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ECLOSION RHYTHM AND ITS ENTRAINMENT BY PHOTOPERIODISM IN *OPISINA ARENOSELLA* WALKER (LEPIDOPTERA : XYLORYCTINAE)

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Pupal eclosion in *O. arenosella* starts usually from about 2 hours after the beginning of the scotophase and ceases 2 hours after midnight. Peak period of adult emergence is between 10 PM and 12 PM. There is an early preponderence of males emerging from a brood. Pupae subjected to constant light condition show the same rhythm of eclosion. Eclosion is also rhythmic when animals are subjected to constant light throughout their life from larval emergence from eggs to adult emergence. The eclosion rhythm in this animal is not entrained by the daily photoperiodism when the animals are subjected to it from early larval stages.

INTRODUCTION

Many developmental events occuring once in the life of insects are controlled by circadian oscillations so that a particular event occurs at a definite time. Imaginal ecdysis, most apparent among these has been observed to follow a circadian rhythm in many insects, correlated with the locomotor activity rhythm and reproductive behavioural patterns of that species. Among Lepidoptera, *Archips negundanus* emerges only during night (Parker & Mayor, 1972), the corn earworm *Heliothis zea* emerges between 7 PM and 11 PM (Beck, 1968) and it is between 9 PM and 11 PM in *Pyrausta machaeralis* (Gopakumar & Prabhu, 1981); though the carpenter worm moth, *Prionoxystus robiniae* has a peak period of emergence around midday (Solomon & Neel, 1972). The dragonfly *Tetragoneuria cynosura* emerges before 9 AM; a number of chironomids emerge between sunset and midnight and dipterans like *Drosophila* spp. and *Scatophaga stercoraria* have morning maxima of emergence (Beck, 1968). On the other hand emergence is an arhythmic event in *Aedes aegypti* (Saunders, 1976). Some endogenous rhythms like feeding activity, locomotor activity etc. freerun in the absence of environmental cues. But an entrainment by light in the pattern of eclosion takes place when the photoperiodic 'Zeitgeber' is included from the very beginning of development. The present paper deals with the circadian rhythm of eclosion in *Opisina arenosella* and its entrainment by photoperiodism.

MATERIAL AND METHODS

O. arenosella was maintained in the laboratory as described earlier (Santhosh Babu & Prabhu, 1987). The pupal behaviour and eclosion rhythm were studied under laboratory conditions. The study was carried throughout in March (28 - 32°C; 70 - 80% RH), June (24 - 29°C; 90 - 98% RH) and September (25 - 32°C; 75 - 90% RH), 1986. Pupae formed each day were collected from the colony. Each day collection was kept in clean specimen jars (13.5 X 6 cm) for adult emergence. The adults emerging from pupae were removed and were counted at one hour interval. A total of 402 pupae were studied during three months. Mode of dehiscence of pupal skin at adult emergence was also observed.

Five pairs of moths were selected from the colony and the progeny of each pair was reared in isolation to study the influence of sex on the pattern of adult emergence under laboratory conditions. Sex of the moths emerging every day from isolated colonies was noted in the morning on ten consecutive days.

Eclosion was studied subjecting pupae during the entire pupal period to constant light (LL) provided by two 40W fluorescent tubes from a height of 9 feet during night, and by day light during day. For this, pupae in six groups of ten each, were kept in specimen jars, opening of which was covered with perforated polythene paper permitting free access of air. Eclosion was recorded at one hour interval. Finally, larvae from the time of hatching out from the eggs, as well as pupae were subjected to continuous light (LL) as before till the adult emerged. Soon after larvae hatched from eggs, they were transferred to matured coconut leaves (13-15 cm length), placed inside the specimen jars. Each bell jar contained only five pieces of leaves. Leaves were changed twice a week. Adult emergence was recorded at one hour interval as done previously.

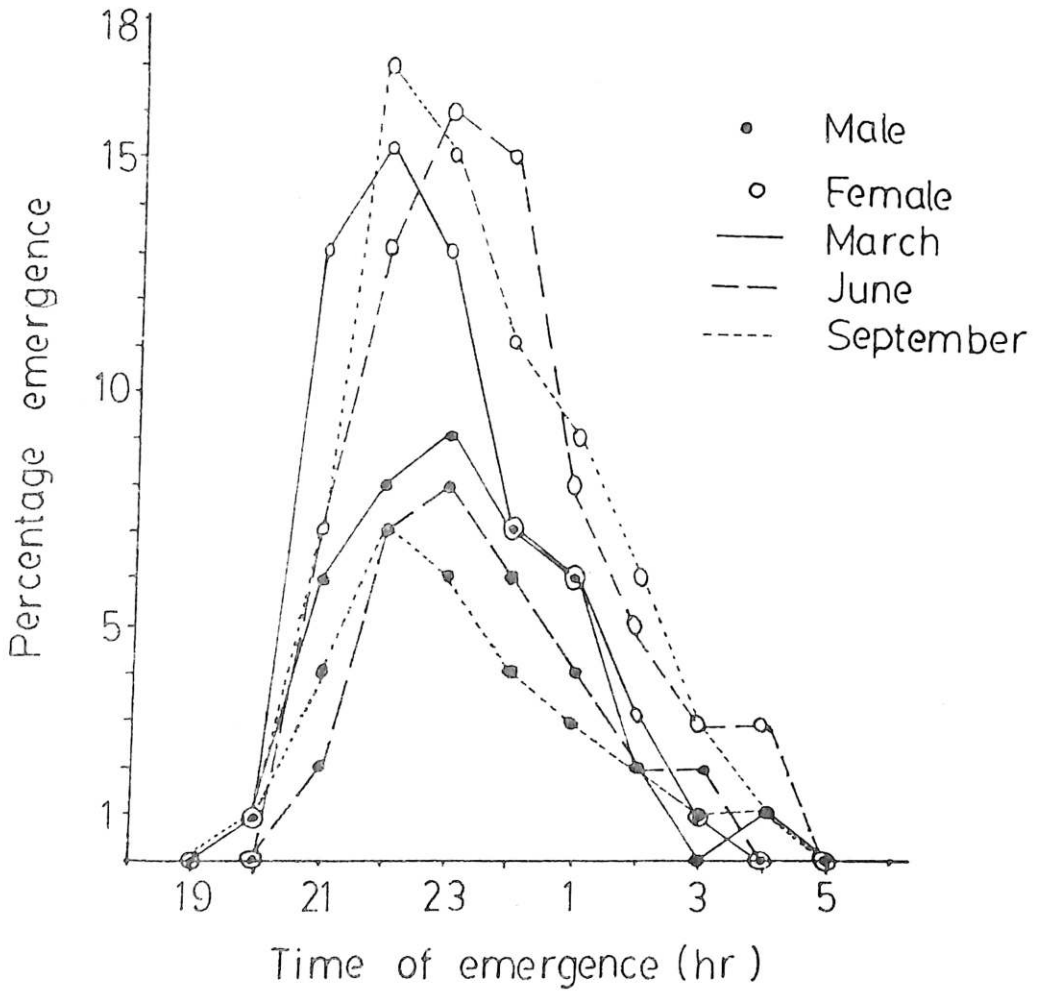

Fig. 1. Graph showing the adult eclosion rhythm under ambient laboratory condition of LD 12 : 12 during the month of March, June and September in *Opisina arenosella* Walker.

RESULTS

Newly formed pupae are greenish white and delicate, enclosed in a translucent cocoon spun by the larvae between the two folds of coconut leaves. The cocoon is oval in outline. Pupae become yellowish green within two hours of their formation and subsequently become brownish. The pupal stage prolongs for 8-9 days. Pupae remain quiescent but if disturbed they may react by twisting the abdominal segments. When they are about to eclose they are slightly more active and appear reddish brown. The pupal case splits along the epicranial suture and along the suture between the pronotum and the occiput. Head and part of the thoracic region come out through the slit first. About one minute later the whole body is liberated from the pupal case by shaking the body from side to side. Quickly the newly emerged adult crawls few feet and pauses for a minute. Then it begins to expand it's wings which are kept folded till then and whichextend only upto three fourth of it's abdomen. Fully expanded wings are kept vertical for drying. They resume normal posture after about five minutes.

It may be seen that the adult emergence starts from two hour after the beginning of scotophase and ceases two hour after midnight (Table I). However, a small percentage continue to emerge early morning. Peak period of emergence is between 22 and 24 hrs. No adult is emerged during photophase. In the heterogenous population both sexes have

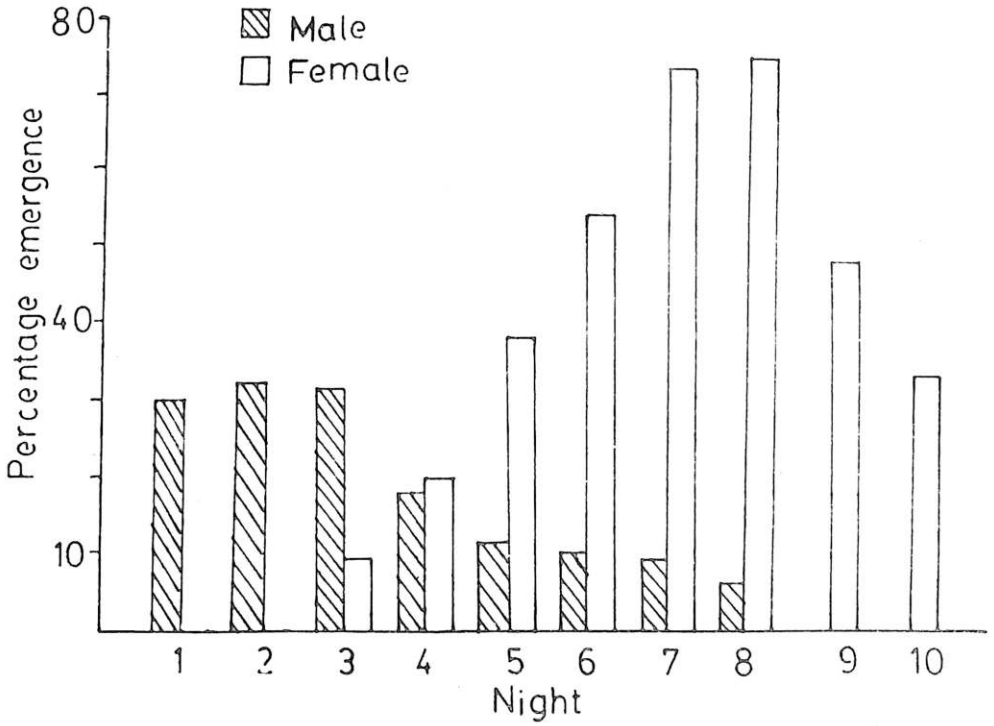

Fig. 2. Graph showing percentage of adult emergence during ten succeeding nights from broods derived from five pairs of moths in *Opisina arenosella* Walker.

the same rhythm of eclosion. There is a slight change in the peak period of emergence during the different months under observation (Fig. 1).

The male begins to emerge from all broods in the first night and it's emergence continue till 8th night in the tenth day consecutive observation (Fig. 2). The percentage of males emerged during the first three night is higher and then decreases gradually. The emergence of female starts of 3rd night only. The percentage of female emergence increases till 7 or 8th night and then diminishes.

Pupae subjected to constant light (LL) condition show the normal rhythm of eclosion (Fig. 3). The adults emerge between 18 and 4 hrs and the peak period is between 21 and 23 hrs. The pupae do not entrain the shift in the photoperiod from LD to LL. Eclosion is also rhythmic when animals are subjected to constant light throughout their life from larval emergence from eggs to adult emergence. Even though adult emergence starts from 19 hrs and ceases in 5 hrs, the peak period is between 22 and 1 hrs.

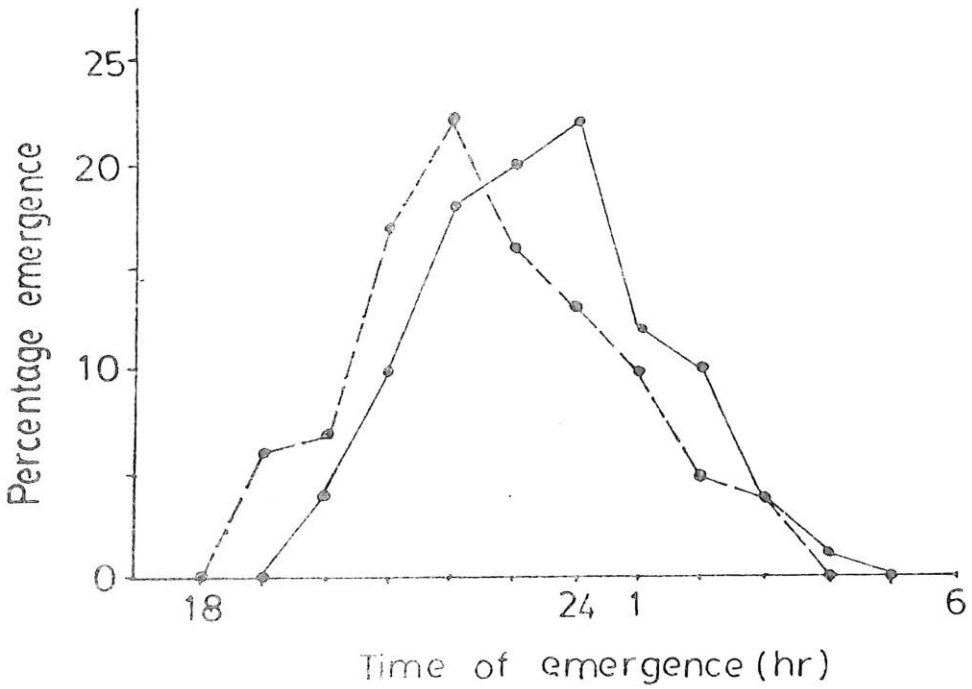

Fig. 3. Graph showing the eclosion rhythm of adult when larvae and pupae are kept under different conditions of illumination in *Opisina arenosella* Walker.

Table I. Eclosion rhythm of adult emerging under ambient laboratory condition of LD 12 : 12 in *Opisina arenosella* Walker (% of adult emerging corrected to the nearest whole number, data pooled from different broods; numerator represents males; denominator represents females).

	PM													AM										
Time of emergence (Hr)	12	13	14	15	16	17	18	19	20	21	22	23	24	1	2	3	4	5	6	7	8	9	10	11
Duration of study and Temperature conditions																								
March																								
28 - 32°C	0	0	0	0	0	0	0	0	1	6	8	9	7	6	2	0	1	0	0	0	0	0	0	0
70-80% RH	0	0	0	0	0	0	0	0	1	13	15	13	7	6	3	1	0	0	0	0	0	0	0	0
June																								
24 - 29°C	0	0	0	0	0	0	0	0	0	2	7	8	6	4	2	2	0	0	0	0	0	0	0	0
90-98% RH	0	0	0	0	0	0	0	0	0	7	13	16	15	8	5	3	3	0	0	0	0	0	0	0
September																								
25 - 31°C	0	0	0	0	0	0	0	0	1	4	7	6	4	3	2	1	1	0	0	0	0	0	0	0
75-90% RH	0	0	0	0	0	0	0	0	1	7	17	15	11	9	6	3	1	0	0	0	0	0	0	0

DISCUSSION

The present studies show that *O. arenosella* resembles *Pyrausta machaeralis* (Gopakumar & Prabhu, 1981) and *Dioryctria abietella* (Fatzinger & Asher, 1971) with regard to the behavioural patterns associated with enclosion from the pupae. In *O. arenosella* adult emerges only during the night as in *Archips negundanus* (Parker & Mayor, 1972) and in *Heliothis zea* (Beck, 1968). The carpenterworm moth *Prionoxystus robiniae* has a peak period of emergence around midday (Solomon & Neel, 1972), while *Pyrausta machaeralis* (Gopakumar & Prabhu, 1981) has the peak between 21.00 and 23.00 hour and in *O. arenosella* the peak period of emergence is between 22.00 and 24.00 hour. The males and females have shown the same maxima of emergence in *O. arenosella* as in *Halisidota argentata* and *Nepytia phantasmaria* (Edwards, 1964) and in *Pyrausta machaeralis* (Gopakumar & Prabhu, 1981), although the present study shows that there is an early preponderence of male emergence from a brood as in *Diatraea grandiosella* (Yin *et al.*, 1987). In the *Prionoxystus robiniae* males and females have different maxima of daily emergence; the peak period in males being 5-6 hours earlier than that of females (Solomon & Neel, 1972). In these animals, the males attain sexual maturity in 5-6 hours and the females within one hour after emergence (Solomon & Neel, 1973). Thus their dual rhythm correlates well with their mating habits. Observation on the mating behaviour of *O. arenosella* shows that males do not start mating activity until the second night after adult emergence, while females show it in the first night (Personal communication). So in *O. arenosella* the early preponderence of males emergence correlates with their mating habits.

Sensitivity to environmental cues vary considerably during different stages of development of an insect. The flesh fly *Sarcophaga argyrostoma* (Saunders, 1976) and *Pyrausta machaeralis* (Gopakumar & Prabhu, 1981) show little sensitivity to light during pupal period and do not entrain a shift in the photoperiod. Their responsive period is restricted to larval instars. In the present study *O. arenosella* shows no response to light during pupal period. In *Pyrausta machaeralis* eclosion is arhythmic when animals are subjected to constant light throughout their life from larval emergence from eggs to adult emergence (Gopakumar and Prabhu, 1981). Adults then emerge at any time during the day or night without showing any peak period. The early morning maxima of emergence of the screw worm fly *Cochliomyia hominivorax* under LD 12 : 12 can be shifted to late afternoon when the photoperiodic regimen to which the larvae and pupae are subjected to is changed to LD 4 : 20. However, the entrained rhythm is unaltered by photoperiodic shift in the pupal period alone (Hightower *et al.*, 1971). In the present study in *O. arenosella* the eclosion is rhythmic when animals are subjected to constant light (L 24 : D O) throughout their life from larval emergence from eggs to adult emergence. The gallaries of larval *O. arenosella* are made up of silk threads coated with faecal matters and small pieces of leaf bitten off by the larvae which may cut off direct light inside the gallery. Therefore, the larvae which remains inside the gallery may not have direct access to light. This explains the absence of a shift in the eclosion in animals subjected to constant light.

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