fourth and fifth instar larvae of PM×CSR2 (Kolar Gold) against *Bm*NPV and *Staphylococcus sciuri*.

Inoculation of silkworms with bacterial isolate

Inoculation of silkworms was done on the fourth and fifth instar first day, *i.e*., immediately after the third and fourth moult. The bacterial stock was prepared, from which 10^{-7} dilution (2.33×10^{9} CFU/ml) was prepared using 9 ml distilled water. The newly moulted fourth and fifth instar larvae were starved for 6 hours and distributed in trays. Each treatment contained three replications (50 larvae/replication). The suspension of haemolymph bacteria was smeared on mulberry leaves and fed to silkworms at 1 ml/50 larvae.

Inoculation of silkworms with *Bm*NPV

The serial dilution (10^{-9}) of *Bm*NPV suspension (6.75×10^{4}) was prepared using distilled water. After the complete feeding of mulberry leaves smeared with bacteria, the larvae were fed with a mulberry leaf smeared with 1.00 ml of diluted PIBs suspension. Three batches were kept as a control in which larvae were fed with leaves smeared with distilled water, the second batch was a leaf with methanol, and the third batch was only mulberry leaves without any application. All the larvae of each treatment and control were fed on fresh mulberry leaves till spinning.

Application of botanical extracts

After 30 minutes of inoculation with PIBs, each botanical extract (1:3) was smeared on leaves and fed to silkworms at 1 ml/50 larvae (Fig. 1). The control batches were fed with distilled water and methanol-sprayed leaves.

Fig 1. Mulberry leaves smeared with leaf extracts before administration

RESULTS AND DISCUSSION

A significant difference was observed between the healthy and inoculated batches, whereas the results were on par with the three controls. The interaction effect between plant extracts and the health of silkworms in both the instars administered showed non-significant results (Table 1). The aqueous and methanolic leaf extracts of *A. vasica* and *P. niruri* were administered to the fourth and fifth instar batches of silkworm (PM×CSR2). The data on cocoon weight registered maximum in methanolic extract of both *P. niruri* (1.94 and 1.81 g/cocoon*)* and *A. vasica* (1.89 and 1.78 g) followed by aqueous extracts (1.81 and 1.72., 1.78 and 1.69 g), respectively. Further, the *Bm*NPV and *S. sciuri* inoculation to silkworms followed by botanical extract administration have recorded the cocoon weight of 1.47, 1.54, 1.48 and 1.56 g in the fourth and 1.52, 1.60, 1.53 and 1.64 g in fifth instar silkworms administered with aqueous and methanolic extracts of *A. vasica* and *P. niruri.* Furthermore, the control batches *viz*., distilled water, methanol and absolute control recorded higher cocoon weight in healthy (1.67, 1.58 and 1.57g in the fourth instar; 1.67, 1.62 and 1.62 g in the fifth instar) compared to inoculated silkworms (1.44, 1.46 and 1.37 g in fourth instar; 1.46, 1.50 and 1.45 g in fifth instar).

Significant results were recorded for shell weight over the control in plant extracts administered in batches of fourth and fifth instars (Table 2). The methanolic extract of *P. niruri* recorded the highest shell weight in healthy and inoculated batches of the fourth (0.326 and 0.255 g) and fifth instar (0.298 and 0.271 g) compared to the methanolic extract of *A. vasica* (0.301 and 0.251., 0.289 and 0.259 g), aqueous extract of *P. niruri* (0.293 and 0.234., 0.278 and 0.247 g) and *A. vasica* (0.291and 0.229., 0.273 and 0.239 g). The fourth instar treated silkworm batch recorded significantly higher shell weight (0.260, 0.276, 0.264 and 0.291 g) than the fifth instar batches (0.256, 0.274, 0.263 and 0.284 g). The control batches *viz.*, distilled water control (0.259 and 0.217, 0.257 and 0.209 g), methanolic control (0.251 and 0.209., 0.250 and 0.210 g), and absolute control (0.249 and 0.206., 0.257 and 0.209 g) recorded significantly lesser shell weight compared to botanical treated batches of both healthy and infected silkworms (Table 2). The interaction effect between plant extracts and the health of silkworms (healthy and infected) was found non-significant.

The effect of administering medicinal plant extracts to healthy and inoculated batches of fourth and fifth instar PM×CSR2 on pupal weight was assessed, and recorded significant results. The pupal weight of 1.58, 1.51, 1.45 and 1.45 g was recorded and found non-significant in the

Table 1. Effect of administration of plant extracts of *Adhatoda vasica* and *Phyllanthus niruri* on cocoon weight (g) of fourth and fifth instar treated batches of *B. mori*

Treatments	IV instar			V instar		
	Healthy	Inoculated	Mean	Healthy	Inoculated	Mean
***A. vasica* -Aqueous**	1.78	1.47	1.63	1.69	1.52	1.61
A. vasica-Methanol	1.89	1.54	1.71	1.78	1.60	1.69
P. niruri-Aqueous	1.81	1.48	1.64	1.72	1.53	1.63
P. niruri-Methanol	1.94	1.56	1.75	1.81	1.64	1.72
Distilled water control	1.67	1.44	1.55	1.67	1.46	1.56
Methanol control	1.58	1.46	1.52	1.62	1.50	1.56
Absolute control	1.57	1.37	1.47	1.62	1.45	1.54
Mean	1.75	1.47	1.61	1.70	1.53	1.62
Results	**A**	**B**	**AB**	**A**	**B**	**AB**
F-test	*	*	NS	*	*	NS
S.Em ±	0.05	0.02	0.06	0.04	0.02	0.06
CD at 5 % level	0.13	0.07	0.19	0.12	0.06	0.17

*Significant at 5 % level, NS: Non-significant; A: Plant extracts, B: Health of silkworm

Table 2. Effect of administration of plant extracts of *Adhatoda vasica* and *Phyllanthus niruri* on shell weight (g) of fourth and fifth instar treated batches of *B. mori*

Treatments	IV instar			V instar		
	Healthy	Inoculated	Mean	Healthy	Inoculated	Mean
A. vasica - Aqueous	0.291	0.229	0.260	0.273	0.239	0.256
A. vasica- Methanol	0.301	0.251	0.276	0.289	0.259	0.274
P. niruri-Aqueous	0.293	0.234	0.264	0.278	0.247	0.263
P. niruri-Methanol	0.326	0.255	0.291	0.298	0.271	0.284
Distilled water control	0.259	0.217	0.238	0.257	0.209	0.233
Methanol control	0.251	0.209	0.230	0.250	0.210	0.230
Absolute control	0.249	0.206	0.228	0.257	0.209	0.233
Mean	0.282	0.229	0.255	0.272	0.235	0.253
Results	**A**	**B**	**AB**	**A**	**B**	**AB**
F-test	*	*	NS	*	*	NS
S.Em ±	0.005	0.003	0.007	0.009	0.005	0.012
CD at 5 % level	0.015	0.008	0.021	0.025	0.013	0.035

*Significant at 5 % level, NS: Non-significant; A: Plant extracts, B: Health of silkworm

fourth instar healthy silkworm batch administered with methanolic extract of *P. niruri, A. vasica,* aqueous extract of *P. niruri* and *A. vasica,* respectively. The trend was the same in the fifth instar healthy batch, which recorded 1.46, 1.44, 1.39 and 1.37 g of pupal weight compared to their controls.

Further, in the pathogen (*Bm*NPV and *S. sciuri*) inoculated batches, significant results were found for the maximum pupal weight of 1.24, 1.22, 1.19 and 1.17 g in methanolic extract of *P. niruri, A. vasica,* aqueous extract of *P. niruri* and *A. vasica* of fourth instar. The trend was same in the fifth instar inoculated batch (1.32, 1.30, 1.24 and 1.22 g). Among the three control batches maintained for healthy and inoculated batches of both the instars, the healthy silkworms recorded maximum pupal weight (1.37, 1.34 and 1.33., 1.35, 1.32and 1.31 g) compared to inoculated batches (1.14, 1.18 and 1.11., 1.16, 1.17 and1.17 g) in distilled water, methanol and absolute control, respectively (Table 3).

The *in-vivo* effect of botanical extracts and their additive effect on *Bm*NPV and *S. sciuri* inoculation to the fourth and fifth instar of PM×CSR2 registered non-significant results for shell ratio (Table 4). The highest shell ratio of 17.65 and 16.21., 16.69 and 16.05 per cent

Table 3. Effect of administration of plant extracts of *Adhatoda vasica* and *Phyllanthus niruri* on pupal weight (g) of fourth and fifth instar treated batches of *B. mori*

Treatments	IV instar			V instar		
	Healthy	Inoculated	Mean	Healthy	Inoculated	Mean
A. vasica -Aqueous	1.45	1.17	1.31	1.37	1.22	1.30
A. vasica-Methanol	1.51	1.22	1.36	1.44	1.30	1.37
P. niruri-Aqueous	1.45	1.19	1.32	1.39	1.24	1.31
P. niruri-Methanol	1.58	1.24	1.41	1.46	1.32	1.39
Distilled water control	1.37	1.14	1.25	1.35	1.16	1.26
Methanol control	1.34	1.18	1.28	1.32	1.17	1.24
Absolute control	1.33	1.11	1.22	1.31	1.17	1.24
Mean	1.44	1.18	1.31	1.38	1.23	1.30
Results	**A**	**B**	**AB**	**A**	**B**	**AB**
F-test	NS	*	NS	NS	*	NS
S.Em ±	0.04	0.02	0.06	0.03	0.02	0.05
CD at 5 % level	0.12	0.06	0.17	0.10	0.05	0.14

*Significant at 5 % level, NS: Non-significant; A: Plant extracts, B: Health of silkworm.

in the methanolic extract of *P. niruri*, followed by *A. vasica* (17.47 and 16.11., 16.64 and 16.00 %). However, the aqueous extract of *P. niruri* (17.18 and 16.09., 16.63 and 15.98 %) and *A. vasica* (16.57 and 16.01., 16.43 and 15.96 %) recorded comparatively less shell percentage in healthy and inoculated batches of both fourth and fifth instars. Between the instars, the fourth instar treated batches found a maximum shell ratio (16.93, 16.64, 16.79 and 16.29 %) compared to the fifth instar (16.37, 16.30, 16.32 and 16.19 %).

Similar results were observed by Rudroju *et al*. (2017), who studied the effect of leaf extracts of *Trichosanthes cucumerina* L. on the cocoon parameters of the flacherie-infected silkworm. The methanolic extract of the leaf showed the highest cocoon characteristics *viz*., cocoon weight (1.94±0.11g), shell weight (0.39± 0.01g) and pupal weight (1.54±0.08g) over the control (1.63±0.02 g). The study on the efficacy of nine different medicinal plant extracts for managing late larval flacherie of silkworm (PM×CSR2) and cocoon parameters was carried out by Manjunatha *et al.* (2020). Among nine medicinal plant extracts administered, *Phyllanthus niruri* was found effective by enhancing the cocoon parameters *viz.,* cocoon weight (10.51 g/10 cocoons), shell weight (1.610 g/10 cocoon shells), pupal weight (8.90 g/10 pupae) and shell ratio (16.46 %) as reflected in the present study.

The aqueous extract of *Ziziphus jujuba* L. was fortified to fifth instar PM×CSR2 larvae (Sunil and Chandrashekhar, 2016) and recorded maximum cocoon weight (1.766, 1.531 and 1.723 g/cocoon), shell weight (0.309, 0.264 and 0.33 g/shell), pupal weight (1.459, 1.267 and 1.393 g/pupa) and shell ratio (17.65, 17.29 and 19.37 %) at 1:2, 1:4 and 1:8 concentrations compared to control (1.322, 0.221, 1.101 g and 16.80 %). Further, the ethanolic extract of *Ocimum sanctum* (2 %) was administered to fifth instar silkworms (PM×CSR2) and recorded cocoon parameters *viz*., cocoon weight, shell weight, pupal weight and cocoon shell ratio (Devi and Bai, 2015), which was found similar with the present study where the cocoon weight, shell weight, pupal weight and cocoon shell ratio were found more in botanical administered silkworm batches compared to healthy and infected controls because of the presence of biomolecules which acts as antimicrobial agents against virus and bacteria in infected batches. In contrast, the biomolecules exhibited an additive effect in healthy batches by supplying extra protein molecules for silk synthesis.

Sisodia and Gaherwal (2019) recorded the effect of amla plant extract on *Bacillus subtilis* infected silkworm and found increased cocoon shell weight (0.178±1.56 g/shell) compared to control (0.16 ±1.40 g/shell). Further, Chavan and Bhawane (2016) also studied the effect of ethanolic plant extract on *Bm*NPV infection and cocoon parameters of pure Mysore and CSR2 silkworm breeds. *Curcuma longa* recorded maximum cocoon weight (995.20 mg/cocoon) and shell weight (147.50 mg/shell) in CSR2. In contrast, in PM, the maximum cocoon weight (931.3 mg/cocoon) was recorded in *Bougainvillea spectabilis,* with shell weight (222.0 mg/shell) in *A. Mexicana,* which is in line with the present findings. Kuntamalla *et al.* (2015) recorded

Table 4. Effect of administration of plant extracts of *Adhatoda vasica* and *Phyllanthus niruri* on shell ratio (%) of fourth and fifth instar treated batches of *B. mori*

Treatments	IV instar			V instar		
	Healthy	Inoculated	Mean	Healthy	Inoculated	Mean
A. vasica -Aqueous	16.57	16.01	16.29	16.43	15.96	16.19
A. vasica-Methanol	17.47	16.11	16.79	16.64	16.00	16.32
P. niruri-Aqueous	17.18	16.09	16.64	16.63	15.98	16.30
P. niruri-Methanol	17.65	16.21	16.93	16.69	16.05	16.37
Distilled water control	16.86	15.62	16.24	16.14	15.92	16.03
Methanol control	16.94	15.61	16.28	16.30	15.84	16.07
Absolute control	16.74	14.99	15.87	16.08	15.82	15.95
Mean	17.06	15.81	16.43	16.42	15.94	16.18
Results	**A**	**B**	**AB**	**A**	**B**	**AB**
F-test	NS	NS	NS	NS	NS	NS
S.Em ±	0.63	0.34	0.89	0.48	0.26	0.68
CD at 5 % level	1.83	0.98	2.59	1.40	0.75	1.98

NS: Non-significant; A: Medicinal plants, B: Health of silkworm

higher single cocoon weight (1.571 g), shell weight (0.258 g), pupal weight (1.316 g) and silk ratio (15.97 %) in 3 per cent concentration of aqueous leaf extract of *O. sanctum* compared to other concentrations (1, 2 and 4 %).

The effect of botanical extract of turmeric, amla, asparagus, bael, berhavia, garlic and basil on the shell ratio of silkworms infected with *Bacillus* sp. revealed that the silkworms treated with Boerhavia leaf extract recorded a maximum shell ratio (18.12 %) compared to amla leaf extract (17.04 %) (Priyadharshini *et al*. 2009). The increase in cocoon parameters may be due to phytochemical constituents such as steroids, alkaloids and flavonoids that inhibit the gut microorganisms which compete with the host for nutrients. The ingredients have stimulated the synthesis of silk proteins and nucleic acids, which there by increase silk content.

CONCLUSION

The plant extracts administered to silkworms were inhibited the pathogen multiplication and recorded maximum cocoon weight, shell weight, pupal weight and shell ratio in methanolic extracts of *P. niruri* followed by *A. vasica*, aqueous extract of *P. niruri* and *A. vasica* administered healthy and pathogen inoculated (*Bm*NPV and *S. sciuri*) silkworms. The reduced pathogenicity and increased cocoon parameters were due to the presence of many secondary metabolites which possess antimicrobial property against wide range of bacteria and virus.

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Biology and morphometrics of peach fruit fly, *Bactrocera zonata* (Saunders) on mango

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ABSTRACT: The investigation on biology and morphometrics of *Bactrocera zonata* (Saunders) was undertaken at the Department of Entomology, Navsari Agricultural University, Navsari, Gujarat, India during 2021-22. The eggs were smooth, white, shiny, translucent, rice grain shaped, slightly curved, elongated and tapered at the anterior end but broadly rounded at the posterior end. The hatching percentage was 82.63±6.94%. The incubation, maggot, pre-puparial, puparial, pre-oviposition, oviposition and post-oviposition periods were 2.40±0.48, 7.20±1.51, 0.77±0.11, 8.10±1.02, 12.3±1.13, 13.30±2.45 and 5.10±0.72 days, respectively. The morphometric measurements of egg, maggot, pre-puparia, puparia, adult male and female were also studied along with duration of different life stages. The pupationtook place at depth of 0.50 to 6.00 cm in moist soil. The sex ratio of male: female was 1:1.20. The fecundity of gravid female was 176±31.8 eggs/female. The total life cycle was completed in 22.00 to 36.00 days on mango.

Keywords: Biology, morphometrics, *Bactrocera zonata*, mango

INTRODUCTION

The peach fruit fly, *Bactrocera zonata* (Saunders) (Diptera: Tephritidae) is one of the most destructive pests of horticultural crops causing huge crop loss in various regions of the world. It is native to South and Southeast Asia. It was first recorded in Iraq in 1972 (El-Haidari *et al*., 1972). It is, a close relative and resource competitor of *B. dorsalis* (Hendle), which is currently distributed in more than 20 countries including India, Pakistan, Mauritius, Reunion, Arabian Peninsula and North Africa. Just as *B. dorsalis*, *B. zonata* adults are highly invasive, strong fliers and have high reproductive potential with females laying up to 564 eggs. It is a polyphagous pest and has been reported to infect fruits of peach, mango, citrus, papaya, watermelon and Alfalfa (Al-Ali, 1977; Alzubaidy, 2000; Stonehouse *et al*., 2002; Abdulrazak *et al*., 2016). The pest caused 25 to 50% losses in guava fruits (Syed *et al*., 1970). The damages caused by peach fruit fly may be reached 100% of fruit without control (Hardy, 1997; Jena *et al*., 2022a). These are regarded as quarantine pests (Joomaye *et al*., 2000; Jena *et al*., 2022b).The knowledge about different life stages of insect pest, morphometrics of various life stages and their developmental time duration is highly helpful to increase awareness about pest. The monitoring of pre-oviposition, oviposition and post-oviposition periods, fecundity and the adult longevity is helpful for developing management strategies that will keep mangoes and environment away from detrimental effect of insecticides. This investigation will be also help in the identification of pest. Therefore, the present investigation was carried out to study the biology and morphometrics of *B. zonata* under laboratory condition.

MATERIALS AND METHODS

Studies on the selected aspects of biology of *B. zonata* infesting mango was carried out at the Department of Entomology, N.M. College of Agriculture, Navsari Agricultural University, Navsari during 2021-22. The data on temperature and relative humidity were recorded daily in the laboratory during the entire investigation period.

Rearing technique: The initial culture of *B. zonata* was raised by collecting infested fruits of mango from the College farm, N.M. College of Agriculture, Navsari and Regional Horticultural Research Station Farm, ASPEE College of Horticulture and Forestry, Navsari Agricultural University, Navsari, Gujarat. Infested fruits were kept in rearing jar having 15cm diameter and 20cm height on a 5cm thick layer of sieved moist sand to obtain the puparia. The top of each jar was covered with white

Table 1. Morphometrics of different life stages of *B. zonata* on mango

Stages	Length (mm)			Breadth (mm)		
	Min.	Max.	Mean±S.D.	Min.	Max.	Mean ± S.D.
Egg	0.72	1.04	0.90±0.10	0.14	0.27	0.20±0.04
Maggot						
First instar	1.34	1.48	1.43±0.05	0.18	0.28	0.23±0.03
Second instar	5.20	6.40	5.90±0.39	0.60	1.20	0.97±0.22
Third instar	7.68	8.80	8.05±0.45	1.40	1.52	1.47±0.04
Pre-puparium	7.10	8.40	7.83±0.40	1.90	2.12	2.01±0.08
Puparium	4.10	8.40	6.75±1.49	2.10	2.12	2.11±0.01
Adult						
Male	4.20	5.10	4.72±0.24	8.42	11.40	10.25±0.93
Female	5.32	6.21	5.87±0.31	10.40	12.60	11.68±0.87

n=20

muslin cloth to prevent the maggots from escaping. When all the full grown maggots entered in to the sand for pupation, rotten fruits were removed from the jars. Sand in the jar was sieved after every 4 to 5 days to collect the puparia. Thereafter puparia were transferred in clean plastic bottle having 1.50cm diameter and 7.50cm height, individually. These bottles were covered with lid to prevent the escaping of flies. The flies emerged were utilized for further studies on biology.

Freshly emerged adults were paired and confined in glass jars having 15cm diameter and 20cm height covered with white muslin cloth bag. One end of bag was held in position on the top of the jar with the help of rubber band, while the other end of the bag was kept open for introducing the adults in to the jar. The open end of the bag was tightened with rubber band to prevent the adults from escaping. Such jars were put in wooden cages (45.50×46.50×76.50cm) to prevent damage of rats and ants. A cotton swab having five per cent sugar solution was suspended inside the jar as food to the adult flies. One physiologically mature fruit of mango was placed inside the glass jar for oviposition by female. The fruit was replaced after observing the oviposition puncture. The fruit punctured due to egg laying was cut open with a fine razor blade and eggs laid if any were confirmed using magnifying lens. About (2×1×1cm) size piece of fruit having eggs was smoothly cut and transferred in a separate Petri dish and it was observed twice a day for their hatching. Eggs were carefully transferred with a fine hair brush on a glass slide and observed under microscope to study their morphometric characters.

When eggs hatched out, the neonate maggots were gently transferred on a fresh fruit slice (2×2×1cm); later on, they were kept in a Petri dish for further rearing. The food (fruit slices) as well as Petri dishes were changed every day to avoid microbial development on fruit slice. The maggots were reared following this method until they were full grown and transferred along with Petri dish in small glass jar having 15cm diameter and 20cm height filled with a layer of 5cm moist sand. The jars were covered with muslin cloth duly tightened with rubber bands to prevent the escape of maggots.

Egg: Eggs were examined under the microscope for studying their colour, shape and size, while for measurement it was gently transferred under compound microscope with the help of moist hair brush. The Trinocular microscope (SZ-61; Make: Olympus) attached with software scope Plate (Version 3.1) was used for measuring the eggs. To study the incubation period, twenty freshly laid eggs on fruit (slice) were observed daily in the morning and evening till hatching. The eggs were considered as hatched when tiny maggots came out from it, whereas hatching percentage was calculated from the number of eggs hatched out of total numbers of eggs kept under observation.

Maggot: About 2cm thick fruit slices of mango were kept individually in Petri dish. A slice was slightly ruptured with the help of scalpel for easy entry of the maggot. The newly hatched maggots were transferred individually on that slice. Maggots were reared till they underwent pupation. The food was changed every morning to maintain sanitation in the Petri dish. Newly hatched,

Fecundity: To determine the fecundity, the number of eggs laid in fruit by females were counted and the average fecundity was calculated.

Longevity: Longevity of male and female were calculated separately from the date of emergence to the death of adult.

Total life cycle: The period from eggs laid to the death of adult was considered as the total life cycle.

RESULTS AND DISCUSSION

Egg: The female *B. zonata* laid eggs in clusters of 2 to 14 eggs underneath the rind of the fruit with the help of a sharp ovipositor at a depth of about 1 to 4mm. The eggs were embedded in the pulp of fruit vertically or slightly angled and twisting with each other. Similar observations were also made by Narayanan and Batra (1960), Butani (1979) and Amur *et al*. (2017). The eggs were smooth, white, shiny, translucent, rice grain shaped, slightly curved, elongated and tapered at the anterior end but broadly rounded at the posterior end. They turned dark brown colour as they were nearer to the hatching. Similar findings were also found by Amur *et al*.(2017) as well as Naik *et al*.(2017).The length and breadth of eggs varied from 0.72 to 1.04mm with an average of 0.90±0.10mm and 0.14 to 0.27mm with an average of 0.20±0.04mm, respectively (Table 1). The present findings are similar to those made by Dale (2002) who recorded that the length and breadth of eggs of *B. zonata* varied from 0.75 to 1.01mm and 0.16 to 0.25mm, respectively in size but it is less accordance with Leghari (2013) who reported that the size of eggs varied from 0.50 to 0.60mm of both fruit flies, *B. dorsalis* and *B. zonata*.

The incubation period of eggs of *B. zonata* varied from 1.60 to 3.40 days with an average of 2.40±0.48 days on mango (Table 2). Almost similar observations on incubation period was also reported by Dale (2002) who reported the incubation period as 1.00 to 2.50 days on mango for *B. zonata*; 10.16, 3.46, 2.04, 1.42 and 1.54 days at 15, 20, 25, 30 and 35°C temperature, respectively for *B. zonata* (Duyck *et al*., 2004); 4.50±0.50, 3.18±0.18, 2.40±0.40 and 2.00±0.50 days at 20, 25, 30 and 35°C

Table 2. Duration of different life stages of *B. zonata* on mango

Stage	Periods		
	Min.	Max.	Mean±S.D.
Incubation period (Days)	1.60	3.40	2.40±0.48
Hatching percentage (%)	65.00	95.00	82.63±6.94
Total maggot period (Days)	4.00	10.00	7.20±1.51
Pre-puparial period (Days)	0.58	0.96	0.77±0.11
Puparial period (Days)	6.00	9.00	8.10±1.02
Sex ratio (Male: female)	1:1.00	1: 1.70	1:1.20
Adult period (Days)			
Pre-oviposition	10.00	14.00	12.30±1.13
Oviposition	9.00	18.00	13.30±2.45
Post-oviposition	4.00	6.00	5.10±0.72
Fecundity (eggs/female)	120	240	176.00±31.81
Longevity (Days)			
Male	10.00	18.00	13.95±2.06
Female	14.00	26.00	21.50±3.14
Total life cycle (Days)			
Male	22.00	29.00	25.58±1.88
Female	28.00	36.00	30.94±2.80

n=20

Plate 1: Eggs of *B. zonata*

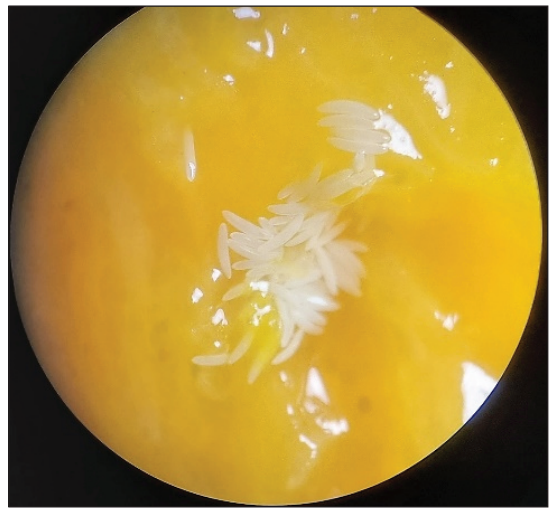

Plate 2: Microscopic view of eggs

Plate 3: First instar maggot of B. *zonata*

Plate 4: Second instar maggot of B. *zonata*

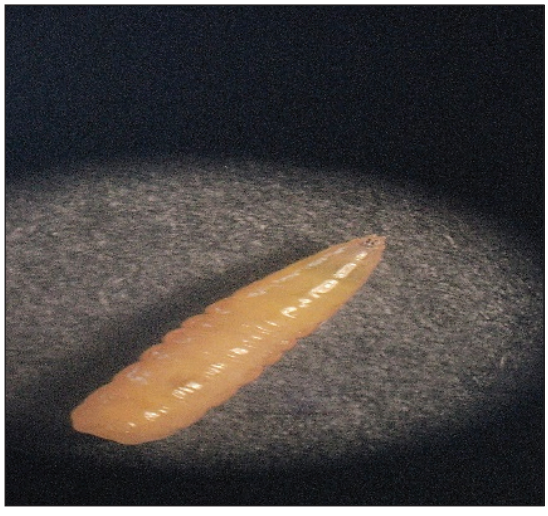

Plate 5: Full grown maggot of B. *zonata*

Plate 6: Pre-puparium of B. *zonata*

Plate 7: Puparia of *B. zonata*

Plate 8: Newly emerged adults of *B. zonata*

Plate 9: Adult male of *B. zonata*

Plate 10: Adult female of *B. zonata*

second instar and fully grown maggots were observed under microscope to study the colour, shape and size.

Pre-puparium: A stage, when full grown maggot ceased feeding and became inactive was considered as pre-puparial stage. Such maggots were transferred with food to glass jar having 15cm diameter and 20cm height and have 5cm layer of moist sand at the bottom to facilitate pupation. Observations on colour, shape and size of pre-puparial stage were also be recorded. The length and breadth of pre-puparial stage were measured under microscope. The pre-puparial period was recorded for individual maggot reared on fruit.

Puparium: The puparia were collected by sieving moist sand in the jar and their shape, size, colour and period were studied. The length and breadth were also measured. Puparial period was calculated from the date of formation of puparium to the date of emergence of the adult from the puparium.

Adult: The newly emerged adults were observed critically for their shape, colour and sex differences while ten adults each of male and female were taken from the stock culture and killed by placing in KCN bottle for studying their size under microscope critically.

Sex ratio: To study the sex ratio, puparia were kept in the glass jar on the layer of 5cm moist sand and jar was covered with white muslin cloth fixed with a rubber band to prevent the escape of adults. Sex ratio was calculated by separating males and females, based on their morphological characters.

Pre-oviposition, oviposition and post-oviposition period: Pre-oviposition period was calculated from the date of emergence of female to the date of starting of egg laying. Oviposition period was calculated from the date of starting egg laying to the date of ceasing of egg laying. Post-oviposition period was calculated from the date of ceasing of egg laying to the death of female.

temperature, respectively for *B*. *zonata* (Younes and Akel, 2010); 11.30±1.50, 6.30±2.10 and 1.80±0.30 days at 20, 25 and 40°C for *B*. *zonata* (Fetoh *et al*., 2012); 1.00 to 2.00 days for *B*. *zonata* (Leghari, 2013); 8.00 to 11.00, 5.00 to 6.00, 1.00 to 4.00 and 1.00 to 2.00 days at 15, 20, 25 and 30°C temperatures, respectively for *B*. *zonata* (Ali, 2016).

The hatching percentage of eggs of *B*. *zonata* varied between 65.00 to 95.00 per cent with an average of 82.63±6.94 per cent on mango (Table 2). The present findings are akin with Dale (2002) who recorded that the hatching percentage of *B*. *zonata* was 66.67 to 91.67 per cent for *B*. *zonata*; 30.24, 83.06, 90.33 and 71.18 per cent at 20, 25, 30 and 35°C temperature, respectively for *B*. *zonata* (Younes and Akel, 2010); 66.00 to 97.00 per cent at 40°C and 25°C, respectively for *B*. *zonata* (Fetoh *et al*., 2012); 86.00, 86.00, 68.00 per cent at 30, 25, 20±2°C temperature and 63.00 per cent at field conditions for *B*. *zonata* (Abu-Ragheef and Al-Jassany, 2018).

Maggot: The damaging stage of *B*. *zonata i.e*., maggot underwent metamorphosis and passed through three instars with different size and morphology which is supported by Christenson and Foote (1960), Weems *et al*. (2015) and Amur *et al*., (2017).

The first instar maggots were translucent and white with slightly yellowish colour except its mouth parts, which were black in colour. The head was pointed and slightly bent downward with a pair of mandibular hooks. The maggot was apodous with three thoracic and nine abdominal segments. The cuticle of maggot was so translucent that the internal organs were visible through it. They were generally less active as compared to other two instars. Similar morphological characters were also observed by Narayanan and Batra (1960) who observed that young maggots of *D*. *dorsalis* were white, translucent as well as Amur *et al*. (2017) who noticed that the 1st instar was inactive and small in size as compared to two other instars. Additionally, similar findings were found by Naik *et al*. (2017) who observed that the freshly hatched maggot of *B*. *dorsalis* was pale white in colour with translucent body. The length of newly emerged maggot varied from 1.34 to 1.48mm, while the breadth varied from 0.18 to 0.28mm on mango (Table 1). The average length of newly emerged maggot (first instar) was 1.43±0.05 mm whereas, the breadth measured was 0.23±0.03 mm. A similar finding was reported by Narayanan and Batra (1960) who observed that young maggot of *D*. *dorsalis* was measured about 1.50×0.30mm. However, the present findings are slightly deviated from the work of Kalia and Yadav (2015) who recorded that the mean body length and width of *B*. *dorsalis* of the freshly hatched maggot were 2.87±0.74 and 2.25±0.70mm, respectively. Further, Amur *et al*. (2017) reported that the first instars measured 2.60±0.75mm in length and 0.27±0.82mm in width; the length and width of maggots of *B*. *dorsalis* on custard apple were 6.07±1.97 and 1.75±0.89mm, respectively (Naik *et al*., 2017) which deviate from the present findings.

The second instar maggot of *B*. *zonata* was slightly larger and more yellowish than first instar maggot possessing the externally visible alimentary canal. These findings are agreed with those of Amur *et al*. (2017) who noticed that the second instar of *B*. *dorsalis* had a distinguishing characteristic *i.e*., presence of externally visible alimentary canal. The length of second instar maggot varied from 5.20 to 6.40mm with an average of 5.90±0.39mm, while the breadth varied from 0.60 to 1.20mm with an average of 0.97±0.22mm on mango (Table 1). These findings are slightly different from those of Amur *et al*. (2017) who reported that the second instars of *B*. *dorsalis* measured 5.88±0.55mm in length and 2.34±0.70mm in width.

The third instarmaggotof *B*. *zonata* was apodous, longer and broader with cephalic end and blunt at posterior end. The colour of full grown maggot was yellowish and more opaque than both newly emerged or young maggot and second instar maggot. A black mole was present on anterior and caudal side. It fed rapidly in the pulp of mango, formed the tunnels and holes in the fruit pulp and peel, came outside the fruit by holes of peel, moved fast and jumped. The black-coloured mouth hooks were retractile and extended outside the body at the time of feeding. The morphological characters and behaviours observed during the present investigation are similar to those described by Narayanan and Batra (1960) who observed that full grown maggot had a habit of jumping short distance for finding a suitable place for pupation. The present findings are also in agreement with those of Butani (1979) who reported that the maggot of *D*. *dorsalis* was yellow at later stage and head of cephalic segment was pointed anteriorly and trapezoidal in outline; Amur *et al*. (2017) who noted that the third instar maggot of *D*. *dorsalis* fed rapidly in the pulp of mango, formed the tunnels and holes in the fruit pulp and peel, came outside the fruit by holes of peel, moved fast and jumped. Black mole was present on anterior and caudal side; Naik *et al*. (2017) who revealed that the matured maggots of *D*. *dorsalis* were brownish yellow, cylindrical, apodous, frugivorous with an elongated body, pointed anteriorly or cephalic end and blunt posteriorly. The black-coloured mouth hooks were retractile and extended outside the body at the time of feeding. The length and breadth of full grown maggot varied between 7.40 to 8.80mm with an average of 8.05±0.45mm and 1.40 to 1.52mm

with an average of 1.47±0.04mm, respectively (Table 1). In past, Narayanan and Batra (1960) who observed that the fullgrown maggot of *B*. *dorsalis* was 8.00 to 9.00mm long and 1.50mm broad across the posterior end which is in favour of the present findings. However, the present findings are slightly deviated from those of Kalia and Yadav (2015) who recorded that the mean body length and width of *B*. *dorsalis* of full grown maggot was 8.18±0.84 and 2.25±0.70mm, respectively; Amur *et al*. (2017) who reported that the third instar maggot of *B*. *dorsalis* measured 7.69±0.72mm in length and 3.58±0.25mm in width.

Initially the young maggots of *B*. *zonata* emerged from eggs were found sluggish but after feeding for a few hours it became active and bored in to the pulp of fruit and fed there on. The maggots inhabited in liquefied pulp and hanged head downward with their posterior spiracles at the liquid surface. The maggots after full feeding moved from the centre of the fruit where they had been feeding on the soft and fermented skin of fruit. On completion of full development, the maggots bored holes; exited out through hole and fell to the sand or soil for pupation by their jumping movement. It was further noted that the exit holes made for pupation by full grown maggot on damaged fruit was very clearly visible. After leaving the fruit, matured maggot wandered on soil haphazardly and looked for suitable site for pupation.

The total maggot period of *B*. *zonata* ranged from 4.00 to 10.00 days with an average of 7.20±1.51 days (Table 1). These findings are more or less in confirmity with Dale (2002) who recorded the maggot period varied from 6.30 to 9.20 days on mango for *B*. *zonata*; 30.00, 10.00, 5.00, 4.00 and 4.00 days at 15, 20, 25, 30 and 35°C, respectively for *B*. *zonata* (Duyck *et al*., 2004); 14.20±0.20, 10.30±0.33, 7.75±0.05 and 7.01±0.01 days at 20, 25, 30 and 35°C temperature, respectively for *B*. *zonata* (Younes and Akel, 2010); 33.70±3.20, 24.30±4.00, 16.70±2.10, 10.30±1.50 and 6.70±0.60 days from 20°C to 40°C for *B*. *zonata* (Fetoh *et al*., 2012); 26.00 to 29.00, 12.00 to 14.00, 7.00 to 9.00 and 4.00 to 5.00 days at 15, 20, 25 and 30°C temperatures, respectively for *B*. *zonata* (Ali, 2016); 8.20, 19.30 and 13.60 days at 30±2°C, 20±2°C (when the maggots fed on artificial diet) and field conditions (When the maggots fed on mandarin fruit), respectively for *B*. *zonata* (Abu-Ragheef and Al-Jassany, 2018). Rashmi *et al*. (2020) who opined that the duration of the maggot stage of *B*. *zonata* significantly shortened with increase in the range of 16 to 36°C from 53.40 to 6.60 days which is again in tally with the present findings.

Pre-puparium: After having full maggot development, the maggot came out of fruit through the exit hole. Thereafter, it fell on the soil by jumping movement (coiling the body), wandered for some time on soil and finally entered in to soil for pupation. The length and breadth of pre-puparium ranged between 7.10 to 8.40mm with an average of 7.83±0.40mm and 1.90 to 2.12mm with an average of 2.01±0.08mm, respectively (Table 1).The pre-puparial period was 0.58 to 0.96 days with an average of 0.77±0.11days (Table 2). Dale (2002) who recorded that the pre-puparial period of *B*. *zonata* was 16.00 to 23.00 hrs on mango which is agree with the present investigation. However, Amur *et al*. (2017) who found that the pre-puparial period was 2.07±0.86 days which is slightly deviated from the present findings.

Prominent. Additionally, there was the presence of black dot on the posterior portion of puparium. These findings are agreed with those of Narayanan and Batra (1960); Kalia (1992); Kalia and Yadav (2015); Naik *et al*. (2017). The length and breadth of puparium of *B*. *zonata* varied between 4.10 to 8.40 and 2.10 to 2.12mm, respectively. The average length and breadth of puparium measured as 6.75±1.49 and 2.11±0.01mm (Table 1).The length and breadth of puparium measured during present studies were more or less similar to the reports of Kalia (1992) who reported that puparium of *B*. *dorsalis* measured 5.15×2.10, 4.10×1.40, 5.30×2.23 and 4.40×2.30mm in average length and breadth on mango varieties, Dashehari, Amrapali, Mallika and Bangalora, respectively; 4.47±0.64mm in length and 2.69±0.16mm in width on mango (Amur *et al*., 2017); 4.08±0.50mm in length and 1.82±0.69mm in width on custard apple (Naik *et al*., 2017).

The puparial period of *B*. *zonata* varied between 6.00 to 9.00 days with an average of 8.10±1.02 days (Table 2). The more or less similar findings was recorded by Rana *et al*. (1992) who observed that the puparial period of *B*. *zonata* ranged between 7.00 to 10.00 days; 7.03 to 40.90 days on guava for *B*. *zonata* (Mohamed, 2000); 7.40 to 8.80 days on mango for *B*. *zonata* (Dale, 2002); 53.00, 20.00, 10.00, 8.00 and 8.00 days at 15, 20, 25, 30 and 35°C temperatures, respectively for *B*. *zonata* (Duyck *et al*., 2004); 14.01±0.01, 9.50±0.25, 7.01±0.01 and 5.81±0.11 days at 20, 25, 30 and 35°C temperatures, respectively for *B*. *zonata* (Younes and Akel, 2010); 47.67±2.50, 14.33±0.60, 7.80±0.30 and 6.67±0.60 days at 20, 25, 30 and 35°C, respectively for *B*. *zonata* (Fetoh *et al*., 2012); 34.00 to 39.00, 15.00 to 17.00, 10.00 to 12.00 and 7.00 to 9.00 days at 15, 20, 25 and 30°C temperature, respectively for *B*. *zonata* (Ali, 2016); 32.40 days (at 16°C), 19 days (20°C), 13.80 days (24°C) and 8.60 days (28°C), 7.40 days (32°C) and 6.20 days (36°C) for *B*. *zonata* (Rashmi *et al*., 2020). However, the present findings are less similar with those of Abu-Ragheef and

Al-Jassany (2018) who noted that the pupation period of *B. zonata* were 10.80, 23.90 and 22.30 days at 30±2°C, 20±2°C temperature and field conditions, respectively.

Adult: When *B. zonata* fly was ready to emerge from the puparium, it pushed the upper end of puparium and came out by bursting the puparial case. Thereafter, it slowly crawled through soil and reached to the soil surface. The newly emerged adult looked faint and sluggish; however, after sometime the wing was found fully opened by fluttering movement. The adults were stout, reddish brown in colour with hyaline wing, yellow legs and the thorax is reddish brown in colour. The adult flies possessed two prominent compound eyes on the dorso-lateral region of the head and aristate type of antennae. The abdominal tergites were free. In scutellar and thoracic region, a pair of yellow coloured lateral vittae were present. A pair of dark marks on tergum III and no medial dark line except tergum was observed on abdomen. The wings of adult consisted of discontinuous band expanding in to a spoton costal margin, which is a typical character of identifying the *B. zonata*. The hind wings were modified in to a short tubular structure with rounded end. In male, the abdominal end was rounded with pecten while, it was developed in to pointed ovipositor in case of female. Moreover, the male *B. zonata* were slightly smaller than female flies. This finding is concurrence with Narayanan and Batra (1960) who reported that the male of *D. dorsalis* was smaller than the female. Naik *et al*. (2017) reported that the abdomen of *B. dorsalis* was blunt in adult male and smaller in size than that of the female, whereas adult females were easily distinguishable by the presence of tapering abdomen extending in to an ovipositor and comparatively larger than the males which is again in favour of the present findings.

The length of adult of *B. zonata* male with wing expansion ranged from 4.20 to 5.10mm and that of breadth varied from 8.42 to 11.40mm. While, the length of adult female with wing expansion ranged from 5.32 to 6.21mm and breadth from 10.40 to 12.60mm, respectively (Table 1). The average length and breadth of male from wing expansion was (4.72±0.24) × (10.25±0.93) mm. The average length and breadth of female from wing expansion was (5.87±0.31) × (11.68 ± 0.87) mm.The present findings are deviated from the findings of Kalia (1992) who reported that the size of females (across the wing × length) of *B. dorsalis* were 14.90×8.65, 12.30×6.25, 14.40×8.20, 14.00×8.20mm and that of the males were 13.80×8.15, 11.50×5.20, 13.70×7.40, 13.70×7.65mm on mango varieties, Dashehari, Amrapali, Mallika and Bangalora, respectively. Naik *et al*. (2017) recorded that the length and breadth of the male adult varied from 4.91 to 7.23mm and 10.10 to 12.65mm, respectively while these were found to vary from 6.70 to 8.98mm and 12.20 to 16.50mm for female adult, respectively which is not in favour of the present findings due to different species.

Sex ratio: The *B. zonata* adults were differentiated in to their sexes based on their morphological characters and the sex ratio was worked out by separating and counting the males and females emerged. The sex ratio of male: female was 1:1.20 (Table 2). A more or less similar trend was seen by Rana *et al*. (1992) who observed that the sex ratio of male and female *B. zonata* was 1:1.10 when reared on guava; 1:1.11 for *B. zonata* on mango (Dale, 2002); 1:1.33, 1:1.12, 1:0.79 and 1:1.04 for *B. zonata* at 20, 25, 30 and 35°C temperature, respectively (Younes and Akel, 2010); 1:1.22, 1:1.10, 1:1.06, 1:1.00 and 1:3.00 on Banana, guava, papaya, sapota and mango, respectively (Kalia, 2015); 1:3.00 for *B. dorsalis* (Amur *et al*., 2017); 1:1.00, 1:1.70, 1:1.10 and 1:1.09 and 1:0.92, respectively when *B. zonata* was reared on papaya, mango, guava and Robusta and Ekaki varieties of banana (Jayanthi and Verghese, 2002). However, Abu-Ragheef and Al-Jassany (2018) reported that the sex ratio female:male were 0.54:1, 0.79:1, 0.79:1 for *B. zonata* at 20, 25, 30±2°C temperature (when the maggots fed on artificial diet), respectively and it was 0.58:1 in field conditions (when the maggots fed on mandarin fruit) which does not support the present findings. Some discrepancy among the results pertaining to sex ratio was observed which is might be due to change in host fruits as well as the prevailing environmental conditions.

Pre-oviposition period: The pre-oviposition period of *B. zonata* ranged between 10.00 to 14.00 days with an average of 12.30±1.13 days on mango (Table 2). These findings are more or less tally with those of Dale (2002) who noted that the pre-oviposition period of *B. zonata* was found to be 12.00 to 14.00 days with an average of 13.20 days on mango; 27.67±2.50, 18.00±2.00, 12.33±0.60, 8.00±2.00 and 0.00±0.00 days at 20, 25, 30, 35 and 40°C temperature, respectively for *B. zonata* (Fetoh *et al*., 2012); 14.00 to 17.00 days on guava for *B. zonata* (Rana *et al*., 1992); 18.00 to 22.00 days for *B. dorsalis* (Qureshi *et al*., 1993); 18.00 to 22.00 days for *B. zonata* (Shehata, 2008); 29.40±2.88, 22.80±2.86, 20.40±1.82 and 17.80±1.10 days at 20, 25, 30 and 35°C temperature, respectively for *B. zonata* (Younes and Akel, 2010); 20.67, 21.71, and 20.71 days of females copulated repeatedly, delayed copulation and copulated once, respectively for *B. zonata* (Younes and Akel, 2010); 26.40, 43.60 and 29.00 days at 30±2°C, 20±2°C (when the maggots fed on artificial diet) and field conditions (when the maggots fed on mandarin fruit), respectively for *B. zonata* (Abu-Ragheef and Al-Jassany, 2018). El-

Minshawy *et al*. (1999) revealed that the pre-oviposition period of *B*. *zonata* was found to be 45.00 to 60.00 days for *B*. *zonata* at 25°C which is deviated from the present findings. The variation in pre-oviposition period was observed due to change in host fruits as well as environmental conditions.

Oviposition period: The oviposition period of *B*. *zonata* varied from 9.00 to 18.00 days with an average of 13.30±2.45 days (Table 2). A similar trend was found by Rana *et al*. (1992) who observed that the oviposition period of *B*. *zonata* on guava was 12.00 to 17.00 days; 13.00 to 18.00 days with an average of 15.00 days for *B*. *zonata* on mango (Dale, 2002); 9.80±2.59, 13.00±2.92, 29.80±3.03 and 28.40±5.41days at 20, 25, 30 and 35°C temperature, respectively for *B*. *zonata* (Younes and Akel, 2010); 29.00 to 38.00 days with an average of 33.14 days in case of repeated copulation and 9.00 and 14.00 days with an average of 11.14 days in *B*. *zonata* females copulated once whereas in females copulated after 14.00 days post-emergence, it was 12.00 and 23.00 days with an average of 16.43 days (Younes and Akel, 2010); 67.33±3.60, 55.00±5.00, 34.33±1.10 and 18.00±2.00 days from 20 to 35°C, respectively for *B*. *zonata* (Fetoh *et al*., 2012).However, the present findings are deviated from those of El-Minshawy *et al*. (1999) who registered that the average oviposition period of *B*. *zonata* was 70.00 to 90.00 days at 25°C; 117.50 days for *B*. *zonata* adult females reared on artificial diet at 25°C (El-Gendy, 2002); 3.00 to 7.00 days for *B*. *zonata* adult females reared on artificial diet at 25°C (Mohamed, 2003). The differences in oviposition period observed due to change in the diet type, copulation type as well as prevailing environmental conditions.

Post-oviposition period: The post-oviposition period of *B*. *zonata* varied from 4.00 to 6.00 days with an average of 5.10±0.72 days (Table 2). These findings are concurrence with those of Fetoh *et al*. (2012) who found that post-oviposition period of *B*. *zonata* was 12.33±2.50, 8.00±1.00, 6.00±1.70 and 4.67±1.50 days at 20, 25, 30 and 35°C, respectively; 4.20, 9.40 and 5.30 days at 30±2°C, 20±2°C (when the maggots fed on artificial diet) and field conditions (when the maggots fed on mandarin fruit), respectively for *B*. *zonata* (Abu-Ragheef and Al-Jassany, 2018). The present findings show a less similar trend with those of Rana *et al*. (1992) who noticed that the post-oviposition period of *B*. *zonata* was found to be 16.00 to 43.00 days on guava; 21.00 to 26.00 days with an average of 22.80 days on mango (Dale, 2002). The variation in the post-oviposition period was due to the change in the hosts as well as environmental conditions.

Fecundity: The egg laying capacity of gravid female varied from 120 to 240 eggs/female with an average of 176.00±31.81 eggs/female (Table 2).In past, Rana *et al*. (1992) recorded that single female *B*. *zonata* laid 191 to 259 eggs when reared on guava; 121 to 146 eggs were laid by single female *B*. *zonata* on mango (Dale, 2002); 62.80±14.24, 224.64±31.79, 241.00±12.96 and 160.20±12.96 eggs were laid by single female *B*. *zonata* at 20, 25, 30 and 35°C temperature, respectively (Younes and Akel, 2010) which are in close proximity with the present findings. Abu-Ragheef and Al-Jassany (2018) revealed that the highest number of eggs were laid by *B*. *zonata* in virgin reproduction was 83.20 egg/female at 30±2°C temperature and the lowest was 65.40 egg/female at 20±2°C and hatching rate was zero which is slightly deviated from the present findings. The deviation is seen due to the change in the type of copulation and environmental conditions.

Longevity: The longevity varied from 10.00 to 18.00 days with an average of 13.95±2.06 days whereas the female longevity ranged from 14.00 to 26.00 days with an average of 21.50±3.14 days (Table 2). Thus, the study indicated that the *B*. *zonata* females lived longer than male. These findings are similar to those of Fetoh *et al*. (2012) who revealed that the male durations of *B*. *zonata* reared on different temperature degrees from 20 to 40°C were decreased in an ascending manner with raising the temperature degrees, as: 87.67±2.50, 65.67±7.40, 37.67±17.60, 16.67±2.90 and 0.00±0.00 days.The female longevity of *B*. *zonata* showed decreasing in the longevity period (107.33±3.80, 81.00±7.00, 52.67±1.50 and 30.67±4.00 days) with increasing temperature from 20 to 35°C.

Total life cycle: The total life cycle starting from egg to death of adult of male and female varied from 22.00 to 29.00 days and 28.00 to 36.00 days, respectively. The average duration of life cycle of *B*. *zonata* male and female were 25.58±1.88 and 30.94±2.80 days, respectively (Table 2). The life cycle (from egg to death of adult) of male is shorter than the female.A more or less similar trend was observed by Dale (2002) who revealed that the total life cycle was 37.00 to 42.00 days for male and 51.00 days for female when *B*. *zonata* reared on mango; male duration of 39.55 days and 43.20 days for females when adults of *B*. *zonata* reared on artificial diet at 25°C (Mohamed, 2003); 87.67±2.50, 65.67±7.40, 37.67±17.60 and 16.67±2.90 days for males and 107.33±3.80, 81.00±7.00, 52.67±1.50 and 30.67±4.00 days for females when *B*. *zonata* reared on different temperature degrees from 20 to 35°C (Fetoh *et al*., 2012); 16.90, 37.10 and 32.60 days at 30±2°C, 20±2°C (when the maggots fed on artificial diet) and field conditions (when the maggots fed on mandarin fruit), respectively for *B*. *zonata* (Abu-Ragheef and Al-

Jassany, 2018); 96.00 days to 14.00 days at 16 to 36°C temperature, respectively for *B. zonata* (Rashmi *et al*., 2020). The slight variation in the longevity of *B. zonata* was noticed due to variation in temperature, humidity, host fruits and other environmental factors.

CONCLUSION

The adult female of *B. zonata* searched for a physiologically mature fruits just after mating and laid eggs just below the rind of the fruit. The maggots emerged from the eggs feed on the pulp of the fruits after sometime and pass through three different instars. The fullgrown maggot enters into the soil for pupation. The adults emerged from the puparia feed on nectar and other liquefied juice, mate and again oviposit in mature fruit. Thus, *B. zonata* complete the life cycle in 22 to 36 days. The life cycle (from egg to death of adult) of male *B. zonata* is shorter than the female. The various descriptions on biology and morphometrics of *B. zonata* would help in identification of the species and distinguish it from other species of fruit flies. It also helps to differentiate the male and female species. Understanding the biology would be helpful for finding out the weak link of the insect and selection of appropriate management practices.

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