated. Longevity of male and female was calculated separately from the date of emergence of adults to the death of the adults.

Nature of Damage

Large number of the gall midge infested mango leaves were collected from Horticulture farm. Mango leaves were observed critically in laboratory under the microscope to study the damage caused by *P. matteiana*. Newly formed leaves as well as old leaves were also observed critically under the microscope to study the nature of damage of *P. matteiana* (Jadhav *et al*., 2013) [8].

Results and Discussion

Egg

The female gall fly laid the eggs singly preferably on upper as well as lower surface of young mango leaves. Very rarely eggs were laid on lower surface of leaves and on the panicles. The oviposition sites are marked with a reddish small spots. Memon *et al.* (2017) [11] reported that female gall fly, *P. matteiana* oviposits on underside of young leaves of mango. Similar egg laying pattern of *P. matteiana* was observed by Jhala *et al*. (1987) [9], Harris and Schreiner (1992) [7], Augustyn *et al*. (2013) [3], Jadhav *et al*. (2013) [8] and Sideeg (2015) [14]. The findings of present investigations are in agreement with the above reports. In addition, Botha and Kotze (1987) [4] noticed the eggs on young leaf buds also.

The freshly laid eggs (when deposited) were minute, translucent, elongated and watery yellowish in colour. The length of eggs ranged from 0.17 to 0.26 mm with an average of 0.22 + 0.03 mm, while the breadth varied from 0.10 to 0.17 mm with an average of 0.14 + 0.02 mm (Table 1). These are in accordance with the report of Jadhav *et al.* (2013) who reported the average length and breadth of eggs as 0.18 to 0.32 and 0.12 to 0.21 mm, respectively and described similar colour and shape of the eggs. According to Memon *et al.* (2017) [11], eggs of mango gall midge, *P. matteiana* were oval and watery yellowish in colour.

The incubation period varied from 1.5 to 2.5 days with an average of 2.25 + 0.35 days (Table 2). Askari and Bagheri (2005) [1], Jadhav *et al.* (2013) [8], Sideeg (2015) [14] and Memon *et al.* (2017) [11] recorded the average incubation period of *P. matteiana* as 2.18±0.64, 2.36 ±0. 34, 2.46±0.24 and 2.6±0.69 days, respectively. These reports are more or less in close agreement with the present findings.

Table 1: Morphometric studies of different stages of mango gall midge, *P. matteiana*

Developmental Stages	Length (mm)			Breadth (mm)		
	Min.	Max.	Mean + S.D.	Min.	Max.	Mean + S.D.
Egg	0.17	0.26	0.22 + 0.03	0.10	0.17	0.14 + 0.02
Maggot						
I instar	0.26	0.35	0.31 + 0.03	0.11	0.15	0.13 + 0.02
II instar	0.50	0.68	0.62 + 0.06	0.31	0.47	0.41 + 0.05
III instar	0.87	1.12	1.04 + 0.08	0.60	0.72	0.67 + 0.04
Pupa						
Prepupa	1.05	1.15	1.12 + 0.03	0.74	0.82	0.81 + 0.04
Pupa	1.00	1.13	1.10 + 0.07	0.73	0.81	0.78 + 0.03
Adult						
Male	1.25	1.35	1.29 + 0.03	2.67	2.90	2.81 + 0.08
Female	1.34	1.47	1.41 + 0.04	2.85	3.15	3.01 + 0.10

Table 2: Duration of different stages of mango gall midge, *P. matteiana*

Developmental Stages	Duration {Day(s)}		
	Min.	Max.	Mean + S.D.
Egg / Incubation period	1.5	2.5	2.25 + 0.35
Hatching (%)	-	-	56
Maggot period			
I instar	1.0	1.5	1.10 + 0.21
II instar	1.5	2.5	2.10 + 0.39
III instar	2.5	4.5	3.20 + 0.67
Total maggot period	5.0	8.5	6.40 + 1.05
Pupal period			
Pre-pupal	0.5	1.5	1.05 + 0.37
Pupal	5.0	7.5	6.15 + 0.82
Adult period			
Pre - oviposition period	0.5	1.5	1.00 + 0.24
Oviposition period	1.0	2.0	1.20 + 0.35
Post - oviposition period	1.0	1.5	1.05 + 0.16
Longevity			
Male	1.5	2.5	2.30 + 0.35
Female	2.0	4.0	3.60 + 0.37
Fecundity	6	9	8.20 + 0.92
Sex-ratio [male: female]	1: 0.67	1: 1.14	1: 0.84
Total life span: Egg to adult death			
Male	15	17	15.80 + 0.79
Female	17	20	18.80 + 1.23
Temperature (^{0}C)	20.06	37.94	29.00 + 2.72
Relative humidity (%)	60.37	24.22	42.29 + 8.28

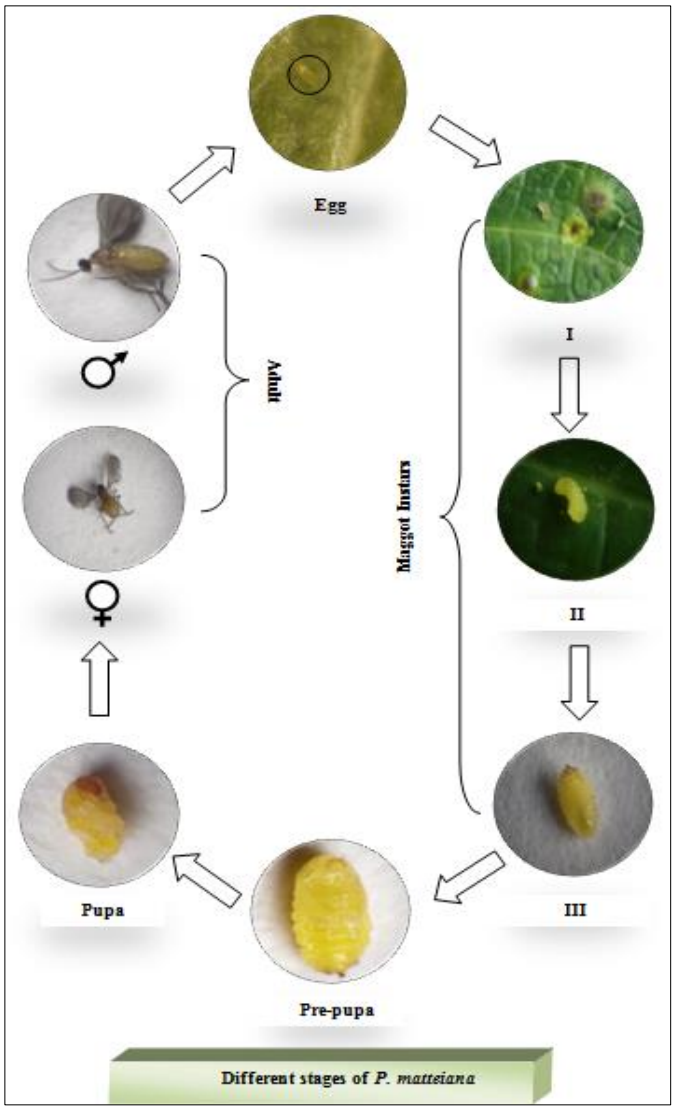

Fig 2: Different stages of *p. matteiana*

The hatching percentage was 56% (Table 2). Almost similar results has been reported by Jadhav *et al.* (2013) [8] who reported that the average hatching percentage of eggs of *P. matteiana* as 54±5.00%.

Maggot

On hatching, maggot (damaging stage) tunnel into the leaf tissue and started forming galls. The oviposition sites were marked with reddish small spots. At the beginning of gall development, it was light green, increased in size and gradually became hard and concave. Tumour-like growth (gall) develop on the host plants as a result of chemical stimuli from the galling insects. These stimuli can be maternal secretions injected during ovipositioning or stimuli produced by larvae developing within the plant tissue. The galls can be distinguished into two types: "true galls" which appear in forms of small round swelling and "pseudo galls" which are tiny indentation on leaves. The infested leaves suffer deformation and as a results reduction in leaf surface area responsible for capturing energy from tree growth and forming fruits. In case of severe incidence, leaves were found to curl up resulting in dieback of whole branches or crinkled and drop prematurely. Gall caused by *P. matteiana* responsible for increasing anthracnose disease, *Colletotrichum gloeosporiodes* Penz on mango leaves which colonize the galls. The present investigation on nature of damage caused by *P. matteiana* is more or less in close conformity with the findings of Van Zyl *et al.* (1988) [18], Srivastava (1997) [15], Githure *et al.* (1998) [6], Pascual-Alvarado *et al.* (2008) [12] and Augustyn *et al.* (2013) [3].

The maggots were found to pass through three instars on mango leaves in the laboratory. The results of present findings are supported by Jadhav *et al.* (2013) [8] (Table 2).

Freshly emerged first instar maggot was minute, delicate, cylindrical, apodous, rounded at both the end and of white in colour. Similar results have been opined by Strydom (2011) [17] who reported that the young maggots of *P. matteiana* were cylindrical with a white colour body. The present findings are in close conformity with the report of Jadhav *et al.* (2013) [8]. The body length of first instar maggot varied from 0.26 to 0.35 mm with an average of 0.31 + 0.03 mm and breadth was 0.11 to 0.15 mm with an average of 0.13 + 0.02 mm (Table 1). These findings are supported by Jadhav *et al.* (2013) [8] who measured the first instar maggots as an average of 0.38±0.03 mm in length and 0.15±0.01 mm in breadth, respectively. Duration of first instar maggot was found minimum of 1.0 and maximum of 1.5 days with an average of 1.10 ±0.21 days (Table 2). Present findings are more or less in agreement with reports of Jadhav *et al.* (2013) [8] and Memon *et al.* (2017) [11].

Freshly moulted second instar maggot differed from first instar in its comparative size and appearance. Maggot was cylindrical and pale yellowish in colour. This instar was active feeder and as a result galls increased in size and gradually became hard and concave. Memon *et al.* (2017) [11] reported that the first instar maggots of *P. matteiana* were yellow in colour. Measurement of the second instar maggot revealed that maggot varied from 0.50 to 0.68 mm with an average of 0.62 + 0.06 mm in length and 0.31 to 0.47 mm with an average of 0.41±0.05 mm in breadth (Table 1). The duration of second instar maggot was observed minimum 1.5 and maximum of 2.5 days with an average of 2.10±0.39 days (Table 2). The present findings are in close conformity with the report of Jadhav *et al.* (2013) [8].

The third instar maggot was flat, sub-cylindrical, eucephalous and dull yellowish in colour. Third instar maggot can be easily distinguished from second instar based on development of mouth parts, it represented jaw shaped hook and cephalic sclerites. According to Memon *et al.* (2017) [11], third instar maggots were yellow in colour. The morphometric study of third maggot instar indicated that each maggot varied from 0.87 to 1.12 mm with an average of 1.04 + 0.08 mm in length and 0.60 to 0.72 mm with an average of 0.67 + 0.04 mm in breadth (Table 1). Duration of third instar maggot (Table 2) was 2.5 to 4.5 days with an average of 3.20±0.67 days. The results of present investigation are more or less in close agreement with findings of Jadhav *et al.* (2013) and Memon *et al.* (2017). Total maggot period was considered from emergence of first instar to the end of third instar. It ranged from 5.0 to 8.5 days with an average of 6.40±1.05 days (Table 2). These findings are more or less similar to Jadhav *et al.* (2013) [8] who reported total maggot period ranged from 6.0 to 8.0 days with an average of 7.1±0.76 days.

Pupa

On completion of development, maggots ceased feeding, became darker and sluggish and suspended feeding and movement considered as pre-pupal stage. During pre-pupal

stage, the colour changed to dark yellow. The body of the pre-pupa was sub-cylindrical in shape. The length of the pre-pupae ranged from 1.05 to 1.15 mm with an average of 1.12±0.03 mm, while the breadth ranged from 0.74 to 0.82 mm with an average of 0.81±0.04 mm (Table 1). The average length and breadth of pre-pupae were 1.25±0.03 and 0.82±0.04 mm, respectively. The findings of Jadhav *et al.* (2013) [8] are more or less similar. The duration of pre-pupal stage varied from 0.5 to 1.5 days with an average of 1.05±0.37 days (Table 2). No published information is available to support present findings on duration of pre-pupal stage.

The maggot of *P. matteiana* pupated inside the galls on mango leaves. Jadhav *et al.* (2013) [8] noticed full fed larva pupating inside a gall on mango leaves. This report tally with the present findings. The newly formed pupa of *P. matteiana* was coarctate type, yellow in colour with a clear dark brown constriction on head. Its puparium was observed embedded over pupa inside the galls which can be seen when adult emerge out from the galls. The length and breadth of pupae ranged from 1.00 to 1.13 mm with an average of 1.10±0.07 mm and 0.73 to 0.81 mm with an average of 0.78±0.03 mm, respectively (Table 1). Sideeg (2015) [14] reported that the pupae were yellow in colour. The freshly formed pupae were yellowish brown in colour and average length and breadth of pupae were 1.28±0.02 and 0.93±0.09 mm, respectively Jadhav *et al.* (2013) [8].

The duration of pupae varied from 5.0 to 7.5 days with an average of 6.15±0.82 days, (Table 2). Jadhav *et al.* (2013) [8] reported the pupal period varied from 6.0 to 8.0 days with an average of 6.9±0.87 days. Sideeg (2015) [14] reported the duration of the pupal stage as 8.62±0.4.6 days.

Adult

The adult of mango gall midge was a tiny and pale yellowish in colour. It was having conspicuous head with prominent dark brown compound eyes and possesses a pair of antennae (Moniliform). The fore wings of adult were transparent and having many minute hairs at the margin and second pair of wing is modified into halters. The metathoracic legs were larger than pro and mesothoracic legs. It possesses yellow colour abdomen distinctly visible. In case of male, abdomen long and slender and minute hairs found at the end whereas in case of female the abdomen was blunt/rounded with presence of ovipositor at the end of abdomen which can be seen by observing under microscope. More or less similar colour pattern and appearance of the adult of *P. matteiana* was observed by Askari and Bagheri (2005) [1], Strydom (2011) [17] and Jadhav *et al.* (2013) [8].

The length of male gall fly ranged from 1.25 to 1.35 mm with an average of 1.29±0.03 mm, while the breadth with wing expanded varied from 2.67 to 2.90 mm with an average of 2.81±0.08 mm. The length of the female gall fly ranged from 1.34 to 1.47 mm with an average of 1.41±0.04 mm, while the breadth with wing expanded varied from 2.85 to 3.15 mm with an average of 3.01±0.10 mm (Table 2). The length and breadth with wing expanded was slightly more in female than the male. The female gall flies were slightly bigger in size than the male. The present findings are supported by Jadhav *et al.* (2013) [8] who reported that the adult male of *P. matteiana* measured on an average of 1.35±0.03 in length and 2.96±0.12 mm in breadth whereas adult female was 1.53±0.04 in length and 3.25±0.15 mm in breadth. Male gall flies were comparatively smaller than female.

The pre-oviposition period of female gall fly varied from 0.5 to 1.5 days with an average of 1.00±0.24 days (Table 2). These findings tally with the reports of Samui and Jha (2012) [13] and Jadhav *et al.* (2013) [8].

The oviposition period of *P. matteiana* female ranged from 1.0 to 2.0 days with an average of 1.20 + 0.35 days (Table 2). Present results are in close agreement with the findings of Jadhav *et al.* (2013) [8] and Sideeg (2015) [14].

The female gall flies lived for 1.0 to 1.5 days after completion of egg laying and occupying on an average post-oviposition period of 1.05 + 0.16 days (Table 2). Jadhav *et al.* (2013) [8] reported an average post-oviposition periods of *P. matteiana* female as 1.24±0.20 days.

The longevity of male gall flies ranged from 1.5 to 2.5 days with an average of 2.30±0.35 days, while the longevity of female gall flies ranged from 2.5 to 4.0 days with an average of 3.60±0.37 days (Table 2). Sideeg (2015) [8] reported the longevity of the adult ranged from 2 to 4 days, with an average of 2.0±0.00 and 3.7±0.41 days for male and female, respectively. These findings are also in line with the results of Jadhav *et al.* (2013) [8]. This duration of male and female gall flies reported by above workers were more or less in agreement with the present findings.

The egg laying capacity of female varied from 6 to 9 eggs with an average of 8.20±0.92 eggs (Table 2). The egg laying capacity of female varied from 7 to 10 eggs as reported by Jadhav *et al.* (2013) [8].

The sex ratio of male: female was varied from 1:0.67 to 1:1.14 with an average of 1: 0.84 under laboratory condition, indicating preponderance of female over male (Table 2). Sideeg (2015) [14] reported the sex-ratio of *P. matteiana* as 1:1. More or less similar results have been opined by Askari and Bagheri (2005) [1] [1:1] and Jadhav *et al.* (2013) [8] [1:0.67]. The total life cycle of *P. matteiana* occupied on an average of 15.80±0.79 days ranging from 15 to 17 days in case of male, while 18.80±1.23 days ranging from 17 to 20 days in case of female (Table 2). The whole life-cycle of *P. matteiana* was completed in 25.24±3.16 days (Memon *et al.*, 2017) [11]. Present findings are in close agreement with the report of Jadhav *et al.* (2013) [8].

Conclusion

It is concluded that the incubation period, maggot period, pupal period, male and female adult period of leaf gall midge, *P. matteiana* on mango was 2.25 + 0.35, 6.40±1.05, 6.15±0.82, 2.30±0.35 and 3.60±0.37 days, respectively. The total life period of male and female adult of *P. matteiana* was 15.80±0.79 and 18.80±1.23 days, respectively. Male gall flies were comparatively smaller than female. The average sex ratio (male: female) of *P. matteiana* was found 1: 0.84.

References

1. Askari M, Bagheri A. Biology and comparative morphology of two cecid flies, *Procontarinia matteiana* and *Erosomyia mangiferae* (Diptera: Cecidomyiidae), in Hormozgan Province. J Entomol Soc Iran. 2005;25(1):27-42.
2. Askari M, Radjabi G. Study on the biology and population fluctuations of mango gall midge, *Procontarinia matteiana* (Diptera: Cecidomyiidae) in Hormozgan province. Appl Entomol Phytopathol.

2003;70:121-35.
3. Augustyn WA, Du Plooy W, Botha BM, Van WE. Infestation of *Mangifera indica* by the mango gall midge, *Procontarinia matteiana*, (Kieffer & Cecconi) (Diptera: Cecidomyiidae). Afr Entomol. 2023;21(1):79-88.
4. Botha W, Kotze JM. Life cycle of the mango gall fly, *Procontarinia matteiana* Kieffer and Cecconi. Year Book South African Mango Growers Assoc; c1987. p. 7-19.
5. Boucek Z. Taxonomic study of Chalcidoid wasps (Hymenoptera) associated with midges (Diptera: Cecidomyiidae) on mango trees. Bull Entomol Res. 1986;76:393-407.
6. Githure CW, Schoeman AS, Mc Geoch MA. Differential susceptibility of mango cultivars in South Africa to galling by the mango gall fly, *Procontarinia matteiana* Kieffer and Cecconi (Diptera: Cecidomyiidae). Afr Entomol. 1998;6(1):33-40.
7. Harris KM, Schreiner IH. A new species of gall midge (Diptera: Cecidomyiidae) attacking mango foliage in Guam, with observations on its pest status and biology. Bull Entomol Res. 1992;82(1):41-48.
8. Jadhav KM, Patel RK, Patel SA. Biology of gall fly, Proconarinia matteiana (Kieffer & Cecconi) on mango. AGRES- An Int e-J. 2013;2(4):358-362.
9. Jhala RC, Patel ZP, Shah AH. Studies on the relative occurrence of leaf-gall midge (*Procontarinia matteiana* Kieffer and Cecconi) on different varieties of mango in south Gujarat, India. Trop Pest Manage. 1987;33:277-279.
10. Kaushik DK, Baraiha U, Thakur BS, Parganiha OP. Pest complex and their succession on mango (*Mangifera indica*) in Chhattisgarh, India. Plant Arch. 2012;12:303-306.
11. Memon MQ, Lanjar AG, Lohar MK, Ristamani MA, Bukero A, Khusk GM, *et al*. The biology of mango leaf gall midge, *Procontarinia matteiana* Kieffer and Cecconi (Diptera: Cecidomyiidae). Sci Int. (Lahore). 2017;29(1):267-269.
12. Pascual-Alvarado P, Cuevas-Reyes P, Quesada M, Oyama K. Interactions between galling insects and leaf-feeding insects: The role of plant phenolic compounds and their possible interference with herbivores. J Trop Ecol. 2008;24:329-336.
13. Samui G, Jha S. Branch gall of mango (*Oligotrophus mangiferae* Keiffer), its bio-ecology and management. J Plant Prot Sci. 2012;4(1):27-32.
14. Sideeg HGM. The biology, ecology and control of mango leaf gall midge, *Procontarinia matteiana* (Kieffer & Cecconi) (Diptera: Cecidomyiidae). PhD Thesis, Sudan University of Science and Technology; c2015. Available from: http://repository.sustech.edu/handle/123456789/12243?show=full
15. Srivastava RP. Mango insect pest management. Int. Book Distributing Co., Lucknow, India; c1997.
16. Srivastava RP. Mango insect pests and their management. In: Mango cultivation. Int. Book Distribution Co., Lucknow; c2000. p. 187-299.
17. Strydom C. Gall fly on mango. S Afr. Mango Grow Assoc Newslett. 2011;57:1-3.
18. Van Zyl E, Kotzé JM, Steyn PL. Isolation of Xanthomonas campestris pv. *Mangiferae indicae* from gall fly induced lesions on mango leaves. Phytophylactica. 1988;20:89-90.
19. Zala MB, Bharpoda TM. Seasonal occurrence of major insect pests of mango. Pharma Innovation J. 2022;SP-11(7):21-28.