

Effect of change of feeding plant on the size of caterpillars of Lime swallowtail butterfly, *Papilio demoleus* L.

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Abstract

Human agricultural development is threatening many butterfly species by destroying their host plants. Each butterfly species is reliant on specific plant or plant families. A best way to conserve the butterfly species is to cultivate their suitable host plants and avoid the use of herbicides landscaping. The lime swallowtail butterfly (*Papilio demoleus*) is one of the *citrus* plant invaders, found throughout tropical and subtropical regions of Southern Asia. The effect of change of feeding plants on the development of caterpillars of *P. demoleus* L. was determined, using leaves of *Cullen corilifolium* and *Citrus* species. Two different generations of *P. demoleus* for two successive years were studied. It was found that overall duration of development of caterpillars were longest ($SD \pm 0.74$). The results revealed that development of the caterpillars of *P. demoleus* was comparatively slow after fed with *Citrus* species leaves while the fast development was found when experimental caterpillars fed with leaves of *C. corilifolium*. We analysed that biochemical constituents of the feeding plant had a significant effect on development of the caterpillars of *P. demoleus*. The reciprocal evolutionary dynamics between butterflies and their host plants have been investigated through a comprehensive analysis of plant utilization patterns and the various factors influencing food plant selection. *P. demoleus* feeds primarily on the foliage of *citrus* trees, and its larval stages can severely damage the *citrus* trees due to their extensive leaf consumption. This is particularly concerning for *citrus* nursery stock, as young *citrus* trees are highly susceptible to larval feeding. Severe infestations can result in substantial defoliation, leading to growth retardation and reduced fruit yield. This study may contribute to the agricultural advancement of *citrus* fruits by incorporating the alternative species *C. corilifolium* in proximity to *citrus* cultivation.

Keywords: Caterpillars, *citrus* species, *Cullen corilifolium*, lime swallowtail, *Papilio demoleus* L.

Introduction

Butterflies play vital ecological role as a bio-pollinators and bio-sensors of nature. Also there is a co-evolutionary association between butterflies and their host plants; hence sustainable development of host plants of butterflies is necessary. Butterflies are more vulnerable to climate change because of their sensitivity to factors including habitat loss and pollination. As a result, a healthy ecology is typically indicated by a high number of butterflies. As a wildlife indicator, butterflies tell us almost everything we need to know about the health of an ecosystem (Dobson, 2012). Ehrlich and Raven developed model for the co-evolution of plants and butterflies and summarized the host plant information for the butterflies. Feeny and Gilbert 1975^[4, 8] described that co-evolution involve adaptive radiation of plants that have evolved relative chemical protection from herbivores, followed by adaptive radiation on these plant groups of herbivores able to get around their defences. Feltwell 1986^[5] observed that the lifecycle of plants and butterflies are exceptionally interlinked.

Butterflies exhibit selectivity in their choice of flowers and plants they visit. Both butterflies and their caterpillars depend on specific host plants for foliage, nectar, and pollen. The selection of food plants for the immature stages by adult females is a well-established phenomenon among butterflies and other insect groups, Lewis (2018)^[9]. Consequently, butterfly diversity serves as an indirect indicator of overall plant diversity, particularly that of herbaceous and shrubby species, in a given area. The lime

swallowtail butterfly (*P. demoleus*) is one of the most wide spread members of the family Papilionidae and it is found throughout the tropical and subtropical areas disseminated from Southern and Southeast Asia (Corbet and Pendlebury, 1992)^[2].

The mean time required completing the development of caterpillars on *C. corylifolium* and *Citrus* species were 16.73 days and 19.46 days, respectively. The larval stage had shown 5 moulting stages and there was a significant change in growth period when they were fed with leaves of two different host plants. The *C. corylifolium* has been recorded as a suitable host plant from Rajasthan (Pandey and Bogawat, 1969)^[13] and other areas of Northern India. In the present study, the caterpillars of *P. demoleus* showed similar preference for leaves of *C. corylifolium* and but the longevity is significantly longest at *Citrus* species. Consequently, this research may facilitate the agricultural enhancement of *citrus* crops through the strategic intercropping of the alternative species *C. corilifolium* adjacent to *citrus* farming practices.

Materials and methods

Lifecycle studies of *Papilio demoleus* L. were conducted at the laboratory of Ghanshyamdas Jalan College. The *Citrus* and *Cullen* species were cultivated in the college garden, from which eggs and larvae were subsequently collected for this study. The larvae were then reared on *Citrus sp.* (*Citrus*) and *C. corylifolium* (Bu Gu Zhi) separately in a glass jar provided with fresh leaves twice a day until

pupation. Data was collected regarding the growth rate of caterpillars and size and shape of each caterpillar is noted. All the observations were taken continuously during 15 daytime hours daily from 6:00 A.M. to 9:00 P.M. Ambient temperature was recorded frequently. This study was initiated using ten caterpillars and divided them into experimental and control. Experimental caterpillars (5) are fed with *C. corylifolium* leaves while control caterpillars (5) are fed with *Citrus sp.* separately. The change in size of caterpillars on two different host plants was recorded every day. Comparative caterpillar's growth of the same generation was noted on *C. corylifolium* and *Citrus* species. At the pre-pupation stage, the pupas were safely released into their natural habitat. The results of the present investigation are also comparable with the results of Lewis who observed the external morphology of *P. demoleus* in *citrus* at different development stages. The larva had 5 instars and at the end of the 5th moulting there was a distinguishable pre-pupal stage which lasted 1–2 days.

Results and discussions

We have identified five larval stages (five instars), consistent with the findings of Ghosh (1914)^[6]. The average duration of larval development on *citrus* plants was approximately 19.46 days, aligning with the observations of Mishra and Pandey (1965)^[11]. *Papilio demoleus* is a significant pest of the Rutaceae family, as noted by Fletcher (1917), Pipatwatankul (1979)^[14], Khan (1940), and Atwal (1976), and it is capable of breeding on all varieties of both wild and cultivated *citrus*. *C. corylifolium* has been documented as a suitable host in Rajasthan (Pandey and Bogawat, 1969)^[13] and other regions of northern India.

The plant samples were authenticated for its botanical identity from the Botany department of G. D. Jalan College (East), Mumbai India. In the present study, *C. corylifolium* L. is also assessed as a significant host plant for *P. demoleus* L.

The caterpillars exhibited five instars, with the first instar emerging from the egg characterized by a brownish-black coloration and a dirty white patch on the dorsal side of the body. Larval coloration varied from dark brown to yellowish green. Morphometric measurements were taken for the body lengths of 10 caterpillars reared individually on *Citrus species* and *C. corylifolium*. In our study, the duration of caterpillar growth ranged from approximately 13 to 26 days, consistent with the findings of Mishra and Pandey (1965)^[11], who reported a range of 12 to 34 days; Badawi (1968)^[1] observed a duration of 18 to 25 days; and Badawi (1981) noted a range of 11 to 31 days. Additionally, Rafi *et al.* (1999d) reported a range of 11 to 30 days of growth period in caterpillars. The extended growth periods observed are indicative of larval development occurring under cooler climatic conditions.

Ist Instar: The freshly hatched larva was cylindrical and brownish black with dorsal dirty white markings, resembled bird droppings. The body length of the 1st instar larvae is measured about 2.27 mm to 2.65 mm on *citrus* species and 2.93 mm to 3.01 mm on *C. corylifolium* (Table 2).

IInd Instar: The second instar larvae came out by leaving the exuviae of the first instar larvae. The body length of the 2nd instar larvae is measured about 7.27 mm to 7.45 mm on *citrus* species and 7.93 mm to 8.11 mm on *C. corylifolium* (Table 2).

IIIrd Instar: After the second instar development the 3rd instar larvae moulted out with degenerating body spines. The body length of the 3rd instar larvae is measured about 16.33 mm to 17.10 mm on *citrus* species and 18.10 mm to 18.71 mm on *C. corylifolium* (Table 2).

IVth Instar: The fourth instar larvae emerged out of the exuviae of third larvae. The fresh fourth instar larvae now turned dark brownish black with divergent change in morph. The body length of the 4th instar larvae is measured about 20.22 mm to 20.95 mm on *citrus* species and 21.93 mm to 22.01 mm on *C. corylifolium* (Table 2).

Vth Instar: After the 4th moulting, the 5th instar larvae emerged out from the exuviae of the 4th instar larvae. The 5th instar larvae now turned yellowish green and the spines on body are completely disappeared. They were green with brownish stripes on the sides of the body. There was a horn like structure present on the last dorsal segment of the body. The body length of the 5th instar larvae is measured about 39.02 mm to 40.05 mm on *citrus* species and 42.5 mm to 45.01 mm on *C. corylifolium*.

The mean time required completing the development of caterpillars on *C. corylifolium* and *Citrus* species were 16.73 days and 19.46 days, respectively. The larval stage had shown 5 moulting stages and there was a significant change in growth period when they were fed with leaves of two different host plants. The *C. corylifolium* has been recorded as a suitable host plant from Rajasthan (Pandey and Bogawat, 1969)^[13] and other areas of Northern India. In the present study, the caterpillars of *P. demoleus* showed similar preference for leaves of *C. corylifolium* (Jahnavi *et al.*, 2018)^[7] and but the longevity is significantly longest at *Citrus* species which was also observed by Minh *et al.* (2015)^[10]. Consequently, this research may facilitate the agricultural enhancement of *citrus* crops through the strategic intercropping of the alternative species *C. corilifolium* adjacent to *citrus* farming practices.

Table 1: Comparative duration of development of caterpillars of *P. demoleus*, on *Citrus sp.* (*Citrus*) and *C. corylifolium*

Sr. No.	Developmental Stage	Total duration of growth of Caterpillars (in days)					
		On <i>Citrus</i> species			On <i>Cullen corylifolium</i>		
After 3.03 days of incubation of eggs		Min.	Max.	Mean	Min.	Max.	Mean
1	First instar	3.91	3.99	3.95	3.04	3.09	3.06
2	Second instar	4.01	4.18	4.09	3.38	3.41	3.39
3	Third instar	4.93	5.01	4.97	3.98	4.02	4.00
4	Fourth instar	3.21	3.66	3.43	3.17	3.33	3.25
5	Fifth instar	2.99	3.03	3.01	2.46	3.59	3.02
Total Larval Period		19.5	19.87	19.45	16.03	17.44	16.72
Standard Deviation (SD)					±0.74		

Table 2: Comparative morphometric measurements of length of caterpillars of *P. demoleus*, on *Citrus sp.* (*Citrus*) and *C. corylifolium*

Total number of eggs incubated (10)	Length of the larvae (mm)					Mean larval size	SD
	Ist Instar	II nd Instar	III rd Instar	IV th Instar	V th Instar		
Normal Larvae (5) (on <i>Citrus</i> species)	N1 (2.27)	N2 (7.20)	N3 (16.33)	N4 (27.41)	N5 (33.1)	17.262	13.27
Experimental Larvae (5) (on <i>Cullen corilifolium</i>)	E1 (2.52)	E2 (7.43)	E3 (16.91)	E4 (28.00)	E5 (33.90)	17.752	13.04

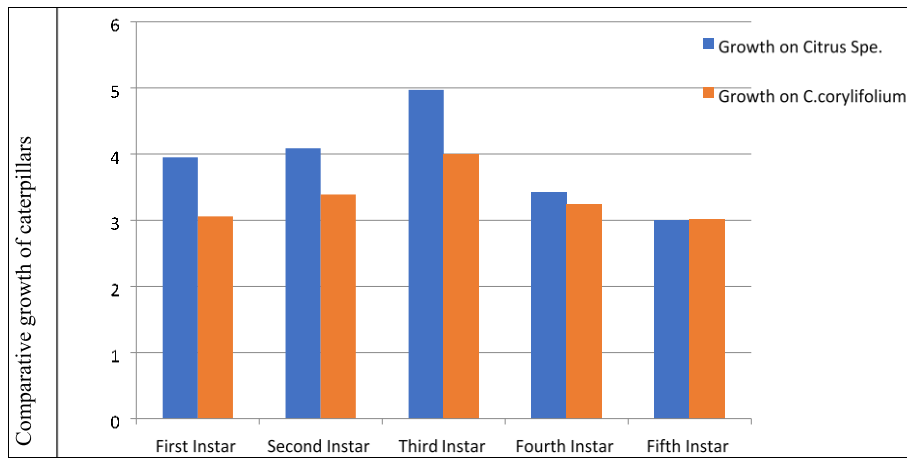


Fig 1: Comparative duration of growth of instars of *P. demoleus* on *Citrus* spec. and *C. corylifolium*

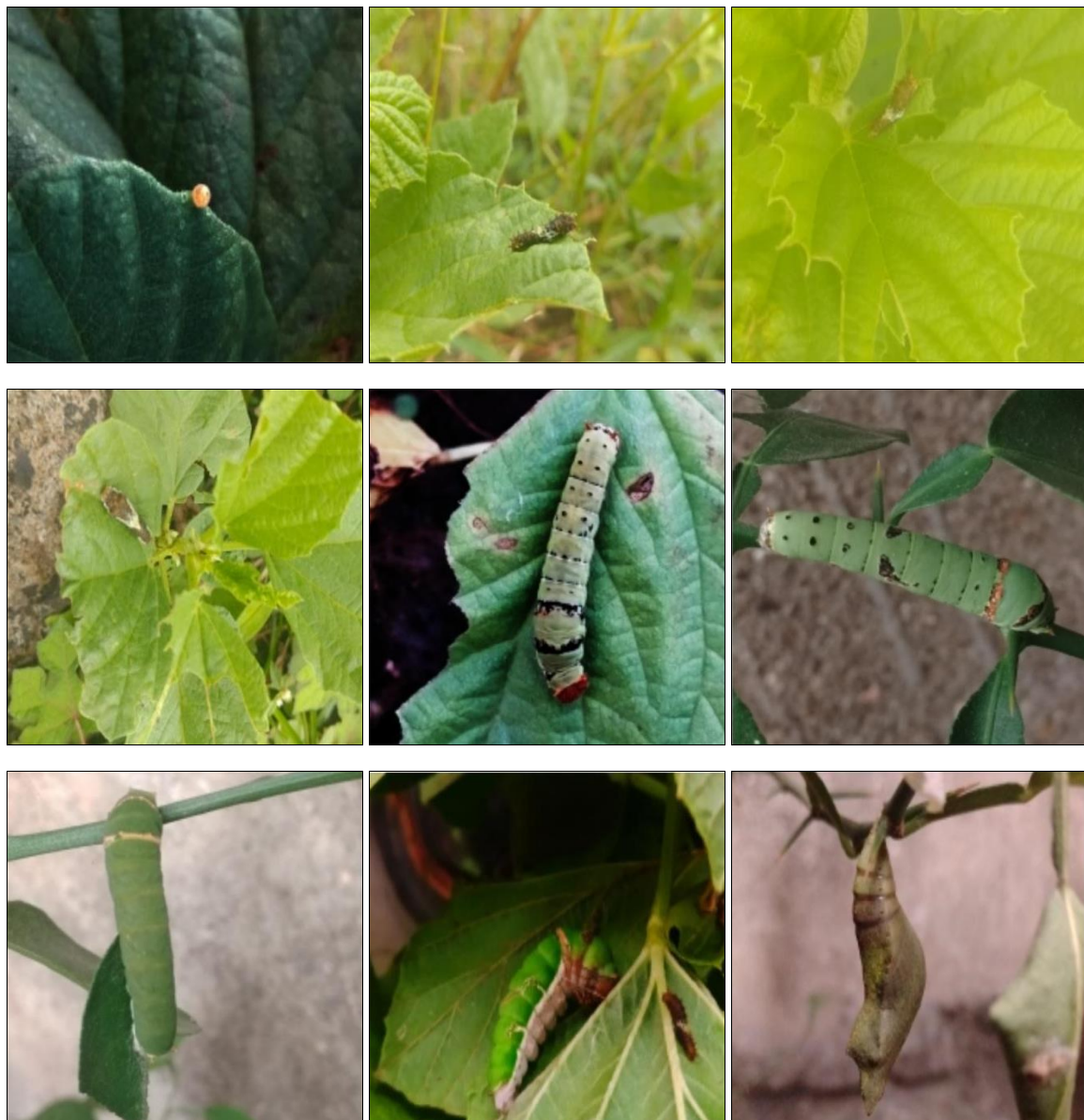




Fig 2: Some of the pictures are clicked during study of *P. demoleus* on *Citrus* species and *C. corylifolium*.

1. Fresh Egg
2. 1st Instar on *C. corylifolium*
3. 2nd Instar on *C. corylifolium*
4. 3rd Instar on *C. corylifolium*
5. 5th Instar on *C. corylifolium*
6. 5th Instar (pre) on *Citrus* species
7. 5th Instar (post) on *Citrus* species
8. 4th Instar on *C. corylifolium*
9. Pupation on *Citrus* species
10. Pupation on *C. corylifolium*

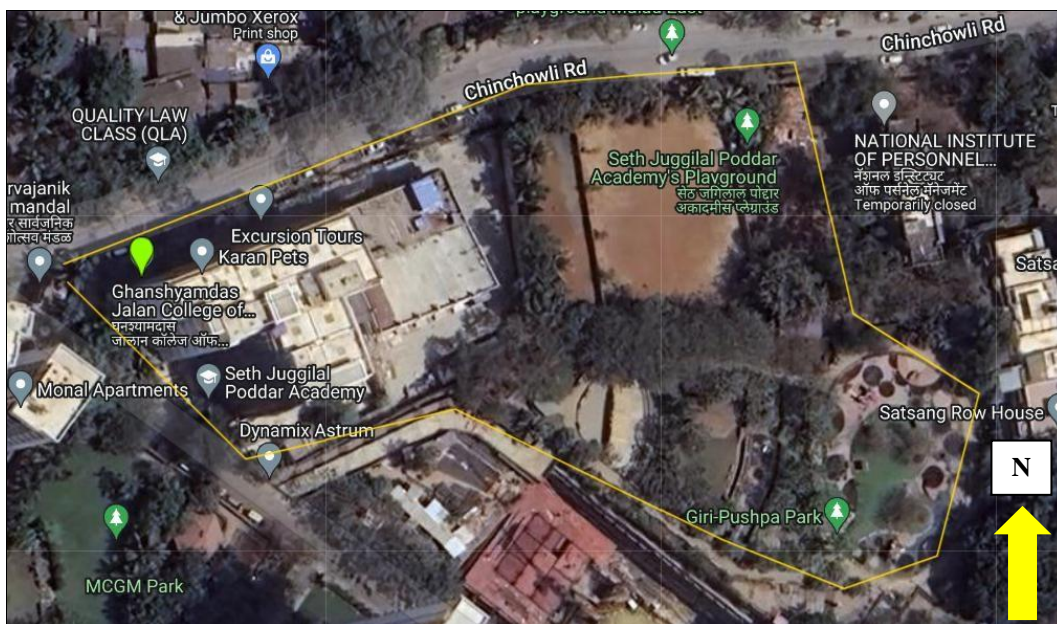


Fig 3: Map (Lat 19.176231° Long 72.8522520) showing different locations in the study area in the campus of Ghanshyamdas Jalan College, Malad East, Maharashtra State, India (Google Map)

Acknowledgements

We acknowledge our Director, Dr. Rajeshwari Ravi and Principal, Dr. Rajeshwary Govindappa for her constant support and permission to work in the college laboratory. Special thanks to our guide Dr. Manisha Kulkarni, Professor of Zoology from the zoology department of the Institute of Science, Dr. Homi Bhabha State University for her invaluable guidance and motivation during this research work. Also, we extend our gratitude to the Botany department of our college for their support in identification of plant species.

References

1. Badawi A. Biological studies on *Papilio demoleus* L. a pest on *Citrus* trees in Sudan (Lepidoptera:

Papilionidae), Bulletin de a Society Entomologique d'Egypte,1968:52:397-402.

2. Corbet AS, Pendlebury HM. The Butterflies of the Malay Peninsula, 66-81.
3. Ehrlich RP, Raven HP. Butterflies and plants: A study in coevolution, Society for the study of evolution,1964:18(4):586-604.
4. Feeny P. Biochemical coevolution between plants and their insect herbivores. In L. E. Gilbert and P. H. Raven (eds.), Coevolution of animals and plants, Univ. of Texas Press, Austin, 1975, 3-19.
5. Feltwell J. The Natural History of Butterflies, Groom Helem Ltd. Provident House, Bureel Row, Beckenham Kent BR3 IAT, 1986, 133.

6. Ghosh CC. Life-histories of Indian insects. Lepidoptera: The lemon caterpillar. Mere Dept. Agric. India, entom. Ser,1914:5:33-58.
7. Jahnvi, *et al.* "Biology and morphology of *citrus* butterfly *Papilio demoleus* Linnaeus (Lepidoptera:Papilionidae) on acid lime" Journal of Entomology and Zoology Studies, 2018.
8. Gilbert LE, Raven PH. Coevolution of animals and plants, Univ. of Texas Press, Austin, 1975, 3-19.
9. Lewis Delano S. Lime Swallowtail *Papilio demoleus* Linnaeus (Insecta:Lepidoptera:Papilionidae) University of Florida. Department of Entomology and Nematology UF/IFAS Extension, 2018.
10. Minh HG, Giang HTT, Trang HTQ. Studies on some aspects of the biology and ecology of *citrus* butterfly *Papilio demoleus* (Papilionidae: Lepidoptera) on *citrus* in Vietnam. Journal of Tropical Asian Entomology,2015:4:20-27.
11. Mishra SC, Pandey ND. Some observations on the biology of *Papilio demoleus* Linn. (Papilionidae, Lepidoptera). Labdev. J. Sci. Technol,1965:3:142-143.
12. Mobeen G. Butterflies and their contribution in ecosystem, Journal of Entomology and Zoology Studies,2016:4(2):115-118.
13. Pandey SN, Bogawat JK. Growth and development of *Papilio demoleus* (L.) in relation to a wild host plant. Indian Journal of Entomology,1969:31(1):92.
14. Pipatwatankul A. Ecological investigation on the Lemon Butterfly *Papilio demoleus* L. (Lepidoptera: Papilionidae) and its natural enemies in Thailand. M.S. Thesis. Kasetsart University, Bangkok, Thailand, 1979, 50.
15. Pruthi H, Mani MS. Our knowledge of the insects and mites pest of *citrus* in India and their control. Imperial Council of Agril. Research Science. Monograph,1945:16:42
16. Robinson, *et al.* K. Kunte pers. Cullen corylifolium obs. 2017, Fabaceae, 2010.