

# Biology, Weight Measurement and Larval Time Consumption of Lemon Butterfly, *Papilio Demoleus* Linnaeus (1758) on *Citrus Limon* Leaves under Laboratory Conditions

Wali Muhammad Mangrio<sup>1\*</sup>, Hakim Ali Sahito<sup>1</sup>

<sup>1</sup>Department of Zoology, Faculty of Natural Sciences, Shah Abdul Latif University, Khairpur Khairpur Mir's, 66020 Sindh-Pakistan.

\*Corresponding author: Wali Muhammad Mangrio

E-mail: wali.muhammadmangrio786@gmail.com Ph.#. (+92) 301-3873230

## ABSTRACT

The research study on the biology of the lemon butterfly was carried out under laboratory conditions in Date Palm Research Institute (DPRI) from July to December 2020-21. The collection was made from lemon leaves and placed into jars, later on inside the mosquito net (4x7ft) reared at 25±2°C relative temperature and 65±5% R.H. For oviposition a couple of adult male/female (♂:♀) were individually released, on tender twigs, an adult female laid egg singly, then separately eggs were placed inside the Petri dishes. The egg incubation period lasted overall 2.99±0.13<sup>f</sup>, 4.00±0.08<sup>e</sup>, 4.20±0.06<sup>e</sup>, 4.98±0.10<sup>d</sup>, 3.98±0.08<sup>e</sup>, and 4.99±0.09<sup>d</sup> mean days for 1<sup>st</sup>, 2<sup>nd</sup>, 3<sup>rd</sup>, 4<sup>th</sup> and 5<sup>th</sup> larvae stages. The pre-pupae 1.84±0.04<sup>g</sup>, pupae 4.04±0.09<sup>e</sup>, post-pupae 1.53±0.10<sup>g</sup> consumed mean days, and adult male consumed 3.81±0.09<sup>e</sup>, female 6.74±0.08<sup>c</sup> mean days, total male longevity 36.18±0.39<sup>b</sup>, female 39.11±0.37<sup>a</sup> mean days lasted. Whereas mean egg hatching % 95.05±0.58<sup>a</sup> and 83.80±1.11<sup>b</sup>, 91.91±0.78<sup>a</sup>, 88.55±1.95<sup>ab</sup>, 85.77±2.56<sup>b</sup>, 74.51±2.98<sup>d</sup> 1<sup>st</sup> to 5<sup>th</sup> larvae stages, pupae 45.92±1.57<sup>c</sup>, adult male 21.21±1.05<sup>fg</sup>, female 24.71±0.93<sup>f</sup> survival % were recorded. The overall different five-stage larvae mean calculated 0.03, 0.05, 0.11, 0.16, 0.48, pre-pupae 0.76, pupae, 0.52 and post-pupae 0.46 in grams, respectively. From 1<sup>st</sup> up to last stage of larvae for food-seeking to reach at 5cm distance lasted 4.39, 3.76, 2.85, 2.01, and 1.12 minutes and seconds. The novelty of this research determines that *Papilio demoleus* serve as citrus destructive pest during their developing stages. It is strictly needed and an immediate call more work should be performed for healthy future perspective to combat form this plague pest.

**Keywords:** Incubation; Matting; Oviposition; Plague pest; Tender twigs

## INTRODUCTION

The citrus fruits are grown in subtropical and tropical regions of the world, these fruits are cosmopolitan and important leading crops (Adenaike & Onyukwo, 2021), massively cultivated in Brazil, Israel, Pakistan, India, Japan, China, Italy, Egypt, Algeria, Bangladesh, Palestine, Central America, Paraguay, Japan, Argentina, Russia, Spain, New Zealand, Uruguay, Mexico etc., (Amutha et al., 2017). The *Citrus limon* fruit is regarded as beneficial for growth and development for human beings, with high content of vitamins C, are delicious, refreshing, and essential for human beings to keep blood pressure at normal range and these fruits are not consumed only as fresh but they are also used for flavoring, fruitful dishes, meat, fish, salads, cold drinks, medicinal purposes, skin, hair, heart benefits, and their pulps are the source of food for cattle animals (Mondal & Rahaman, 2020) but the

drying temperature has a wide influence on phenolic acid, polyphenols, and content of lemon peel flavonoids (Haida et al., 2022).

The Planet of the earth consisting 1.4 million species but the only insect having unrivaled supremacy (Yunus & Munir, 1972), of which 53.1% are insects and more than 15000 to 16000 spp., belongs to butterflies throughout the world, in the case of Pakistan nearly 5000 insects species have been documented of which 400 are moths and butterflies (Sarfraz et al., 2006), and these species give much more generation as compared to other vertebrates and agri-ecosystem is suitable habitat for their survival and the lemon butterflies are plant-pollinator, with high visual olfactory responses and respond rapidly to environmental changes, arthropods are extensive in order, due to coloration many species puzzle in identification, the density of population relies upon negative effect (Khan & Parveen, 2015).

The citrus pest insects suck plant juices, affect stems, trunks, damage fruits, turn yellow-pale to leaves resulting in retard plant growth, decrease fruit production, and intense invasion causing defoliation eventually falling off trees (Matsumoto, 2002). The variety of pest insects harming citrus orchards and nurseries cause massive economic losses of which some species of insects are serious pests to citrus i-e., *Diaphorina citri* Kuwayama, *Aonidiella aurantii* Maskell, *Dialeurodes citiri* Ashmead, *P. polytes* Linnaeus, *Phylloncostis citrella* Stainton and but *P. demoleus* is a key pest species their larvae make a close specific relationship, feed and devouring a huge number of host plants and cause heavy economic loss (Chatterjee et al., 2000).

The lemon butterfly is frequently found in different regions of the world such as; Pakistan, New Guinea, Australia, Iran, Formosa, India, Indonesia, China, and Japan (Kunte, 2006). The *P. demoleus* in nature is the symbol of beauty and grace, their flight gives pleasure attraction and bright colors are still attention and in agriculture fields, on hind wings the tornal spots marks the male and female identification (Mangrio & Sahito, 2021). The flora provides the best habitat for pollination dispersal, because sometimes these pest insects due to the unavailability of host plants and their nectars facing anxiety (Pywell et al., 2011). It consists of two paired wings with black and yellow markings, yellow radish patches on their darker body, egg lying on tender leaves, overshoot that is rounded, smooth, yellow-white (Jahnavi et al., 2018). The *P. demoleus* mostly prefer *C. limon* as host plants defoliate and suck the juice from the flowers causing a significant threat to citrus orchards throughout the world (Homziak et al., 2006). Adults using biting-chewing mouthparts, there is an association of their larvae for drinking floral sap liquid substances with their host plants (Yunus & Munir, 1972). The larvae of this pest by slow-moving may cause 83% defoliation of *C. limon* during their developmental stages, choose frequently citrus orchards and defoliate completely (Narayanamma et al., 2001). This species of pest insect significantly increasing due to suitable habitats and food availability on citrus leaves larvae also consume whole eggshells damaging the citrus plants found not only in Sindh, but Pakistan also comprise potential power rapid growth and extensive migration (Ackery et al., 1995).

The *P. demoleus* biological developmental depends on host plants, breed once or twice in a year in temperate regions, show bivoltine, multivoltine, univoltine characters, and in tropical regions found both seasons of the year (Patel et al., 2017). The life cycle, developmental stages, and biology are essential factors, and the biological study of egg, larvae, pupae, and an adult lemon butterfly is essential because it is compulsory to know their survival status dependent on various plant communities and breeding places of the *P. demoleus* (Greenberg et al., 2001). For effective management and proper information, the biological study of the lemon butterflies is quite necessary,

and study on the larval stages, and duration of the life cycle because of voracious feeding behaviour on citrus orchards (Mangrio et al., 2019). Hence; it is necessary to research the biology of pest insects and their pest influence and conservation the study on the biology, seasonal influence is an authentic tool (Dennis et al., 2003). Throughout the Sindh province, citrus fruits are being cultivated for a few decades but these fruits are massively growing in district Naushahro Feroze is main hub with sufficient productive basis (Mangrio et al., 2020), but *P. demoleus* vigorously damaging and causing severe economic losses to citrus plants. Keeping in view, this research was conducted in view to know the different biological stages proper identification and their citrus host destructive behaviours. It is strictly needed to carry out the biological study of *P. demoleus* to save the citrus orchards appropriately because is no finest information and satisfactory scientific documentation of the LBF in Pakistan.

## MATERIALS AND METHODS

Under laboratory conditions, the research work on different developmental stages of the lemon butterfly was performed (DPRI) in the Entomology laboratory, Shah Abdul Latif University, Khairpur, 2020-21.

### *Papilio demoleus* eggs collection

The collection was made from lemon plantations and newly lemon growing lemon fruit from Kauro Khan Sahito of district Naushahro Feroze during 2020-21. It is the sahati and fertile plain areas situated at 27°12'7.45"N latitude and 68°19'59.96"E longitude Fig 1. For humid maintenance and to avoid desiccation the petioles of the collected lemon leaves containing eggs were covered with a cotton swab which was soaked in water. The eggs were reared about 7cm in length in plastic glass vials as time passes the egg started to hatchability and starts to feed on leaves which were given once a day.



**Fig 1. The sampling area was 27°12'7.45"N latitude and 68°19'59.96"E longitude from which LBF populations were collected.**

### ***Rearing of larvae under laboratory conditions***

The eggs along with *C. limon* leaves were brought for immature development maintained at 28°C, 65±5% RH, and photoperiod 12L: 12D (L: Light and D: dark) under Entomology laboratory examination situated at 27°29'37.53"N latitude and 68°46'3.69"E longitude Fig 2. After egg hatching, new larvae emerged, later to accommodate good space they were shifted to large-sized plastic vials. The fresh leaves were given and an older one was removed daily until larvae pass in all stages and convert into pupae. For ensuring a good hygienic condition plastic vials were cleaned by removing the feed waste material including the fecal of larvae. As larval size increases they needed wide space from previous stages then from less space to enlarge space larvae were transferred in plastic vials were covered by a mesh for free ventilation. For smoothly shifting of different stages of larvae the camel hair brush was used and all stages were determined when thoroughly larvae cast their outer layer.

### ***Rearing of *Papilio demoleus* pupae***

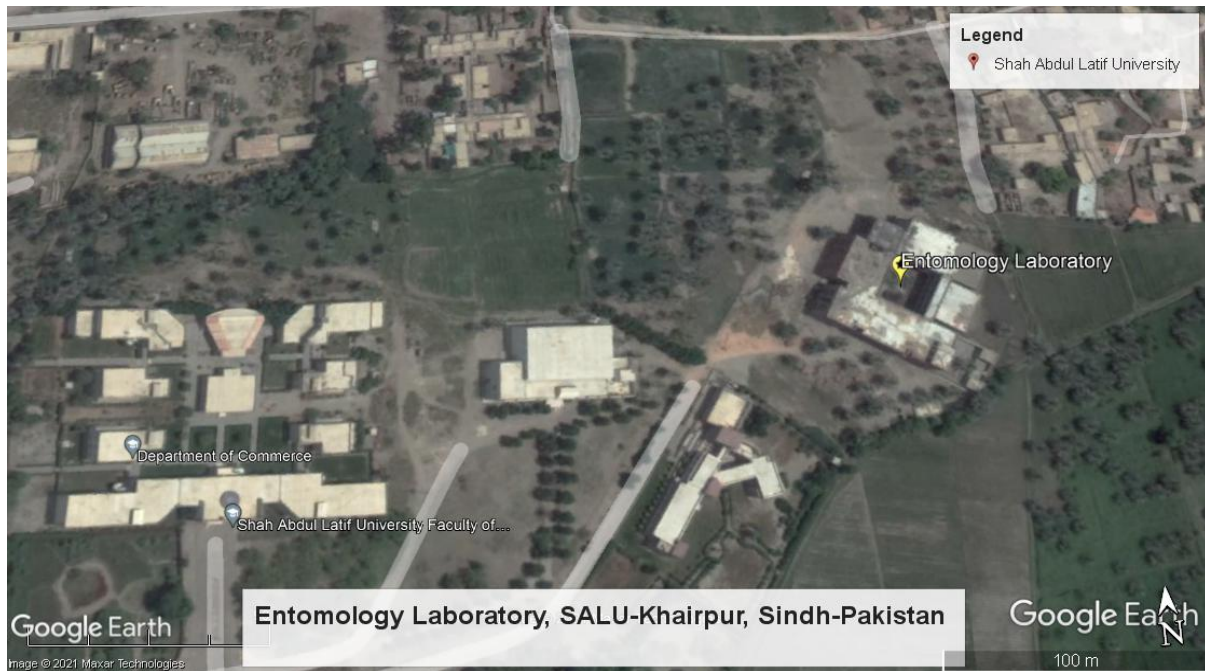
When fifth stage larvae were found sluggish they were shifted into fresh sterilized large-sized jars to convert into pupae by exhausting the saliva inside the upper and medium levels of jars the clenched. For resting to mature whole body covered with whitish saliva within few hours or in a day. Then larvae converted into pupae with the prominent legs, wings, abdomen, antennae found to live to prolong up to either male or female adults.

### ***Adult male/female rearing***

The adult male and female emergence starting time from the day of incubation was recorded and when from pupae the adult emerged they were released into the mosquito net attached one side sleeve muslin cloth 4x7" containing zip for entrance, handling facilitate, cleaning, and for fresh food to insects inside the net in which they easily fly and copulate. Adult butterflies were given cotton rolls soaked in 10% honey solution as their extra nutritional value inside the mosquito net for feeding. For the egg-laying inside of each mosquito net, fresh twigs up to two feet of lemon orchards were settled in big-sized plastic jars containing water. Whereas; freshly collected leaves were given as a food source on an alternate day.

### ***Biological study***

During the biological study of *P. demoleus* attention was given i.e., incubation, pre-oviposition, and oviposition, hatching and unhitching % with days consumption, pupae, sex ratio, pre-mating and mating time, adult formation and longevity, survival, mortality and total life span. All stages of LBF for authenticity and validation were replicated six times. The data was gathered regarding larval weight in grams, and different stage larval loops counted in minutes and seconds. Regular photography was done for proper color pattern identification and variation in their behaviors. At Herbarium Biodiversity Conservation SALU, Khairpur the camera-connected microscope with CPU was used for authentic confirmation of all egg to adult stages. For statistical analysis, ANOVA was done through Randomized Complete Block Design for different developmental stages and least significant difference test at 5% probability level means of different all six replications were separated through 8.1 software.

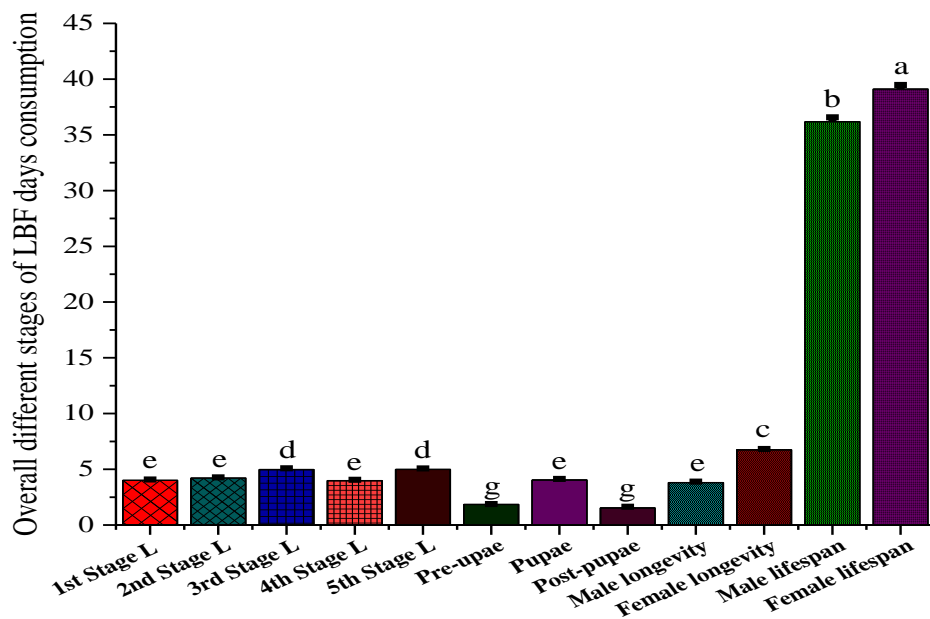


**Fig 2. Entomology laboratory, 27°29'37.53"N latitude and 68°46'3.69"E longitude where the biological study of *P. demoleus* was conducted.**

## RESULTS

### *The lemon butterfly has different developmental stages*

In this research work, the period of different stages of *P. demoleus* from egg-incubation up to the adult stage on citrus leaves was counted under laboratory conditions. The adult female was observed to vibrate the posterior body part by abdominal portion curling to adhere the eggs on lemon leaves, the most preferred food of LBF. The egg incubation mean value was recorded as  $2.99 \pm 0.13$  with day's consumption. Typically larvae with five distinct stages consumed  $4.00 \pm 0.08$ ,  $4.20 \pm 0.06$ ,  $4.98 \pm 0.10$ ,  $3.98 \pm 0.08$ , and  $4.99 \pm 0.09$  mean days from 1<sup>st</sup>, 2<sup>nd</sup>, 3<sup>rd</sup>, 4<sup>th</sup>, 5<sup>th</sup> instars, respectively. The pre-pupae mean developmental period recorded  $1.84 \pm 0.04$ , pupae  $0.04 \pm 0.09$ , post-pupae  $1.53 \pm 0.10$ , male adult longevity  $3.81 \pm 0.09$ , female  $6.74 \pm 0.08$  with overall male life span  $36.18 \pm 0.39$  and female  $39.11 \pm 0.37$  days, respectively. The longest development duration was seemed in the last stage of larva compared to previous stages but adult females consumed maximum days as compared to all developmental stages of *P. demoleus*. The differences in fecundity, development time, and adult longevity were tested through (ANOVA) showing the significant difference in days consumption among various biological stages (DF=11; F=7332.03; P=0.00), and all pairwise comparisons into *P. demoleus* homogenous groups, further justification summarized in Fig 3.

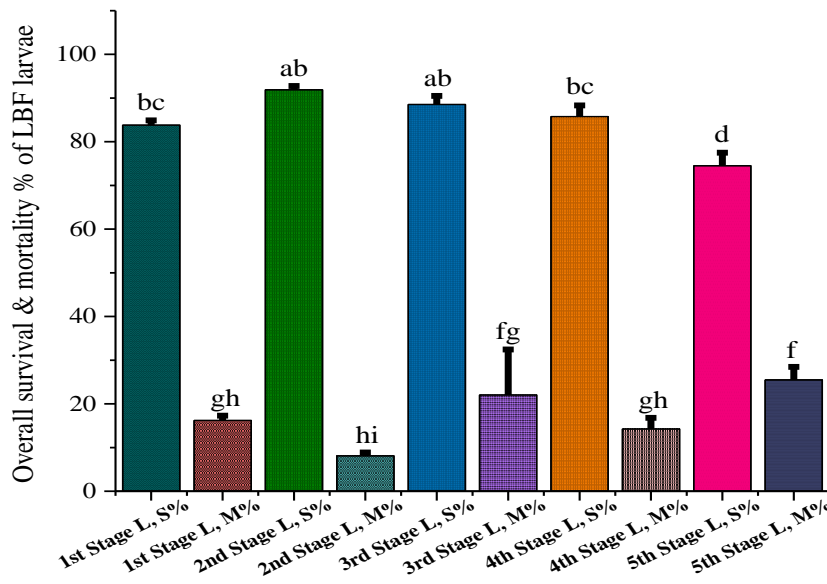


**Fig 3. Overall mean of biological stages of LBF in days consumption during, 2020-21**

#### ***Survival and mortality %***

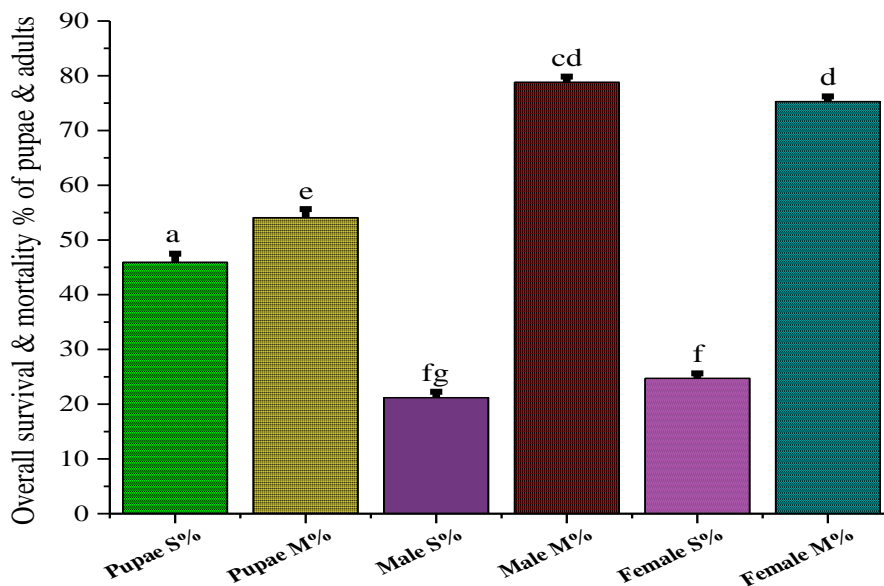
Under laboratory examination the survival and mortality % from the egg up to different intrinsic rates were counted, the adult female laid maximum to minimum 95 to 65 per female eggs in which overall egg hatching and un-hatching % counted  $95.05 \pm 0.58$ ,  $4.99 \pm 0.59$ . The survival and mortality % in 1<sup>st</sup> stage larvae were found  $83.80 \pm 1.11$ ,  $16.20 \pm 1.11$ , 2<sup>nd</sup> stage  $91.91 \pm 0.78$ ,  $8.09 \pm 0.78$ , 3<sup>rd</sup> stage  $88.55 \pm 1.95$ ,  $22.01 \pm 10.44$ , 4<sup>th</sup> stage  $85.77 \pm 2.56$ ,  $14.24 \pm 2.56$ , and 5th stage  $74.51 \pm 2.98$ ,  $25.49 \pm 2.98$ . When data was statistically subjected to analysis of variance in survival and mortality % was found with significant differences among the different stages (DF=4; F=125.06; P=0.00), and comparison test of all pairwise homogenous groups was observed with significant differences in their survival and mortality % further shown in Fig 4.





**Fig 4. Under laboratory conditions larvae survival and mortality % during, 2020-21**

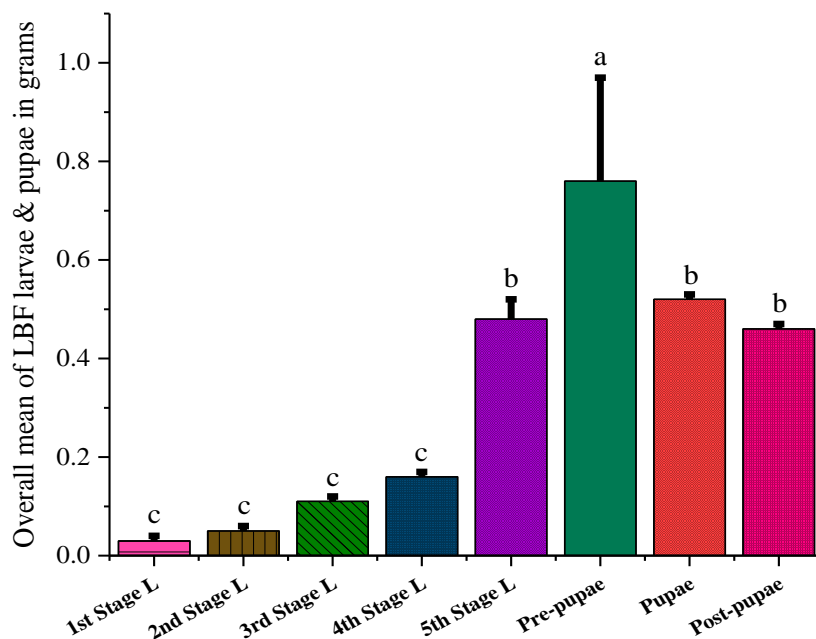
While as; pupae calculated with overall survival and mortality %  $45.92 \pm 1.57$ ,  $54.08 \pm 1.57$  and the survival % in adult male recorded  $21.21 \pm 1.05$ , mortality %  $78.79 \pm 1.05$ , the survival % in adult female  $24.71 \pm 0.93$ , mortality  $75.29 \pm 0.93$ , respectively. Overall maximum mortality occurred in males than females of *P. demoleus*. The analysis of variance was subjected to the statistical analysis found with the significant difference in pupae and adult stages (DF=2; F=105.02; P=0.00), and homogenous groups pairwise observed with significant differences in survival and mortality %, respectively, the further justification given in Fig 5.



**Fig 5. The pupae and adults survival and mortality % during, 2020-21**

**Lemon butterfly larvae weight in grams**

The weight of newly caterpillar from the first stage to the fifth was observed  $0.03\pm 0.00$ ,  $0.05\pm 0.01$ ,  $0.11\pm 0.01$ ,  $0.16\pm 0.01$ , and  $0.48\pm 0.04$ , pre-pupae  $0.76\pm 0.21$ , pupae  $0.52\pm 0.00$  and post-pupae  $0.46\pm 0.01$  in grams, respectively. In all treatments, the analysis of variance was found with significant differences from first up to fifth stage larvae weight in grams (DF=7; F=12.81; P=0.00). The LSD test of all pair-wise comparisons was found with the significant difference among the treatments which were divided into homogeneous groups of lemon butterfly weight in grams that are shown in Fig 6.

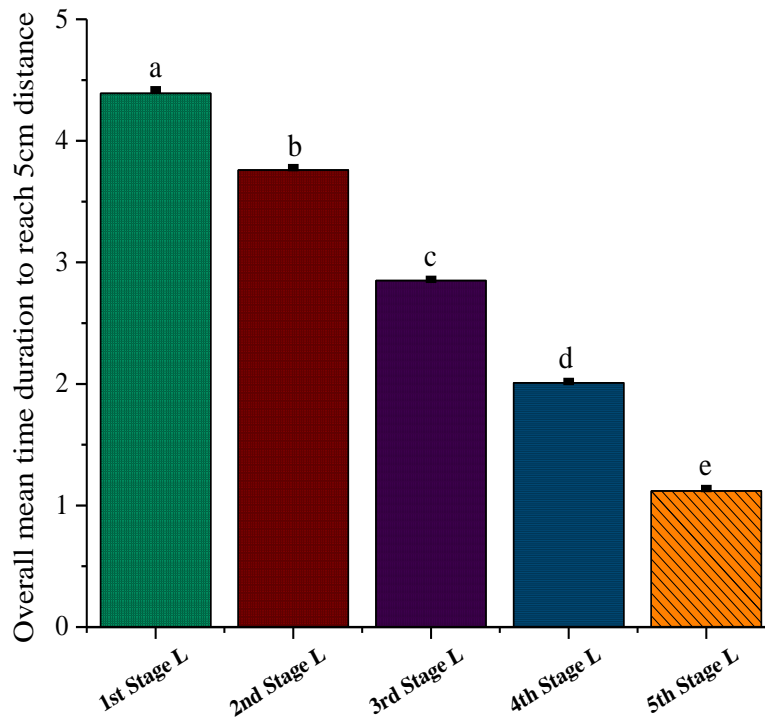


**Fig 6. The overall mean of LBF larvae and pupae in grams during, 2020-21**

**Lemon butterfly larvae time consumption minutes and seconds**

The larvae of *P. demoleus* took overall mean period such as; 1<sup>st</sup> stage  $4.39\pm 0.03$ , 2<sup>nd</sup> stage  $3.76\pm 0.02$ , 3<sup>rd</sup> stage  $2.85\pm 0.01$ , 4<sup>th</sup> stage  $2.01\pm 0.01$ , 5<sup>th</sup> stage  $1.12\pm 0.02$  minutes and seconds to reach a distance of 5 cm distance. From the first to the fifth stage of larvae to reach 5 cm distance analysis of variance shows significant difference duration of time (DF=4; F=68.25; P=0.00), in all treatments. The significant difference observed during minutes and seconds in all treatments through LSD pair-wise comparison test, the further justification given in Fig 7.

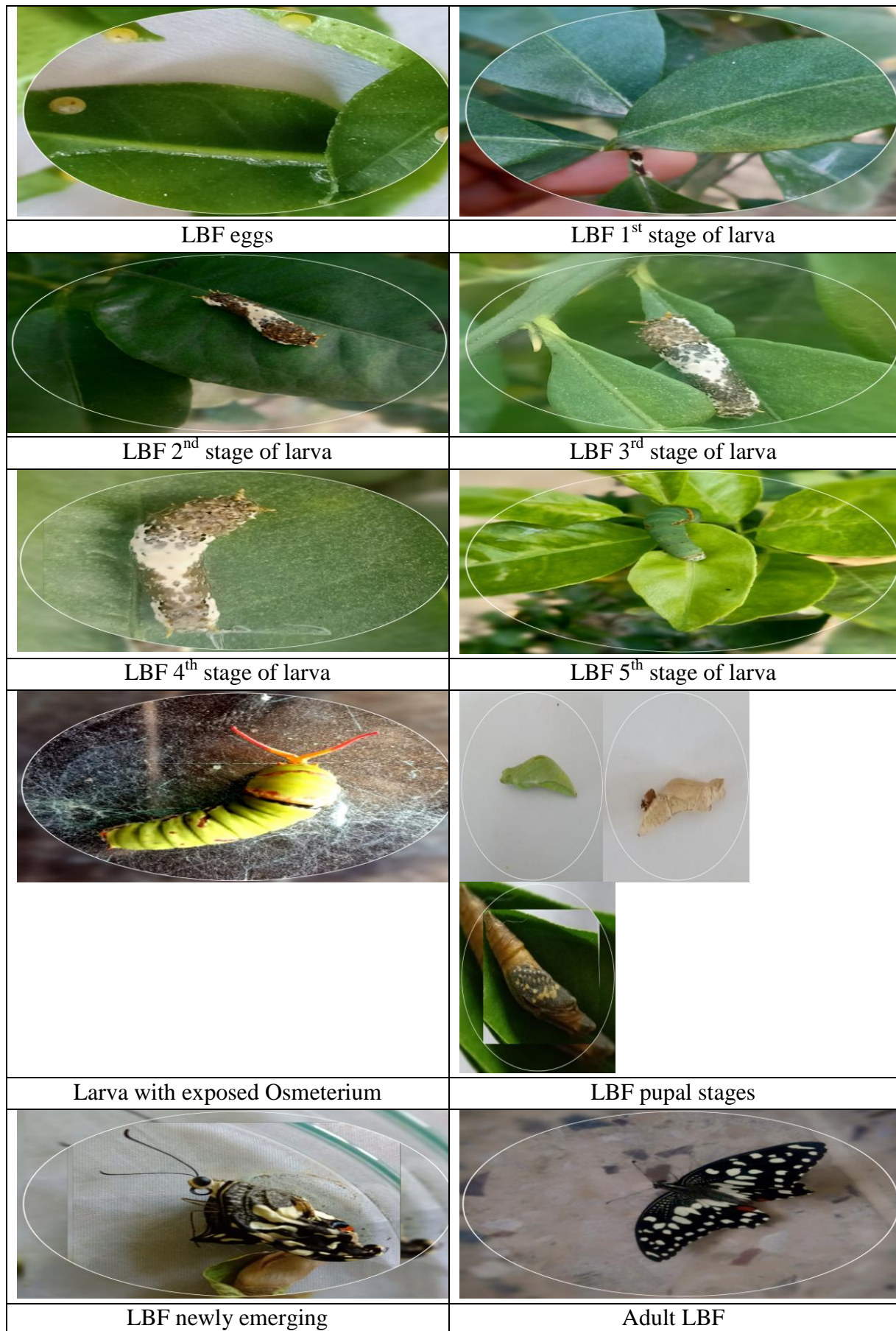




**Fig 7. The overall mean of LBF larvae time duration to reach 5cm during, 2020-21**

#### ***Egg to adult body color patterns***

The *P. demoleus* eggs were observed pale-yellow, spherical, flattened and smooth. On the abdominal dorsal side, the 1<sup>st</sup> stage of larvae contains little spines with white margins and the coloration of this larvae stage was observed brown-blackish. The color of the 2<sup>nd</sup> stage larva was observed dark with milky white patches. The 3<sup>rd</sup> stage larvae seemed visible white patches and nearly resembles the previous stage. The 4<sup>th</sup> stage was almost black with greenish patches on the body surface. The body color patterns of 5<sup>th</sup> stage larvae seemed to change from all other stages found greenish with brownish patches. The pupae reported green in color earlier but turns into brown later. By splitting the anterior part of the puparium from the post-pupae fully developed adult emerged out by containing wide forewings black in color comprising yellow margins irregularly, hind wings with tornal spots, blue crescent-shaped eyes. Form pupae cocoon silky layer initially paired front legs emerged out, then climb slow and gradually and ultimately set free from layer like as mammalian and before fluttering expands wings for dehydration. After emergence from the pupae layer, it is unable to fly for one to five hours then able to fly further characteristics and color patterns highlighted in Fig 8.



**Fig 8. Under Laboratory conditions different developmental stages of LBF**

## DISCUSSIONS

The *C. limon* leaves were observed most reliable food source of larvae with the work similarity of (Chatterjee et al., 2000; Narayanamma et al., 2001; Alturi et al., 2002; Kunte, 2006; Munir et al., 2007), in their findings documented that lemon as their most suitable host plants species.

It was frequently observed incubation lasts 2.99 mean days and in females, egg-laying capacity at earlier observed slower but gradually increase in later with work similarity of (Resham et al., 1986), documented the same egg-laying behavior (Rao et al., 2014), they discussed that after matting adult females lasted 1.22-1.36 days then start to lay eggs continued from first to up to fifth days (Islam et al., 2019) documented 2.91 days observed on *Citrus limon*. On the host plants, *C. aurantiifolia* (Ackery et al., 1995) reported 2.77- 2.98 days. On the leaves of *M. koenigii*, *C. sinensis*, and *C. limonia* host plant leaves (Alturi et al., 2002), documented 2.96 days (Chen & Ouyang, 2007), 3.00-4.60 days and (Santhosh & Basavarajappa, 2017) three to four days. The mean fecundity capacity was recorded at  $81.37 \pm 3.35$  (Munir et al., 2007) documented 13-40 eggs and (Maheswarababu, 1988) 103-121 eggs per female.

The 1<sup>st</sup> stage larvae lasted  $4.00 \pm 0.08$  mean days, with the agreement of (Patel et al., 2017), who recorded 2.00-4.00 days, 3.00 days documented (Rajendra et al., 1997), and 3.05 mean days (Jahnavi et al., 2018). The 2<sup>nd</sup> stage larvae consumed  $4.20 \pm 0.06$  mean days with the agreement of (Patel et al., 2017), who reported 2.00-4.00 days. The 5.50 days documented (Rajendra et al., 1997), 3.00 days (Ackery et al., 1995), 3.12 mean days (Rao et al., 2014), respectively. The 3<sup>rd</sup> stage of larvae lasted  $4.98 \pm 0.10$  mean days it is with more or less similar work to (Patel et al., 2017), they calculated 2.00-4.00 days, 2.92 mean days (Rajendra et al., 1997), 4.00 mean days (Jahnavi et al., 2018), 1.48-1.59 mean days (Rao et al., 2014), and 2.01 on *M. koenigii*, 1.72 *C. jambhiri*, 1.64 *C. aurantiifolia*, 1.47 *C. sinensis* days reported (Maheswarababy, 1988), respectively. The 4<sup>th</sup> stage larvae consumed  $3.98 \pm 0.08$  mean days is with similar results (Rao et al., 2014), who observed 1.98-2.06 mean days. On the leaves of *C. jambhiri* consumed 1.72, *C. aurantiifolia* 1.64 and *C. sinensis* 1.47 mean days documented by (Maheswarababy, 1988), respectively. 3.25 mean days on the *C. aurantiifolia* leaves (Jahnavi et al., 2018), 2.00-4.00 days (Patel et al., 2017), 3.00 days (Ackery et al., 1995), respectively. The 5<sup>th</sup> stage larvae consumed  $4.99 \pm 0.99$  mean days the same combination reported (Jahnavi et al., 2018), 4.04 mean days (Ackery et al., 1995; Patel et al., 2017), 4.00-6.00 days (Rajendra et al., 1997), 3.38 mean days on Curry leaves, 2.56 Rough lemon, 2.60 Rangpur lime, 2.56 Sweet orange leaves (Maheswarababy, 1988), and 2.24 mean days were observed on *Citrus limon* leaves (Rao et al., 2014), respectively.

In present research all five distinct larvae consumed 22.15 total days similar to the work of (Jahnavi et al., 2018) who counted 17.53 mean days on *C. aurantiifolia* leaves, 8.96 mean days reported 16.50 mean days on Curry leaf, 10.54 Rough lemon, 9.49 Rangpur, 8.96 *C. sinensis* (Maheswarababu, 1988), 14.00-18.00 days (Patel et al., 2017), 17.00-40.00 days (Phartiyal et al., 2012), 8.50-9.03 days (Rao et al., 2014), 23.50 mean days (Rao et al., 2014). Whereas, 12.00-16.50 days (Islam et al., 2019), 8.00-14.50 days (Munir et al., 2007), 27.00-35.00 days (Alturi et al., 2002), 18.00-32.00 days (Ackery et al., 1995), and 15.06 mean days (Islam et al., 2019). The weight of all larval and pupal stages are with the work agreement of (Karim et al., 2006), the measured weight of 3<sup>rd</sup>, 4<sup>th</sup> and the 5<sup>th</sup> instar were,  $0.72 \pm 0.04$ ,  $1.65 \pm 0.01$  and  $3.47 \pm 0.22$  grams, Pupae, average  $5.63 \pm 0.02$  grams, respectively (Islam et al., 2019), reported pupae weight 0.72 grams, respectively.

In present findings, the pupal stages lasted 7.41 mean days with the more or less with the findings of (Islam et al., 2019), documented on the leaves of *Citrus limon* 8.00-9.50 days, 8.11 days documented (Maheswarababu, 1988), pupae lasted 10.00-12.00 days reported (Alturi et al., 2002), 5.50-20.00 days (Minir et al., 2007), respectively. In the present study, the longevity of adult females was  $6.746 \pm 0.08$  and male  $3.81 \pm 0.09$  mean days with the work agreement of (Jahnavi et al., 2018), who documented the female longevity reported 6.75 and male 3.81 mean days. The female 7.00 and male 4.90 longevity mentioned (Munir et al., 2007), the female longevity counted 6.80 and male 3.73 mean days documented (Rao et al., 2014), male and female on *C. limonia* lasted 4.00-9.96, Sathgudi leaves 4.00-7.00, *C. jambhiri* 3.90-6.87, and *M. koenigii* 3.85-6.51 mean days (Maheswarababu, 1988), female lived 6.00-7.00 and male 3.00-4.00 days (Patel et al., 2017), female 6.50-9.00 and male 3.50-5.50 days documented (Islam et al., 2019), respectively.

In our research study, the total lifespan from egg to adult male recorded  $36.18 \pm 0.39$  and female  $39.11 \pm 0.37$  mean days with work similarity of (Jahnavi et al., 2018), counted 30.33 mean days, female consumed 30.00-39.00 days and male 27.00-35.00 reported (Islam et al., 2019), 23.00-26.00 for female and 24.00-26.00 for male days documented (Patel et al., 2017), 24.50 days reported on the leaves of *Psoralea corylifolia* and 22.12 days on *Citrus medica* hosts, 21.03 on *C. sinensis* and 28.69 mean days on the leaves of *M. koenigii* host plants (Maheswarababu, 1988), respectively.

The freshly laid eggs were observed smooth and spherical it is with the work similarity of (Rao et al., 2014), they reported for courtship adult male LBF search female and at the time of matting end to end male touches their bodies with the female. Similarly, the eggs were observed creamy pale yellow in outer coloration but became dark brown at the time near to hatching (Homziak et al., 2006), described the LBF eggs at initial pale-yellow but near to hatching dark-yellow, spherical, flattened and smooth. In the 1<sup>st</sup> stage, the larvae observed cylindrical and light brown with the agreement of (Rao et al., 2014), who reported darker black with yellow milky white patches. The 2<sup>nd</sup> stage was darker with the work similarity of (Munir et al., 2007) documented this stage is brown with white patches, spines are present at the caudal region. The 3<sup>rd</sup> stage is nearly similar to the 2<sup>nd</sup> stage as described (Munir et al., 2007). The 4<sup>th</sup> stage is blackish with green patches and more slippery as documented (Jahnavi et al., 2018). The 5<sup>th</sup> stage contains brown patches and yellow-green (Patel et al., 2017), also documented the green color of this stage of the larvae and (Islam et al., 2019) observed multi-colored pink, straw, and green with several black patches. The *P. demoleus* adult's body characteristics and color patterns are similar as already described (Haroon et al., 2013).

The present results the *P. demoleus* overall egg hatching and un-hatching% counted  $81.37 \pm 3.35$  it is with the work similarity of (Fazil & Ansari, 2011), they reported *Pieris brassicae* eggs survival and mortality 86.34-13.66% on Cauliflower, and 1<sup>st</sup> stage larvae population survival and mortality on same host plants 81.67-18.33, 2<sup>nd</sup> stage 84.34-15.66, 3<sup>rd</sup> stage 88.00-12.00, 4<sup>th</sup> stage 90.34-9.66, 5<sup>th</sup> stage 92.34-7.66, pupae 94.00-6.00, adults total mortality and survival 74.66-25.34%, respectively (Alturi et al., 2002), egg hatchability counted 70.48% was on citrus leaves (Jaafar et al., 2013), the egg hatching % recorded  $86.4 \pm 11.41$  and they also discussed the presence of predators, humidity, and temperature affecting eggs hatchability. The mortality seemed to increase due to the increased nutritional value (Saeed et al., 2010), documented that oviposition, larval developmental steps and adults longevity are significantly affected by certain host plants. The adult male/female net survival was counted as 21.21 and 24.71 this is with the work agreement of (Fazil & Ansari, 2011), who counted 14.96 on Broccoli, 7.76 on Radish, 10.15 on Mustard, 24.89 on Cabbage, and 27.10 on Cauliflower, respectively (Debora et al., 2019), reported the *Striacosta albicosta* eggs, larval, pre-

pupae, and pupae survival rate on Pinto bean leaves 75.71, 98.50, 51.78, and 95.10 with adult net reproductive 36.72%, respectively.

## CONCLUSION

This research work was performed at (DPRI), in the entomology laboratory during, 2020-21. It was frequently concluded that male has a short life period compared to female. Male fly over the surface of the lemon twigs, took initiative to search females for courtship. For mating purposes, towards the citrus orchards male and female back again and again, sometimes flying adults on the citrus leaves or shoots seeks to sit and frequently by flying male over the female seeking to sit and hold to female body strongly by vibrating paired wings touches to female body with jointed legs. Then fertilized females lay an egg and after egg hatching, larvae emerged which intensely harm the citrus green leaves. In this region, citrus fruits are vulnerable crops but wide dispersal ability and rapid growth rate make LBF serious potential pest insects. In this scenario for keeping up growing citrus production and beneficial economic impact proper management regarding this plague pest is urgently needed. Because for appropriate management of any kind of pest insect, it is required to get proper knowledge and awareness about the biology of the insects. In this context, the main motto of this work intends some light on the little awareness of this pest insect, the *P. demoleus*, and in upcoming present research will be the source of knowledge, management, host plants consumption and biology of this pest insect.

## AUTHORS CONTRIBUTION

W.M.M, the prime author of this research paper, conducted and carried out the experimental research work, statistical analysis of the data, and wrote the article. H.A.S, the supervisor, supervised and guided the experiments and reviewed the write-up.

## IMPACT STATEMENT

The *C. limon* are the main fruits of district Naushahro Feroze. The findings of this study lead us to know about the destructive severe hazardous of problematic lemon butterflies. Therefore the results of the present study may help to know the biology of this plague pest insect. There is no best and latest scientific documentary about this harmful hazardous pest insect, the management, host plant leaf consumption feeding behaviour, and proper knowledge reported from district Naushahro Feroze, Sindh.

## DECLARATION OF COMPETING INTEREST

The authors affirm that they have no competing financial interests or personal relationships that could have appeared to persuade reported work in this manuscript.

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## AVAILABILITY OF DATA AND MATERIALS

At the request of the corresponding author, the data and findings are available due to ethical restrictions and privacy.

**CONSENT FOR PUBLICATION;** The authors accept responsibility for releasing this material.

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