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Morphometric life stages of a lemon butterfly, *Papilio demoleus* Linnaeus (Lepidoptera: Papilionidae) on *Citrus limon* (L.) Osbeck

Wali Muhammad Mangrio*[1], Hakim Ali Sahito[1,2]

[1]*Department of Zoology, Shah Abdul Latif University, Khairpur, Sindh, Pakistan*

[2]*Date Palm Research Institute (DPRI), Shah Abdul Latif University, Khairpur, Sindh, Pakistan*

Key words: Lemon butterfly, Matting, Morphometrics, Oviposition, Tornal spots

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Abstract

This research was aimed to evaluate the morphometric study of *Papilio demoleus* (L.). The adult's collection was made from lemon orchards surrounding of Moro, Naushahro Feroze, Bhiria, Kandiaro, and Mehrabpur talukas of the district; Naushahro Feroze and brought under laboratory conditions during 2019. The paired male and female were released inside the mosquito net for copulation and oviposition by given fresh shoots of lemon. The average diameter of eggs was observed (0.02)cm, and the overall maximum mean length of instars form 1st (0.06), 2nd (0.78), 3rd (2.07), 4th (3.29), 5th (4.13) incm, pre-pupae (2.43), pupae (2.06) and post-pupae (2.05) incm. While as; maximum width of instars recorded at 1st (0.02), 2nd (0.02), 3rd (0.04), 4th (0.17) 5th (0.05)cm, pre-pupae at (0.05), pupae (0.06) and post-pupae (0.05)cm. However, the length and width of adults male and female eyes measured at (0.03), (0.04), head capsule (0.05), (0.07), thorax (0.06), (0.48), abdomen (0.48), (0.57), forewings (2.48), (2.87), hindwings (1.68), (2.17), antennae (0.98), jointed legs (1.43), (1.75) incm respectively. It was concluded from first to fourth-stage larvae possess little difference in morphometrics but the fifth instar found almost change. Generally, females found larger than male and tornal spots on hind wings marks the male and female identification. Findings suggest that *Papilio demoleus* larval stages surviving as destructive agents for lemon orchards and causing massive economic losses to lemon growers of this region. Therefore; intensive attention is needed to manage this citrus plague pest insect through IPM environment-friendly techniques to secure this fruit industry for upcoming.

* **Corresponding Author:** Wali Muhammad Mangrio ✉ wali.muhammadmangrio786@gmail.com

Introduction

Citrus, the most popular and widely grown fruits in the world (Talon and Gmitter, 2008) with an average annual production of 102 million tons (Mehl *et al.,* 2014). The citrus plants are fairly smaller in size my attain up 5 to 15 m tall, possess solitary flowers, numerous stamens, spiny shoots, with four white pet als, flavonoids, juice-laden, fragrance, limonoids, strangely scented, nutritionally beneficial, and higher vitamin C content (Lenne, 2000). Citrus fruits include lime, lemon, oranges, pomelo, grapefruit, etc, are evergreen, commercial crops, giving surplus to the citrus growers, world-leading fruit including the 3rd largest fruit industry after banana and mango and rank 6th amongst the other fruits (Jahnavi *et al.,* 2018). These fruits can grow in many parts of the world but fifty-two countries of the world rank maximum yield production than the rest countries and it has been estimated that 70% citrus production came from Brazil and China but Brazil is the topmost citrus producer, while as; India hold 8th position and Pakistan has 13th position in citrus production amongst the world (FAO, 2009). All citrus fruits contain a pleasant fragrance and their juices are being used in a variety of beverages and prevention of certain diseases (Park *et al.,* 2013). Mostly citrus orchards are severely infested by a variety of fruit sucking moths, mealybugs, leafminers, scales, psylla, mites, whiteflies, thrips, aphids, and blackflies (Sandhu *et al.,* 2012). However, amongst these pest insects, the citrus butterfly relaying a critical impact and it is a major citrus pest throughout Asia hence some time lemon butterfly called plague to citrus (Sharifi and Zarea, 1989).

Citrus butterfly belongs to the highly recognized insect order Lepidoptera and scientists documented more than 180,000 species of Lepidopterans of which 16,000 species are butterflies (Hassan, 1994). Both butterflies and moths come in this wide insect order but show variation in their body pigmentation, distribution, and lifestyles (Owen *et al.,* 2011). *P. demoleus* is an extensive pest of curry leaf and citrus species having ample ecological broadmindedness, enabling to flourish a broad variety of climatic conditions and distributed in all four provinces of Pakistan (Roberts, 2001). lime swallowtail is frequently found in tropics and sub-tropics regions of Asia, Indonesia, Taiwan, Japan, New Guinea, Middle East, Nepal, Saudi Arabia, Iran, Philipines, and Australia also recently it has been documented in the Caribbean (Homziat and Homziak, 2006).

Citrus orchards have been infested from several pest insects, but more than fifty species are regarded as major pests to citrus and commonly these insect pest species found an association to their host plant species cause to damage and drastically reduce fruit production (Sharifi and Zarea, 1989). Citrus butterfly harmonizes commonly at the time of the emergence of new foliage hence denoted as a key pest to citrus (Munir *et al.,* 2007). The larvae voraciously feed lush green leaves from edges up to midribs finally defoliate the leaves or sometimes leaving only midribs and hits severely to citrus crops from nursery up to harvest stage causes quiet damage (Yunus and Munir, 1972). The butterflies are energetic with strong flight and commonly hovering over flowers for their nectar diet and show multiplicity especially on citrus plants (Rafi *et al.,* 1989).

Lemon butterflies are a beautiful insect with charming external features, comprises two paired wings with yellow and black margins, no prominent tail, larvae bear at prothorax an organ called osmeterium it turns outward with flickering movement by releasing fluid (Sarada *et al.,* 2014). The wings of *P. demoleus* contain overlapping scales with dimorphism color pattern to distinguish from other insects also males and females undergo complete metamorphosis with four different life stages viz; egg, larvae, pupae, and adult (Radke and Kandalkar, 1988). Adult's forewings are nearly black but the outer edge has a series of asymmetrical yellow spots wider at discal cells, smaller at the apical region and sexes are nearly comparable (Haroon *et al.,* 2013). Red tornal spots are situated on hind wings and dusty yellow scales on the discal region. Underside the wings pale yellow with black margins situated and the adults can fly well frequently after the monsoon. The first instar larvae are black with fleshy spines at the head capsule region, second, third, fourth, and fifth

caterpillars are dark brown with a silky head capsule (Beck *et al.,* 1999). The transverse broad off-white bands giving bird dropping disguise model situated at the posterior, middle, and anterior parts of the body. The paired fleshy spines are found at the thorax and small-sized hairs at the smooth brown colored head. The larvae attach themselves to green leaves with silky threads and convert themselves into pupae (Ramakrishna, 2015).

Intensive practices in agriculture by the application of toxic chemical pesticides are the main cause of widespread ecological imbalances resulting in massive problems of pest resurgence, pesticide residues, and insecticide resistance. But many pest insects have complexes of wealthy natural enemies serving as a natural biological controlling agent. The leaf miners, whiteflies, citrus psylla, butterflies, scale insects, fruit flies, mealybug are fine under natural control in this region and all above-described pests have too good natural enemies. The present study aimed to easily identify this pest insect, enhance techniques to combat, modify and to get a better natural controlling mechanism.

Materials and methods

Observation method

The observation on the morphology of LBF was conducted in an Entomology laboratory at Date Palm Research Institute (DPRI) Shah Abdul Latif University Khairpur, during 2019.

Mass culture

With the purpose to have an adequate number of LBF for study understanding (Haldhar, 2017) described methodology was followed. The population of different larval stages was collected from different locations of the district; Naushahro Feroze, Sindh. After collection, each stage of larvae was separately placed in Petri dishes (12cm diameter) and given green new emerging fresh leaves as a food source. The leaves were renewed after the passing of twenty-four hours intervals and regularly faecal material from Petri dishes was removed and cleaned. As the larvae attempted a third, fourth, and fifth stage they were shifted into big sized Petri dishes (14cm diameter). For better determination data of each larval stage were replicated eight times. When fifth stage larvae clenched inside the Petri dishes they were shifted to another sterilized Petri dishes and finally, larvae converted into pupal stages.

Morphological studies

For male and female mating and morphological studies, a double bed mosquito net was used and Petri dishes containing the larval population were placed inside the net. An additional muslin cloth sleeve was attached at one side to facilitate handling, cleaning, and feeding of LBF inside the net. Adult butterflies were provided a solution of cotton rolls soaked in 10% sugar as a portion of food inside the net followed by (Patel *et al.,* 2017). Few fresh twigs of a lemon plant were kept in big sized two jars and both jars were placed inside the net for LBF oviposition. The external features, the morphometrics, and the colors of different stages are also recorded. During the morphological study, the shape of eggs, larval stages, coloration, antennae segments, pupae, adults, overall stages from egg to adult, and body segments were observed by the source of the inter-connected camera with the microscope to CPU monitor and digital camera at Herbarium Biodiversity Conservation, SALU- Khairpur.

Lemon butterfly collection and preservation

When adults emerged they were technically collected and placed inside a bottle containing chloroform a passage of time for killing purpose and then killed LBF were subjected for preservation. By the use of entomological pins specimens were pinned, whole body parts including; eggs, larval and pupal stages, adult's eyes, head capsule, antennae, head, thorax, abdomen, forewings, hindwings, and legs measured incm. Then specimens were accurately labeled and mounted. For pest security, naphthalene balls were placed inside the collection boxes as a method introduced (Jahnavi *et al.,* 2018).

Statistical analysis

The descriptive data were subjected to statistically analyzed according to their means separately by LSD at a 5% probability level to compare the different

treatments through statistical software student package Statistics- 8.1 USA.

Results

For morphological evaluation of the lemon butterfly, all life cycle stages (egg to adults) in color patterns, morphological differentiation, and all body parts measurement were noticed and their descriptions are given as under.

Eggs

The eggs were observed nearly oval, rounded yellow-colored before hatching turns in slow brown commonly found at the surface of new emerging leaves near the terminal parts attached through silk-like glue. The egg diameters were measured at an average of (0.02)cm.

Eggs of LBF

1st stage instars

At the anterior tip of the egg whole like appearance found the form which neonate larvae emerged, which observed light brown but head observed much darker with yellow-white margins and at the prothorax region, a row of milky-white patches situated at third, fourth, and fifth abdominal segments but eighth and ninth segments possess brown-yellow patches. Remanning segments found darker with black patches, thorax wider than head, and cuticle with dark brown spines. There were no locomotors found at the mid-region of the body but five pairs at posterior and three pairs at anterior abdominal regions were observed. The minimum length and width of the first stage larval with the length of the head capsule were recorded at average (0.06), (0.02), and (0.01)cm, respectively.

1st stage instars of LBF

2nd stage instars

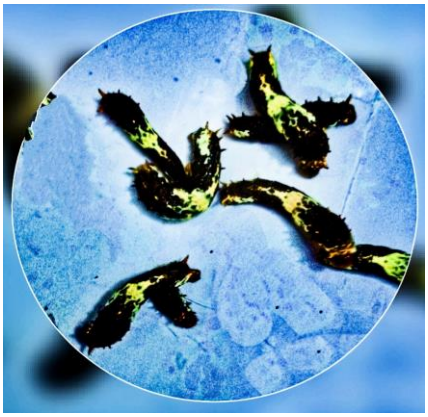
The body color of this stage was observed much darker with a brown head but prothorax color observed yellow-brown. Milky patches are situated at first abdominal and yellow-brown patches at posterior abdominal segments. The locomotor's defensive organs and spines found much wider at the thorax region. The overall mean length and width of second-stage larvae with head capsule observed at (0.78), (0.02), and (0.02)cm, respectively.

2nd stage instars of LBF

3rd stage instars

The body color of this stage larva found dark-brown, head much darker, laterally milky white and brown-yellow patches at prothorax. The third, fourth, and fifth abdominal segments contain white markings dorsally runs either body sides but the eighth and ninth segments possess paired white patches at lateral sides.

The locomotory muscular structures and spines are found. The overall mean length and width of third-stage larvae with a length of the head capsule was measured at (2.07), (0.04), and (0.02)cm, respectively.



3rd stage instars of LBF

4th stage instars

This stage of larvae greater in size more yellow in color but the whole body including the head region contains dark-white pigments. The anterior abdominal region contains paired milky-white markings, the second segment broader sized with black marking, and at the base of third to eighth segments, small-sized white patches are found laterally. The muscular paired locomotory organs are downside the larval body. The overall mean length and width including body head capsule observed at (3.29), (0.17), and (0.03)cm.

4th stage instars of LBF

5th stage instars

The fifth instar larva came out after the fourth moult and this stage is different from previous stages, spineless and green-yellow with milky white ventral and lateral patches. Light-brown head, one pair of black colored with black bands at the region of meso-metathorax and also same colored patches at anterior abdominal segments. At the dorsolaterally paired eyespot and third to seventh segment very minute black spots are situated. The length and width of this stage larva with head capsule measured at (4.13), (0.05), and (0.04)cm, respectively. LSD of all pairwise homogenous groups showed (DF= 15, 7; F= 1089. 03; P= 0.00) and (DF= 7, 15; F= 1.50; P= 0.17), further description of eggs and from 1st stage to 5th stage larvae are shown in (Table 1).

5th stage instars of LBF

Pre-pupae, pupae and post-pupae

The pre-pupae stage occurs before pupae in which larvae from silk pad on the shoots or leaves, larvae form the curved shape by forming conspicuous segments and shrunk their body lengthening measured overall mean at (2.19 to 2.43)cm and width (0.04 to 0.05)cm. The pre-pupae into pupae observed green-yellow colored with frontal projections hold themselves with silk girdle and a further decrease in length but increase in width overall mean at (2.05 to 2.06)cm and (0.04 to 0.06)cm.

The pupae by changing green to yellow-white color into post-pupae with two anterior projections measured overall mean length at (2.03 to 2.05)cm, width (0.04 to 0.05)cm and all pairwise comparisons showed least significant difference (DF= 13, 7; F= 359.04; P= 0.00) and (DF= 7, 13; F= 0.62; P= 0.73) among the variance description given in (Table 2).

Pre-pupae

Post-pupae

Pupae

Adults

The adults emerged gradually after post-pupae after shedding the cocoon layer and by releasing dirty pus-like watery secretion ultimately slow and gradual movement adult emerged out from the layer. After emergence adults seemed unable to fly but run gradually for a few hours then able to fly very strongly as compared to other insects. However, the female found somewhat larger than the males. The adult's morphometrics is given below.

Table 1. Overall mean length and width of eggs and larvae of LBF in (cm) under laboratory conditions at DPRI.

Particulars	T1	T2	T3	T4	T5	T6	T7	T8	Mean±SD
Egg	0.01	0.02	0.02	0.01	0.03	0.01	0.02	0.03	0.02±0.01^{f}
1st instar L	0.06	0.05	0.05	0.07	0.06	0.07	0.05	0.06	0.06±0.00^{ef}
W	0.02	0.02	0.02	0.02	0.02	0.02	0.03	0.02	0.02±0.00^{d}
HC	0.01	0.02	0.01	0.02	0.01	0.01	0.02	0.01	0.01±0.01^{c}
2nd instar L	0.81	0.57	0.57	0.57	1.05	0.82	1.05	0.83	0.78±0.07^{b}
W	0.03	0.02	0.03	0.02	0.03	0.03	0.02	0.02	0.02±0.00^{a}
HC	0.02	0.02	0.01	0.02	0.01	0.03	0.02	0.01	0.02±0.01^{f}
3rd instar L	2.04	2.04	1.86	2.03	2.24	2.25	2.06	2.06	2.07±0.04^{f}
W	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.03	0.04±0.00^{f}
HC	0.02	0.01	0.03	0.02	0.03	0.01	0.03	0.02	0.02±0.01^{e}
4th instar L	3.29	3.05	3.30	3.29	3.29	3.31	3.30	3.54	3.29±0.05^{f}
W	0.04	0.04	0.04	0.05	0.04	0.05	0.04	1.04	0.17±0.12^{f}
HC	0.02	0.04	0.03	0.04	0.02	0.03	0.04	0.02	0.03±0.02^{f}
5th instar L	4.07	4.06	4.24	4.25	4.06	4.25	4.06	4.07	4.13±0.03^{f}
W	0.04	0.05	0.05	0.05	0.06	0.05	0.05	0.05	0.05±0.00^{f}
HC	0.05	0.03	0.04	0.03	0.05	0.03	0.05	0.05	0.04±0.03^{f}

Mean of sixteen samples, All samples replicated eight times, L= for length, W= for width, HC= for head capsule

Table 2. Overall mean length and width of pre-pupae, pupae and post-pupae of LBF in (cm) under laboratory conditions at DPRI.

Particulars	Days	T1	T2	T3	T4	T5	T6	T7	T8	Mean±SD
Pre-pupae, L	1st	2.06	2.08	2.07	2.09	3.03	2.08	3.02	3.00	2.43±0.17^{a}
	2nd	2.07	3.01	2.08	2.06	2.09	2.06	2.08	2.06	2.19±0.12^{ab}
W	1st	0.03	0.05	0.07	0.04	0.06	0.05	0.03	0.06	0.05±0.01^{d}
	2nd	0.04	0.03	0.05	0.05	0.02	0.03	0.04	0.02	0.04±0.02^{d}
Pupae, L	1st	2.05	2.08	2.07	2.06	2.09	2.08	2.03	2.05	2.06±0.01^{bc}
	2nd	2.06	2.05	2.04	2.08	2.06	2.04	2.02	2.03	2.05±0.02^{bc}
	3rd	2.06	2.05	2.04	2.03	2.05	2.06	2.05	2.04	2.05±0.01^{bc}
W	1st	0.07	0.06	0.03	0.08	0.06	0.05	0.06	0.05	0.06±0.01^{d}
	2nd	0.06	0.05	0.03	0.06	0.04	0.06	0.05	0.04	0.05±0.02^{cd}
	3rd	0.04	0.03	0.05	0.03	0.02	0.04	0.03	0.04	0.04±0.03^{d}

Particulars	Days	T1	T2	T3	T4	T5	T6	T7	T8	Mean±SD
Post-pupae, L	1st	2..04	2.03	2.05	2.05	2.03	2.06	2.08	2.05	2.05±0.01^{bc}
	2nd	2.03	2.04	2.02	2.01	2.04	2.03	2.02	2.04	2.03±0.02^{c}
W	1st	0.05	0.03	0.04	0.08	0.05	0.04	0.05	0.05	0.05±0.01^{d}
	2nd	0.04	0.02	0.03	0.02	0.04	0.06	0.03	0.04	0.04±0.00^{d}

Mean of six samples, All samples replicated eight times, L= for length, W= for width.

Adult's dorsal view Adult's ventral view Newly adult emerging Adult with antennae

Adult's eyes, head capsule, Antennae, Jointed legs

The eyes color of male and female observed pragmatic darker blue with overall mean length and width of a male at (0.03)cm and female (0.04)cm.

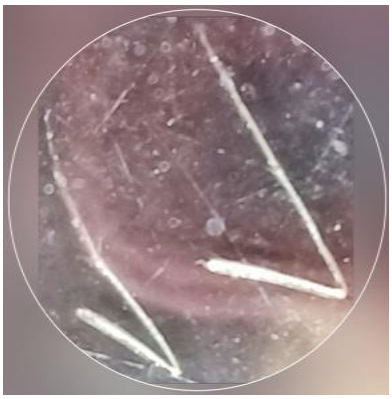
The head capsule found with dark-whitish minutes puffy hair-like appearance and overall little difference was measured in the mean length and width between males (0.05)cm and females (0.07)cm.

The one paired mobile jointed and much darker clavate shaped antennae articulated on the front side with head between the eyes. The overall mean length of antennae measured (0.98)cm in both sexes.

The jointed legs found dirty blackish colored and in male fore, middle and hind legs measured at (1.43) and female (1.75)cm, respectively.

Eyes with head capsule

Antennae



Jointed legs

Thorax, Abdomen

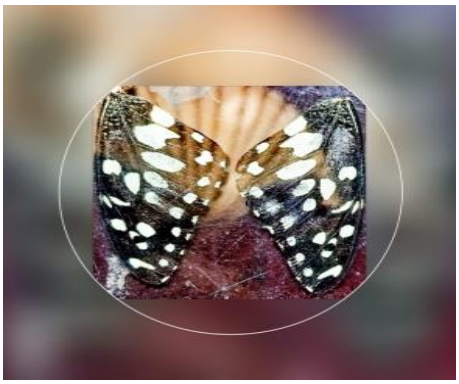
Thorax of male and female observed black colored but either side of the body yellow-creamy patches are situated and the mean length and width of male observed (0.06)cm female (0.48)cm and adult's abdomens originate dorsally black with black yellow margins on the lateral side and ventrally whitish. The overall mean length and width of both sexes measured (0.48)cm and (0.57)cm, respectively.

Thorax

Abdomen

Forewings

The forewings found black colored and dorsal side twenty-nine pairs of half white pigments located of which seven pairs found larger than the rest measured (0.07)cm in length and four pairs of yellowish pigments ventral side observed (0.06)cm in length of both sexes. The total mean length and width of forewings of male recorded (2.48) and female (2.87)cm.

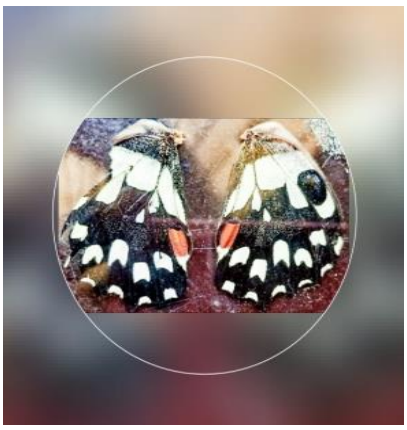


Forewings dorsal view

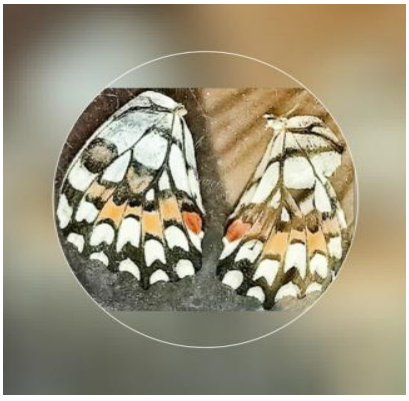
Forewings ventral view

Hindwings

The hindwings are the same in color but smaller in size contains twenty half white pigments measured (1.01)cm and seven pairs of yellowish pigments ventral side (0.09)cm in length. At the base of hindwings red patches, tornal spots are present to mark the male and female identification. The total mean length and width of both sexes were found (1.68) and (2.17)cm, respectively. The LSD of all body parts shows significant difference (DF= 14, 7; F= 222.53; P= 0.00) and (DF= 7, 14; F= 0.72; P= 0.65) among the homogenous groups. From egg to adult detailed descriptions are given in (Table. 3).



Hindwings dorsal view



Hindwings ventral view

Table 3. Overall mean measurements of different body parts of adults male and female LBF in (cm) under laboratory conditions at DPRI.

Particulars	T1	T2	T3	T4	T5	T6	T7	T8	Mean±SD
Male eyes, L/W	0.03	0.02	0.03	0.03	0.03	0.02	0.04	0.03	0.03±0.00^{h}
Female eyes, L/W	0.04	0.04	0.04	0.03	0.04	0.04	0.03	0.05	0.04±0.00^{h}
Male head capsule, L/W	0.05	0.05	0.05	0.05	0.07	0.05	0.06	0.06	0.05±0.00^{h}
Female head capsule, L/W	0.07	0.06	0.06	0.08	0.06	0.07	0.07	0.08	0.07±0.00^{h}
Male thorax, L/W	0.06	0.06	0.05	0.05	0.05	0.07	0.06	0.06	0.06±0.00^{h}
Female thorax, L/W	0.54	0.52	0.07	0.54	0.57	0.54	0.54	0.54	0.48±0.06^{g}
Male abdominal, L/W	0.54	0.56	0.53	0.54	0.55	0.07	0.54	0.56	0.48±0.06^{g}
Female abdominal, L/W	0.59	0.56	0.59	0.56	0.58	0.55	0.59	0.58	0.57±0.01^{g}
Male fore wings, LW	2.56	2.53	2.54	2.50	2.55	2.55	2.06	2.55	2.48±0.06^{b}
Female fore wings, L/W	3.04	2.58	3.03	2.59	3.04	2.57	3.06	3.05	2.87±0.08^{a}
Male hind wing, L/W	1.57	1.57	1.57	2.03	1.56	1.58	2.03	1.58	1.68±0.07^{d}
Female hind wings, L/W	2.05	2.05	2.05	2.04	2.53	2.06	3.02	1.57	2.17±0.15^{c}
Male, Female antennae, L	1.06	1.03	1.06	1.04	1.04	0.58	1.04	1.04	0.98±0.06^{f}
Male jointed legs, L	1.39	1.39	1.38	1.38	1.07	1.70	1.70	1.39	1.43±0.07^{e}
Female jointed legs, L	2.03	1.40	1.71	1.70	1.72	2.02	1.39	2.04	1.75±0.09^{d}

Mean of fifteen samples, All samples replicated eight times, L= for length, W= for width

Discussion

In the present research work, it was frequently observed that after matting, female lay eggs bypassing only two days the same findings documented by Rafi *et al.,* (1999c). The colors of eggs were observed spherical pale yellow, smooth, and flattened compared with the findings of Suwarno, (2010), the diameter of the eggs similar to the work of Krishnakumar, (2008). When eggs became hatch first small-sized instar emerges which passes five-stages and each stage convert into the next stage through the molting process with the agreement of Ghosh, (1914).

The difference in larval size and feeding behavior is with the agreement of Mangrio *et al.,* (2020) and color in each larval stage with the agreement of Badawi, (1981). The larval length and width were observed with the work similarity of Patel *et al.,* (2017). The pupae measurement and color with the more or less comparable work of Depury, (1968). The LBF is very active and serves in both seasons of the year at upper Sindh. The adult's eyes, head capsule, antennae are with the more or less comparable with the work of Haldhar *et al.,* (2010).

The thorax, wings, and abdomen are with the agreement of Ramakrishna, (2015). Paired forewings, hind wings, and jointed legs with the work similarity of Singh and Gangwar, (1989). The main motto of this morphometrics study of LBF is to introduce general characteristics and to reorganize the severe effects of this pest in citrus crops. In this regard for proper management of this pest insect integrated pest management program is an effective tool for control, prevention, monitoring because IPM offers the timed opportunity to drastically reduce pesticide usage, also slower the exposure and toxicity because when there are no proper management strategies and programs then certain pests cause massive losses throughout the year. The present research work was done in a view to providing the basic knowledge to the citrus growers of this area and this morphometrics documentary of LBF will be an informative tool due to which local growers can easily recognize all aspects of this harmful insect pest.

Conclusion

It is concluded that LBF serves as the harmful insect pest to citrus species lay eggs on tender twigs near edges of fresh leaves and from eggs larvae emerge which pass five stages through molting. It was frequently observed in each moult, the larvae exuviae and eat it but did not use hard sclerotized parts. More or less differentiation was observed in the size of each stage larvae. Morphologically the fifth stage larvae found different from other stages. Generally, females were observed larger than males. Tornal spot on hind wings is the characteristics of male and female identification. LBF in Pakistan is found in wide ecological zones and having sufficient patience power

to survive in different climatic conditions but no work has been done on the morphological perspective.

The study on the morphology of lemon butterfly conducted the first-time form this area and this scientific work will be the source of information for a better understanding of LBF because of their role as a key pest to citrus orchards. Furthermore, the present study aimed to determine the different morphological aspects of the lemon butterfly including all life metamorphic characteristics from egg to adult. It is an immediate call to promote awareness, biological, structural, cultural, and suitable remedial measures to secure citrus fruits from this pest insect.

Recommendations

It is recommended that LBF serve as a destructive agent for citrus orchards, the larvae of this pest insect widely use fresh and new emerging leaves. As a result, the reduction occurs in the growth and yield production of citrus fruits. Due to severe infestation citrus growers face certain economical losses. The knowledge of parasitoids association with their host insects, mortality factors, nonpesticide measures, parasitoid conservation with a holistic approach is immediately needed. Currently, many natural enemies from Pakistan and other neighboring countries are exported to the USA to enhance and establish sustainable control over the citrus pests. It is further suggested that effective management and control at the proper time should be applied to secure the quality and quantity of citrus fruit production.

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