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From Fruit to Fly: Dissecting the Life Table and Biological Traits of *Bactrocera dorsalis* on Varied Host

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Abstract

Problem: The oriental fruit fly, *Bactrocera dorsalis* (Hendel), is a major global pest affecting various fruit crops. Understanding the pest's developmental biology on different host fruits is essential for effective management. This study aimed to investigate the biology of *B. dorsalis* on four host fruits—guava, banana, apple, and pear—under controlled laboratory conditions.**Approach:** Larvae collected from infested fruits were reared in cages (38 × 38 × 45 cm) under laboratory conditions (25 ± 2°C, 65 ± 5% RH, and a 14L:10D light cycle). Pupation was facilitated using a sand-sawdust mixture. Adults were fed a 10% protein hydrolysate solution, and fresh fruits were provided for oviposition. Biological parameters such as egg incubation period, larval and pupal durations, adult longevity, fecundity, pre-oviposition and oviposition periods, and generation time were recorded. Statistical analyses were conducted using the Shapiro–Wilk test, one-way ANOVA, and Tukey's HSD post hoc test. Life table parameters were calculated using TWOSEX-MS-Chart software, with bootstrap testing for accuracy.**Findings:** The results indicated significant differences ($P<0.05$) in biological parameters across the four host fruits. Guava was the most suitable host, with the shortest egg incubation period (1.69 ± 0.11 days), larval duration (7.38 ± 0.21 days), pupal period (7.34 ± 0.31 days), and generation time (44.47 ± 1.37 days), along with the highest fecundity (91.00 ± 1.23 eggs). Conversely, pear showed the longest developmental times and the lowest fecundity (64.50 ± 2.92 eggs), indicating its lower suitability as a host.**Conclusion:** This study highlights guava as the most favorable host for the development and reproduction of *B. dorsalis*, while pear is the least suitable. These insights are vital for identifying high-risk host crops and developing targeted pest management strategies to mitigate the impact of *B. dorsalis*.

Keywords: Fruit fly, *Bactrocera dorsalis*, Biology, Life cycle, Life table, Management.

Introduction

Bactrocera dorsalis, commonly known as the Oriental fruit fly, is a highly destructive pest belonging to the order Diptera and the family Tephritidae(Huang and Chi, 2014). This pest poses a significant threat to global agriculture, affecting over 250 host species, including fruits such as guava, mango, peach, and various citrus varieties (Schutze et al., 2017). *Bactrocera dorsalis* currently occurs in over 65 countries of Oceania, America and Africa (Steck et al., 2019, Mutamiswa et al., 2021). It has been listed among quarantine targets, and strict quarantine measures on fruit import and export have been implemented in many countries and regions (Vargas et al., 2015). In India, where fruit production is a vital component of the agricultural sector, the situation is particularly concerning. The country produced around 30 million tons of bananas, 2.6 million tons of guava, 0.4 million tons of pears, and 2.5 million tons of apples in the 2022-23 agricultural year (FAO, 2022). However, infestations by *B. dorsalis* have led to significant yield losses, threatening the livelihoods of farmers, and impacting food security across the nation (Billah et al., 2015).

The life cycle of *B. dorsalis* consists of four stages: egg, maggot (larva), pupa, and adult, all of which are influenced by environmental conditions such as temperature, rainfall, and humidity, as well as the nutritional quality of host fruits (Jaffar et al., 2023). The female adult of fruit fly laid the eggs into semi-matured or matured fruits with their pointed ovipositor. After egg hatching maggotsstarts feeding on fruit pulp, causing substantial rotting, and leading to fruit drop. (Saeed et al., 2022). Fully developed maggot leave fruit and goes into soil for pupation, adult was released from pupa start damaging new fruits. Basically, female adult and maggot was damaging stage, male adult was not harmfully to the crop. (Reddy et al., 2020)This complex biology, high reproductive rate and adaptability of *B. dorsalis* make its management particularly challenging. (Jaffar et al., 2023).

Life tables are essential tools for studying population ecology and monitoring field dynamics, providing valuable insights into the risk of damage caused by invasive pests (Huang et al., 2018; Huang and Chi, 2012). Building on traditional life table concepts, (Chi and Liu,1985 and Chi, 1988) introduced the age-stage two-sex life table, which significantly enhances population predictions and plays a critical role in pest management strategies (Huang et al., 2018; Chi, 1990). This advanced life table approach has since been widely applied in studies of various pest species, including mites like *Luciaphorus perniciosus* Rack (Acari: Pygmephoridae) (Bussaman et al., 2017), and insect pests such as *Bemisia tabaci* (Hemiptera: Aleyrodidae) (Li et al., 2018) and *Bactrocera dorsalis* (Huang and Chi, 2014; Jaleel et al., 2018).

This research aims to investigate the biological traits and life table parameters of *B. dorsalis* when reared on different fruit hosts. By examining the relationship between fruit type and the life history traits of this pest, the study seeks to contribute to the development of effective integrated pest management (IPM) strategies(Yang et al., 1994; Chen et al., 2017; Roy, 2019[a] and Roy, 2020[b]). The age-stage two-sex life table overcomes many of the inherent limitations and inaccuracies associated with traditional female-based life tables, offering a more comprehensive and precise approach to population analysis (Chen et al., 2017;

Mobarak et al., 2019 and Roy, 2020[b]).Biological studies on its different hosts and even potential hosts are fundamental for risk prediction models of pest dispersal (Marchioro, 2016). This research is particularly important in the context of global trade, where the movement of fruits can inadvertently spread this pest, worsening agricultural challenges and threatening food security (Aluja and Mangan, 2008). By enhancing our understanding of the biology and behaviour of *B. dorsalis*, this study aims to provide valuable insights that can help protect fruit production and ensure food security.

Materials and methods

The research was conducted in the Department of Entomology, School of Agriculture, at Lovely Professional University, Phagwara, Punjab, India.

Rearing of *Bactrocera dorsalis*

Fruit fly larvae were gathered from infected fallen fruits of guava, pear, apple, and banana collected from the orchard at Lovely Professional University, Phagwara. These fruits were taken to the entomology laboratory for mass rearing of fruit flies. The maggots were placed in specially designed fruit fly rearing cages (dimensions: 38 × 38 × 45 cm). In the lab, *Bactrocera dorsalis* was reared using selected hosts—guava, banana, pear, and apple—under controlled conditions of 25 ± 2°C, 65 ± 5% relative humidity, and a 14L:10D light cycle, as described by (Miyatake, 1998).

The bottom of each rearing cage was lined with a polythene sheet and covered with a 5 cm layer of a mixture of sterile fine sand and sawdust (in a 70:30 ratio) for pupation. After pupation, individual pupae were placed in separate containers with soil, and water was sprinkled to maintain soil moisture at 5%. Observations continued until adult emergence. Once adults emerged, a male and female pair was placed in smaller rearing cages. The adults were provided with 10% protein hydrolysate via cotton swabs as their food, with the cotton being changed daily to prevent fungal growth. Fresh fruits of guava, banana, pear, and apple were supplied for oviposition. Once oviposition occurred, infected fruits were replaced with healthy ones, and the infested fruits were used for subsequent studies.

Biological Parameters

Male and female biological parameters are evaluated using the two-sex life table. A total of 120 eggs were gathered for this evaluation, 30 from each of the following host fruits: apple, banana, guava, and pear. The eggs were oviposited by female *B. dorsalis* within the last 24 hours. Each fruit type was cut into small pieces, and a single egg of *B. dorsalis* was placed on an individual piece of fruit inside small rearing cages. A soft fine hair brush was used to handle the eggs, fruit pieces were replaced daily. Prior to adult emergence, the puparia were transferred to separate plastic containers lined with a 3 cm layer of soil. Daily observations were made to track the development and survival of the immature stages. After adult emergence, pairs of adults (one male and one female) were placed in small rearing cages with two pieces of fresh fruit. For every fruit variety, biological and fitness metrics such fecundity, oviposition length, adult pre-oviposition period (APOP), adult developmental stages, and total pre-oviposition period (TPOP) were tracked every day. Each treatment, corresponding to each fruit, was replicated ten times following the methodology described by (Jaleel et al.,2017).

Statistical analysis

To analyse the effects of different treatments (guava, banana, pear, and apple) on the growth and reproduction of *Bactrocera dorsalis*, several statistical methods were applied. First, the Shapiro–Wilk test was conducted to check the normality of the data. Once normality was confirmed, a one-way analysis of variance (ANOVA) was carried out, followed by Tukey's HSD post hoc test to identify significant differences between the treatments. The statistical analyses were performed using R software, version 4.3.3, with a significance threshold set at $p < 0.05$.

Life table analysis

The TWOSEX-MS-Chart application (Chi, 1988 and He et al., 2021) was used to analyse life table parameters, including the age-stage-specific survival rate (s_{xj}), where x represents age in days and j denotes the developmental stage. Additionally, the analysis included age-stage-specific fecundity (f_{xj}), age-specific survival rate (lx), age-specific fecundity (mx), and age-stage life expectancy (e_{xj}).

In addition, life table parameters such as the net reproductive rate (R_0), intrinsic rate of increase (r), finite rate of increase (λ), doubling time (DT), and mean generation time (T) were calculated. To ensure accurate estimates of the means and standard errors for these demographic parameters in fruit flies reared on different host fruits, a bootstrap test with 100,000 replications was conducted using the TWOSEX-MS-Chart software (Akcaet al., 2015 andChi, 2020).

In the age-stage, two-sex life table, the *lx*, *mx*, and R_0 values are calculated as,

$$lx = \sum_{j=1}^{m} S_{xj} \qquad (1)$$

$$mx = \frac{\sum_{j=1}^{m} S_{xj} f_{xj}}{\sum_{j=1}^{m} S_{xj}} \qquad (2)$$

$$R_0 = \sum_{x=0}^{\infty} l_x \, m_x \qquad (3)$$

In this study, the intrinsic rate of increase (r) was calculated using the iterative bisection method based on the Euler–Lotka equation, with age starting from 0 (Goodman, 1982), as shown in equation (2). Here, "k" represents the number of life stages.

$\sum_{x=0}^{\infty} l_x \, m_x \, e^{-r(x+1)} = 1$ (4)

The symbol λ represents the long-term population growth rate, achieved when the population stabilizes across age and stage distributions. At this point, the population size increases by a factor of λ for each time unit. The value of λ was computed as follows,

$\lambda = e^r$ (5)

The 'T' represents the time needed for a population to increase by a factor of R0 from its initial size, once the population has reached a stable age distribution.

$T = \frac{l_n R_0}{r}$ (6)

The term e_{xj} refers to the expected lifespan or the predicted length of time an individual insect at age x and stage j is expected to survive. This is calculated using the method proposed by (Chi and Su, 2006), as shown below:

$e_{xj} = \sum_{i=x}^{\infty} \sum_{y=j}^{k} Siy$ (7)

S_{xj} represents the probability that individuals at age x and stage j will survive to reach age i and stage y. This probability is calculated with the assumption that S_{xj} = 1, as proposed by (Tuan et al.,2014).

Result and Discussion

Biology of fruit fly *Bactrocera dorsalis*

More than 250 species in the genus *Bactrocera* are known to be fruit pests, with *B. dorsalis* being primary agricultural crop pest in the world (Ekesi et al., 2016; Aluja and Mangan, 2008). (Table 1) represents the results for various biological parameters of *B. dorsalis* reared on four different host fruits. Significant differences were observed across host treatments for the egg incubation period, larval and pupal durations, adult longevity, fecundity, and pre-oviposition and oviposition periods (P<0.05; Table 1). In contrast, no significant differences were found in the durations of the 1st and 2nd instar larval stages, pre-pupal period, or post-oviposition period.

The eggs of *B. dorsalis* are shiny, white, cylindrical, slightly curved, and tapered at one end, and are laid in clusters. The incubation period of *B. dorsalis* eggs varied significantly across different host treatments (df = 4, 10; P<0.05; Table 1). The longest incubation period was observed when *B. dorsalis* was reared on pear, with a mean ± S.D. of 2.37±0.10 days, while the shortest was on guava at 1.69±0.11 days, which was significantly lower than other treatments. The larvae (maggots), which are white to yellowish-white, develop through three instars. No significant difference was observed in the duration of the 1st and 2nd instar stages across treatments. However, the 3rd instar and the total larval period showed significant variation across treatments (df = 4, 10; P<0.05; Table 1). The total larval duration was shortest on guava (7.38±0.21 days), followed by banana, apple, and pear at 7.84±0.16, 8.99±0.28, and 8.28±0.28 days, respectively. Singh and Sharma, (2013) had reported that maggots require minimum time to emerge out from infested fruits of guava as compared to others fruits such as kinnow, pear and peach.

Table. 1. Developmental period of different life stages of *Bactrocera dorsalis* on different fruit.

Life stages	Duration (Days)				P value
	Hosts				
	Guava (Mean ± SE)	Banana (Mean ± SE)	Pear (Mean ± SE)	Apple (Mean ± SE)	
Eggs period	1.69 ± 0.11 b	1.72 ± 0.12 b	2.37 ± 0.10 a	1.99 ± 0.11 b	0.001**
1st instar maggot	1.55 ± 0.11 a	1.60 ± 0.10 a	1.84 ± 0.09 a	1.81 ± 0.11 a	0.145 NS
2nd instar maggot	2.43 ± 0.10 a	2.57 ± 0.15 a	2.72 ± 0.25 a	2.62 ± 0.23 a	0.774 NS
3rd instar maggot	3.40 ± 0.13 c	3.67 ± 0.16 ab	4.42 ± 0.09 a	3.85 ± 0.16 b	0.001**
Fully matured maggot	7.38 ± 0.21 c	7.84 ± 0.16 ab	8.99 ± 0.28 a	8.28± 0.28 b	0.001**
Pre-pupa	0.65 ± 0.05 a	0.70 ± 0.08 a	0.82 ± 0.07a	0.77 ± 0.07 a	0.353 NS
Pupa	7.34 ± 0.31c	7.71 ± 0.29 c	11.49 ± 0.43 a	9.12 ± 0.37 b	0.001 **
Pre-adult period	17.07 ± 0.43 c	17.98± 0.37 c	23.68± 0.46 a	20.17 ± 0.15 b	0.001*
Adult longevity	27.04± 1.26b	31.30 ± 1.99 b	38.45 ± 1.32 b	34.00 ± 0.84 a	0.002*
Total generation period	44.47 ± 1.37b	49.28 ± 1.81b	62.13± 1.56b	54.17 ± 0.81 a	0.000***
Pre-oviposition period	13.07 ± 1.81b	15.90 ± 0.92b	20.10± 1.36b	18.10 ± 0.97 a	0.001**
Oviposition period	12.09 ± 0.87b	14.90± 0 .95ab	17.90± 1.24ab	16.70 ± 0.77 a	0.013*

Post-oviposition period	2.40 ± 0.33^{a}	3.10± 0.43^{a}	2.60± 0.30^{a}	2.50 ± 0.37^{a}	0.467^{NS}
Fecundity per female	91.75± 1.21^{a}	80.30± 3.68^{b}	64.50± 2.92^{b}	72.30 ± 3.36^{c}	0.000***

Values in the same row followed by different lowercase letters indicate significant differences between different diets (one-way ANOVA, Duncan; p < 0.05) P<0.05 (*); P<0.01 (**); P<0.001 (***); non-significant (NS)

Mature third-instar larvae of *B. dorsalis* leave the infested fruits, cease feeding, and remain stationary before pupation. At this stage, the maggots contract longitudinally and assume a spiral shape characteristic of the prepupal phase. In this study, the duration of the prepupal stage was recorded in hours. The pre-pupal period showed no significant differences among treatments, likely due to its brief duration ($F_{(4, 10)}$= 1.12; P > 0.05; Table 1). Freshly formed pupae were cylindrical, eleven-segmented, and deep brownish-yellow in color, which later transitioned to a dark reddish-brown to ochraceous hue. The pupal period varied significantly across host fruits ($F_{(4, 10)}$= 27.38 P= 0.001; Table 1), with individuals reared on guava exhibiting the shortest pupal period, averaging 7.34±0.31 days, followed by those reared on banana, apple, and pear.A study was conducted by (Singh, 2008) to check the preferable host of fruit fly,he reported that guava is most preferable host plant of fruit flies

The pre-adult and adult stages of *B. dorsalis* are directly influenced by the type of host fruit on which the larvae feed. Both the pre-adult and adult periods varied significantly across different hosts (P= 0.000; Table 1). The longest pre-adult duration was observed on pear, followed by apple, banana, and guava, with mean ± S.D. values of 20.10±1.36, 20.17±0.15, 17.98±0.37, and 17.07±0.43 days, respectively. Adult flies have a black thorax with broad lateral vittae and a prominent facial spot. Female adults can be identified by their pointed ovipositor, which is absent in males. The adult period differs between sexes, with males having a shorter lifespan than females. The mean adult lifespan also showed significant variation depending on the host fruit ($F_{(4, 10)}$= 32.15; P= 0.000). The shortest adult duration was recorded on guava, with a mean ± SD of 27.04±1.26 days, followed by banana, apple, and pear at 31.30±1.99, 38.45±1.32, and 34.00±0.84 days, respectively.

The period from adult emergence to the deposition of the first egg is defined as the pre-oviposition period. The pre-oviposition period in female *Bactrocera dorsalis* varied significantly among different host treatments ($F_{(4, 10)}$= 6.73; P= 0.001). The shortest pre-oviposition period was recorded on guava with a mean ± S.D. of 13.07±1.81 days, followed by banana, apple, and pear. Similarly, the oviposition period differed significantly across treatments ($F_{(4, 10)}$= 4.09; P= 0.013), with the longest period observed on pear (mean ± S.D 17.90±1.24), followed by apple, banana, and guava. In contrast, the post-oviposition period did not show significant differences among treatments (P>0.05), with the longest duration on banana (mean ± S.D= 10.00±0.43), followed by pear, apple, and guava.

Female fruit flies of the genus *Bactrocera*show oviposition preferences when presented with several hosts, laying significantly more eggs on suitable fruit hosts. (Rattanapun et al., 2009; Aluja et al., 2008). In this study, fecundity levels varied significantly among the tested host fruits ($F_{(4, 10)}$= 12.77; P= 0.000), with the highest mean fecundity (mean ± S.D.) observed on guava (91.00 ± 1.23 eggs), followed by banana (80.30 ± 3.68 eggs), apple (72.30 ± 3.36 eggs), and pear (64.50 ± 2.92 eggs). Guava, recognized as the most favoured host, attracted the highest number of visits and egg-laying punctures, possibly because of its softer skin compared to other examined fruits. The extent of damage caused by oviposition punctures depends on the toughness of the fruit's skin, as softer and thinner-skinned fruits are more susceptible to infestation (Rattanapun et al., 2009; Fitzpatrick, 2008;Yashoda et al., 2007). In contrast, fruits with harder skins or thicker pericarps are less preferred because their toughness can hinder egg deposition, and the resin or sap released from punctures in such fruits may expel the eggs, preventing successful oviposition (Joel, 1981; Rattanapun et al., 2009).The total generation time, from egg-laying to adult death, also differed significantly across host fruits ($F_{(4, 10)}$= 57.90; P= 0.000). Generation time was longest on pear, followed by apple, banana, and guava, with mean ± S.D. values of 62.13±1.56, 54.17±0.81, 49.28±1.81, and 44.47±1.37 days, respectively.

Life Table Parameters of *B. dorsalis* on Different Host Fruits

The life table parameters of insect pests are greatly affected by biotic factors, with food being a key determinant of population dynamics and fecundity (Chen et al., 2017; Shen et al., 2014; Huang and Chi, 2012). A suitable host not only facilitates the completion of an insect pest's life cycle but also boosts its reproductive potential (Musa and Ren, 2005; Reader, 1991). In this study, guava emerged as the most suitable host for the development and reproduction of *B. dorsalis*. Among the tested hosts, guava supported significantly higher values for population parameters such as the net reproductive rate (R_0), intrinsic rate of increase (r), finite rate of increase (λ), and fecundity compared to banana, apple, and pear.The doubling time (DT) and mean generation time (T) of *B. dorsalis* were notably longer on pear, followed by apple, banana, and guava (Table 2). Parameters such as age structure, sex ratio, survivorship, and fecundity are essential for comprehending the population dynamics of insect pests. Among these, the intrinsic rate of increase (r) is particularly significant as it reflects the pest population's potential for growth, development, and survival (Chen et al., 2017; Varley and Gradwell, 1970). Demographic theory suggests that a host supporting population growth will exhibit a positive intrinsic rate of increase ($r > 0$) (Chen et al., 2017; Southwood and Henderson, 2000). These findings are consistent with the results observed in this study (Table 2).

A higher intrinsic rate of increase signifies a host's greater susceptibility to insect infestation, while a lower rate indicates stronger resistance to pest attacks (Musa and Ren, 2005). The net reproductive rate (R_0), a critical measure of population growth, is closely linked to the number of eggs laid (Sayyed et al., 2008). In this study, *B. dorsalis* demonstrated the highest net and gross reproductive rates when reared on guava (Table 2). The gross reproductive rate (GRR), which reflects the rapid expansion of an insect population, is determined by fecundity and adult eclosion rates—both of which are influenced by the host food source (Huang and Chi, 2013). Among the four *Bactrocera* species, *B. dorsalis* has previously been reported to exhibit the highest GRR (Jaleel et al., 2017a). Consistent with these findings, our study also observed the highest GRR when flies were reared on guava.

Table 2: Life table parameters (mean± SE) of *Bactrocera dorsalis* individuals reared on different hosts.

Parameter	**Guava**	**Banana**	**Apple**	**Pear**
Net Reproductive rate R_0 (offspring/individuals)	72.6 ± 10.20^{a}	56.8 ± 11.45^{a}	37.5 ± 11.99^{ab}	26.5 ± 10.31^{ab}
Mean generation time T(d)	21.86 ± 0.37^{ab}	22.89 ± 0.59^{ac}	25.33 ± 0.50^{b}	30.09 ± 0.98^{b}
Intrinsic rate of natural increase $r(d^{-1})$	0.19 ± 8.17^{a}	0.17 ± 1.05^{a}	0.14 ± 1.51^{ab}	0.10 ± 1.58^{bc}
Finite rate of increase λ (d^{-1})	1.21 ± 0.0098^{a}	1.19 ± 0.012^{a}	1.15 ± 0.017^{ab}	1.11 ± 0.017^{ac}
Doubling time (DT)	3.53 ± 0.15^{bc}	3.92 ± 0.26^{b}	4.84 ± 0.66^{ab}	6.36 ± 1.30^{a}
Fecundity	90.75 ± 1.21^{a}	81.14 ± 3.98^{b}	75 ± 5.08^{bc}	66.25 ± 5.79^{cd}

Values in the same row followed by different lowercase letters indicate significant differences between different diets

The survival dynamics (S_{xj} curves) of both immature (eggs, larvae, and pupae) and mature (female and male adults) stages of *B. dorsalis* across four different fruits are illustrated in Figure 1. The longest cohort survival was observed on pear, followed by apple, banana, and guava. The developmental time for both immature and mature stages varied significantly among the fruits, as shown in Table 2.

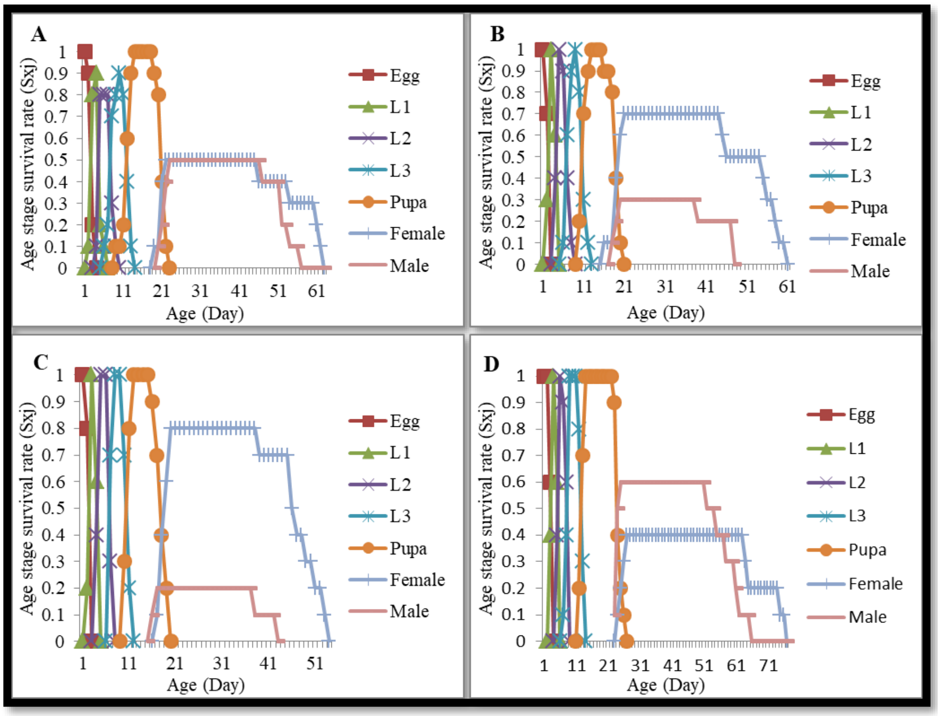

Figure 1 Age stage-specific survival rate (Sxj) of *Bactrocera dorsalis* on different fruits, (A) Apple, (B) Banana (C) Guava, (D) Pear

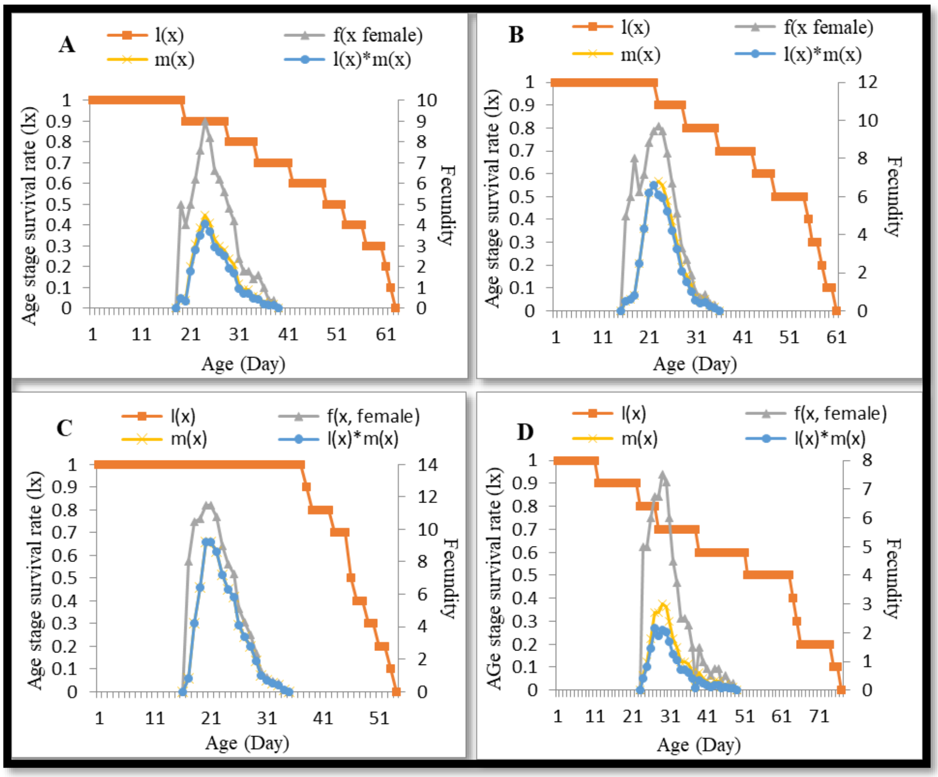

Figure 2 Influence of different fruits on the age-specific survival rate (lx), female age-specific fecundity (fx), age-specific fecundity (mx), and age-specific maternity (lx * mx) of *Bactrocera dorsalis*.

Daily fecundity, represented as f_{xj}, shows the number of eggs laid by females at age x and stage j, and these patterns are depicted in (Figure 2). The lx curve highlights the variations in survival rates of *B. dorsalis*with age, while the lx and mx curves further illustrate age-specific survival and fecundity trends illustrate in (Figure 2). The maximum life expectancy of female *B. dorsalis* differed across the fruits, with 45.25 days recorded on pear, 37.30 days on apple, 37.28 days on banana, and 31.12 days on guava, as presented in (Figure 3).

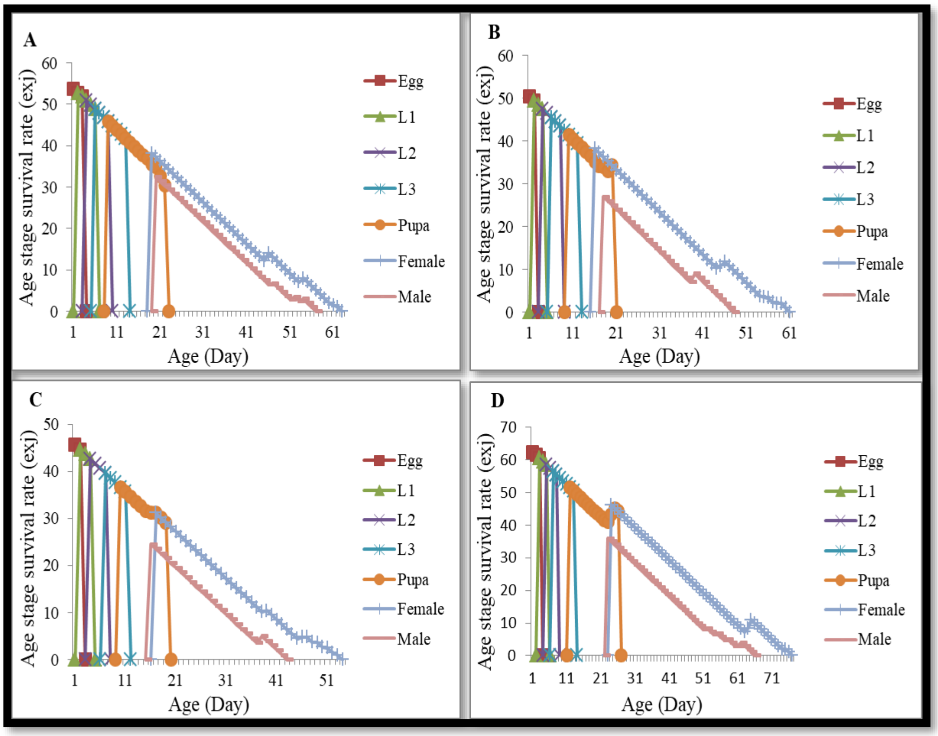

Figure 3 Age-stage specific life expectancy (exj) of *Bactrocera dorsalis* individuals reared on different hosts (A) Apple, (B) Banana (C) Guava, (D) Pear

Conclusion:

Bactrocera dorsalis is a significant pest of horticultural crops, causing substantial economic losses worldwide. This research is crucial as it provides valuable insights into the pest's life table parameters across different host fruits, which are essential for developing effective pest management strategies. The study reveals that the host fruit plays a critical role in influencing the survival, development, fecundity, and life expectancy of *B. dorsalis*. Among the tested fruits, pear supported the longest survival and maximum life expectancy, while guava facilitated faster development and higher fecundity. The observed variations in life table parameters across different fruits emphasize the importance of host suitability in shaping the population dynamics of *B. dorsalis*. These findings underscore the significance of host selection in pest control, offering essential information for the design of targeted and sustainable strategies to mitigate the economic impact of *B. dorsalis* on horticultural crops.

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