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BIONOMICS OF *DEUDORIX ISOCRATES* FABRICIUS (LEPIDOPTERA: LYCAENIDAE), A NEW POTENTIAL HOST OF SWEET ORANGE, *CITRUS SINENSIS* L. OSBECK IN J&K, INDIA

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ABSTRACT
Deudorix isocrates Fabricius is an important pest of pomegranate and guava causing extensive damage to these fruit crops worldwide. The insect is seen damaging citrus fruits grown in sub-tropical belt of J&K, India in the last few years. The objective of this study was to obtain information on the biology of *D. isocrates* on *C. sinensis* cv 'Mosambi' under laboratory conditions in room temperature so as to maintain a natural environment in order to establish the peak infestation of the pest on citrus for its timely management strategies. The results showed that *D. isocrates* preferred to oviposit and attack along the middle region of the fruit. Biological studies include morphometric measurements of different stages from egg to adult, incubation period, duration period of larval instars (first to fifth), prepupal and pupal stage, and adult longevity (male and female). Incubation period varies from 6 to 10 days (8.0 ± 0.38 days). Larval period varies from 24 to 38 days (33.2±1.10) days. Pupal period ranges from 13 to 16 days (14.55±0.32days). Adult longevity of male and female is 10 to 12 days (11±0.26 days) and 15 to 18 days (16.75±0.35 days) respectively.

KEY WORDS: *Deudorix isocrates*, *Citrus sinensis*, bionomics, Lepidoptera, Pomegranate butterfly.

INTRODUCTION

J&K State has varied agro-climatic conditions ranging from sub-tropical, sub-temperate, temperate and cold arid making it possible to grow different varieties of fruits. It has monopoly in growing quality apple, walnut, cherry, pear, pomegranate and almond. Besides these temperate fruits that hold a great importance to build up the economy of this state, subtropical fruits like Citrus are now gaining a prominent place among fruit growers. *Deudorix isocrates* Fabricius (fruit borer) commonly called as Pomegranate butterfly has been a limiting factor in growing pomegranate in higher altitudes and Guava in lower altitudes of J&K State. In last few years, *D. isocrates* has been recognized as an emerging pest causing a potential damage to the citrus fruit orchards in Jammu region. During the unavailability of pomegranate fruit, *D. isocrates* prefer citrus fruit as a secondary host plant besides guava during winter season. Attack of *D. isocrates* is noticed in the field by the appearance of holes on the fruit and the exudation of the faecal matter. For many years, *Deudorix isocrates* caused only a little damage in citrus orchard. So, not much chemical control was performed against this pest. However, there is now increasing concern that the pest attack may dramatically increase in citrus groves in Jammu. About 12-18% damage has been recorded in *Citrus sinensis* cv. Mosambi orchard in winter season. The infested fruit becomes totally unfit for marketing. This is a result of the lack of safe and feasible management practices to minimize the fruit borer damage. The adult is moderate size butterfly showing sexual dimorphism. Females pale violet-brown with an ochreous spot on the forewings. Males are deep violet blue. The larva is hairy, brownish in color with a conspicuous pale yellow or orange spot on first and second thoracic segments, and third and fourth abdominal segments. The larva feeds on the fruit pulp that also leads to secondary infection of fungus and bacteria.

As *D. isocrates* lays its eggs directly on the fruit, control strategies must be applied during the short interval *i.e*., from the time of oviposition to the time the first instar penetrates inside the fruit. So far, no detailed work is available on the bionomics and associated study of this pest on citrus except observation of its infestation in mandarin orchards in Maharashtra, India (Aherkar *et al*., 1993). Despite the potential damage caused by *D. isocrates* during the last few years, there is still need for basic studies on the spatial and seasonal distribution of eggs and injuries. Therefore the objective of this study was to analyse the biology of *D. isocrates* on *C. sinensis* cv 'Mosambi' under laboratory conditions in room temperature so as to maintain a natural environment in order to establish the peak infestation of the pest on citrus for its timely management strategies.

MATERIALS & METHODS

Random samples were taken biweekly in a plain irrigated orchard land of *Citrus sinensis*, cv. 'Mosambi' in Vijaypur, J&K, India from August 2007 to January 2008 having 500 plantations of 5 years old, with inter tree distance of about 3.65 m located in Vijaypur (District Samba) (32°34'N and 75°01'E; 360 m). For the purpose of sampling, the field was divided into five blocks covering all the four directions and one from the centre. Each block comprising of 20 trees, with one tree randomly selected. Five fruits were randomly observed for the sign of infestation (egg or holes made by the larvae). Thus, the

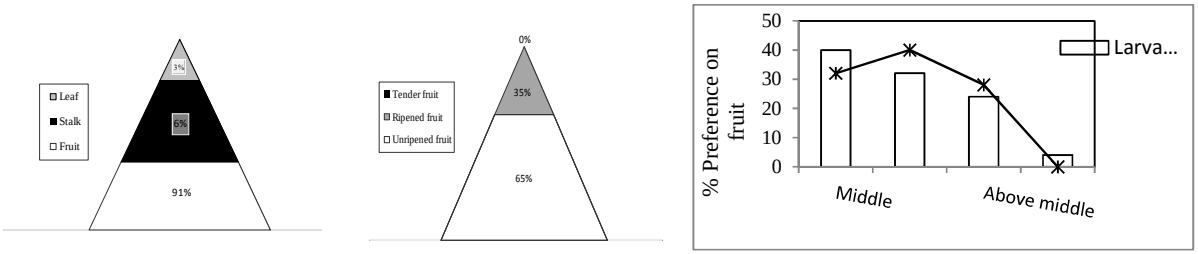
population records were made on twenty five fruits per sampling date. Selected fruits were tagged for the record. The orchard was kept free from insecticidal treatments throughout the period of study. Studies included the percentage of damaged fruit, location and number of bored fruit sites, and location of the fruit borer eggs.

Freshly laid eggs were taken to the laboratory where the life cycle of various stages was studied. These eggs were placed on fruits in pertidishes before studying them for hatching. Immediately after hatching, the individual larvae were transferred to separate young and fresh citrus fruits with the help of moist fine camel brush kept in plastic rearing boxes (22 X 12 X 10 cm). These fruits were kept with a half opened incision to locate the head capsule released during larval development and were replaced every third day to avoid their damage by fungal and bacterial infection. Newly hatched larvae and the subsequent larvae of different age groups and size were utilized, and subjected to Dyar's law (Dyar, 1890) for analysis to determine the number of larval instars. After emergence of adults, each pair was released in the cage (30 X 30 X 30 cm). These adults were fed daily with 10 per cent sugar solution through cotton swab to record the longevity of adults. Evaluation includes duration of egg, larva, pupa and adult stages. Morphometric measurements of different developmental stages of *D. isocrates* were made by standard graph paper method. For the study of different instars, the head capsule width was obtained using an ocular micrometer attached to a stereoscopic microscope.

RESULTS

Distribution of Eggs and Damage

The analysis of the spatial distribution of eggs revealed that in 91% cases, eggs were laid on the fruit, 6% on stalk and (3%) cases on leaves (Fig. 1a). In no case the eggs were laid on the tender fruit (Fig. 1b). Preferred site for oviposition was below the middle region of the fruit (40%), however first instar larvae preferred middle region of the fruit for penetration (Fig. 1c).



A **B** **C**

FIGURE 1: Distribution of *Deudorix isocrates* eggs (A) on different parts of the tree (B) on different stage of the fruit (C) on different parts of the fruit and larval entrance preference

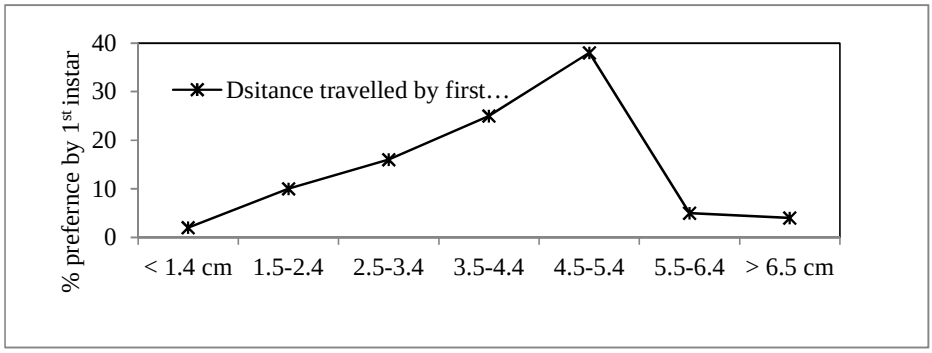


FIGURE 2: Distance travelled by first instar larva before penetration inside the fruit

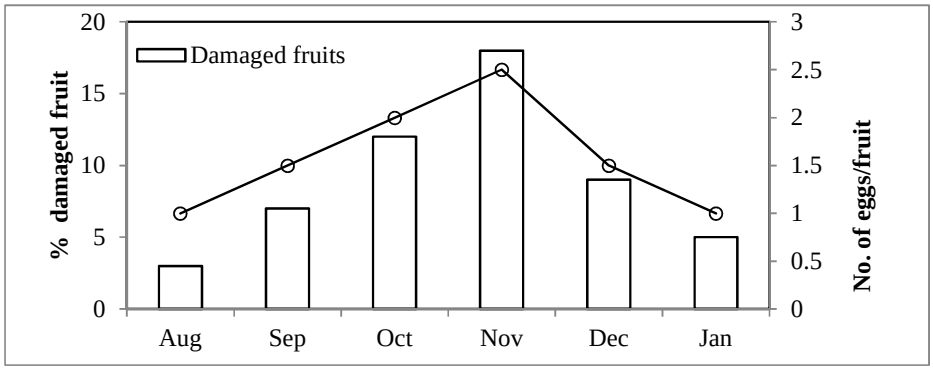


FIGURE 3: Percentage of damaged citrus fruits and numbers of Deudorix *isocrates* eggs/fruit (n= 200 fruits/month)

Majority of the *D. isocrates* larvae preferred to travel some distance on the fruit (Fig.2) before penetration in the fruit.

Larva feed voraciously inside the fruit on its pulp and seeds. The excreta produced were regularly pushed out from the entrance hole which could be seen in the form of exudation on the outer side of the infected fruit. During the developmental period, the larva comes out of the fruit many times and spins a web which ties the fruit to the stalk on which it is attached. The number of eggs laid by *D. isocrates* as well as the percentage of fruits attacked by the larvae showed a rapid increase with time and stage of the fruit. Injured fruits reached high values in the late stages of fruit development, 12% in October, and exceeded 18% in November (Fig. 3).

The number of eggs laid per fruit coincided with the monthly percentage damage. Although the losses increased with time during the fruiting season, it was not possible to visualize the increments in damage along the whole crop season. The premature dropping of infested fruits increased the number of healthy fruits in the orchard, thus biasing the number of healthy fruits in the subsequent samplings.

Developmental Stages

Average egg diameter varied was 1.22±0.11mm (1.15mm–1.27mm). Incubation period varied from 6 to 10 days with an average of 8.0±1.2 days. Caterpillar passed through five instars based on head capsule measurements before transforming into pupa (Table1). The larval length varied from 2.43 mm to 27 mm. newly hatched larva were hairy, cylindrical, light brown with first and second thoracic segments, and third and fourth abdominal segments pale yellow. Anal segment was large and ventrally directed. A faint light brown continuous line ran at the mid dorsal side of the body. Average body length of first instar was 4.36±0.8 mm (2.43-5.0 mm) with an average width of 0.95±0.49 mm (0.8-1.0mm) and the developmental period of 4.8±0.36 days (3-6 days). Second instar measured 6.8±0.91mm (4.5-7.89mm) in length and 1.46±0.5mm (1.0-1.64 mm) in width with an average duration of 5.4±0.39 days (4-7 days). Third larval instar resembled second instar except the length increased to 13.0±2.06 mm (8.0-15.0 mm) and average width of 3.60±1.2 mm (1.58-4.00 mm) with the developmental period of 7.15±0.24 days (6-8 days). Each segment of third instar bears dark brown spot at the mid dorsal side of the body. Body became slightly dark in fourth instar having the body length of 18.5±1.08 mm (15.0-20.0 mm) and average width of 4.5±0.23 mm (4.00-5.00 mm). Average duration of fourth instar was 7.3±0.21 days. Fully mature larva was blackish brown with first and second thoracic segments, and third and fourth abdominal segments turned orange. Anal segment became brownish orange. Average body length of fully mature larva was 23±2.04 mm (19-27mm) with an average width of 6.4±0.75 mm (5-8 mm).

Final instar stage lasted for 7.65±0.43 days (5-9 days). Thus, total larval period on *C. sinensis* was of 33.2±1.10 days. Prepupal period lasted for 1.25±0.08 days (1-1.5 days). Pupa is dark brown with an average body length of 12.0±0.40 mm and an average width of 6.0±0.25 mm. The duration of the pupal period ranged from 13 to 16 days (14.5±0.32 days). Sexual dimorphism was seen in adults. Females are larger in size than males in wing expanse. Females pale violet-brown with an ochreous spot on the forewings. Males are deep violet blue. Underside is pale buff with darker brown scalloped bands and white vertical lines. Average body length of adult male was 14±0.7 mm and female measured 17±0.56 mm. Average width including wing span of adult male was 24.0±0.60 mm and longevity was 11±0.26 days whereas, of female butterfly was 38.0±0.3mm with a longevity of 16.75±0.35 days.

TABLE 1: Head capsule width in different larval instars of *Deudorix isocrates* Fab.

Larval Instar	Observed head capsule width (mean± SE) mm	Range (mm)	Growth ratio	Calculated width (mm)	Progressive factor
I instar	0.54±0.03	0.44-0.66	-	-	
II instar	0.80±0.04	0.69-0.97	1.48:1	0.79	
III instar	1.23±0.11	0.82-1.56	1.53:1	1.16	1.43
IV instar	1.61±0.11	1.27-2.24	1.30:1	1.71	
V instar	2.29±0.05	2.05-2.53	1.42:1	2.50	

DISCUSSION

As the larva is a fruit borer and for minimum mortality of the newly emerged larva, egg was preferably laid on the fruit rather than on the stem and leaves by the females so that larvae could enter the fruit soon after hatching. Lower middle region of the fruit selected as the site of the oviposition could be for the protection of the fruit from direct exposure to the predators. Middle region of the fruit could be the preferred site for larval penetration due to the reason that the fruit starts ripening from the middle portion. The existence of an interval of 6-10 days between oviposition and first instar larva penetration is significant to put in practice the control measures. Karuppuchamy *et al*. (1998) recorded the total larval period of 22.8 days on pomegranate in Tamil Nadu. The total larval period recorded on Guava in Jammu plains was of 15 to 23 days (Tara *et al*., 2006); however, it was almost double in case of citrus in the same region. Karuppuchamy *et al.* (1998) recorded pupal period of 7-10 days and 8 to 18 days by Singh & Singh (2001) on *Emblica officinalis.* Kabre and Mohalkar (1992) recorded an average of 6.1 days longevity in males and 11.2 days in females. Singh & Singh (2001) observations revealed body length of 20.5 to 24 mm and 22.5 to 25 mm and wing expanse of 40 to 46.05 mm and 44.5 to 49 mm in males and females respectively. The first egg appearance on the fruit was observed in early August. Total lifecycle of 44 to 65 days suggest that the butterfly can complete about 2-4 generations during the fruiting season prior to harvesting period in January-February. Although the loss inflicted by *D. isocrates* to citrus has not reached economic threshold, but the recent trends of its infestation suggest that there is

the need to work on the impact of this insect on citrus industry.

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