THE INFLUENCE OF SOME CARBOHYDRATE DIETS AS ADULT FOOD OR GROUP INTERACTION DURING IMMATURE STAGES ON THE PROGRAMMING OF OVIPOSITION IN THE SPOTTED BOLLWORM, *EARIAS FABIA* STOLL (LEPIDOPTERA : NOCTUIDAE)

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Mated females of *Earias fabia* Stoll, although capable of laying eggs when fed only plain distilled water, required a carbohydrate nutrient as their adult food to realise full fecundity. Amongst the five sugars tested maximum egg deposition occurred if the moths ingested raffinose instead of galactose, sucrose, fructose or glucose (the last four carbohydrates arranged in the descending order according to the egg yield obtained). The mean number of eggs laid during the most productive phase of oviposition also varied interestingly in relation to differences in the adult foods ingested by the moths. Mated females which emerged from well nourished, group-reared larvae and pupae deposited significantly fewer eggs than their fattened counterparts. The implications of all these findings are appropriately discussed.

INTRODUCTION

Our knowledge of reproduction in *Earias fabia*, a major pest of cotton and okra in the tropics (Wyniger 1962; Lall 1964; Sohi 1964), is mainly derived from the published accounts on, (*i*) the oviposition and fecundity of this insect on the cotton plant (Khan and Rao 1960; Sohi 1964), (*ii*) the pest's ovipositional responses to different malvaceous and non-malvaceous plants and the factors regulating these responses (Mehta and Saxena 1970), and (*iii*) the reproductive capacity of this moth reared on whole fruit of okra or on its components (Vishwapremi and Krishna 1974*b*). However, nothing is yet known about the influence of adult diet (nutritional) or the effect of population density during larval and pupal development (environmental) on the reproductive potential of this insect. Our findings concerning the effect of these two factors, which play a vital and variable role in the egg production and egg laying (essential components in the establishment of a phytophagous insect on its host plant (Mehta and Saxena 1970; 1973) in insects (Engelmann 1970), on the ovipositional programme of this pest are presented in this communication.

MATERIALS AND METHODS

Fattened adults of either sex of *E. fabia* (Vishwapremi and Krishna 1974*b*), reared from the egg stage on the developing seeds of okra (Vishwapremi and Krishna 1974*a*), were exclusively employed in experiments concerned with determination of the influence of the adult diet on the reproductive potential of the females.

However, tests designed to evaluate the effect of group interaction during larval and pupal stages on the egg laying pattern of these females entailed the utilisation of laboratory-reared adult individuals developing from batches of at least 25 larvae or pupae kept together. Care was taken to provide abundant food (developing okra seeds) in the rearing medium for these larvae and pupae during their postembryonic development.

Investigations into the assessment of the role of adult food needs on the reproductive capacity of these pests were restricted to a comparative experimental analysis of the nutritional effect of five different carbohydrates and pure distilled water on the egg output by the fattened mated females. The carbohydrates chosen for this study were : raffinose, sucrose, fructose, galactose and glucose. 0.8 ml of a freshly prepared 15 per cent solution of one of these sugars or an equal volume of distilled water was provided daily as the adult diet for the test individuals.

All oviposition trials relating to each of the different experimental regimens outlined above began with pairing and mating a freshly emerged female on one regimen with a newborn male on the same regimen. The general layout of all these oviposition experiments and the monitoring of egg laying by the moths in these tests were similar to that described earlier (Vishwapremi and Krishna 1974*b*). The data obtained were then subjected to appropriate statistical analysis for interpretation.

Results

Observations on the nutritional influence of the different carbohydrates and distilled water, provided as adult foods, on the oviposition of *E. fabia* are variously displayed in Table I and Fig. 1.

Notwithstanding absence of any pronounced difference in longevity or in length of oviposition period between moths ingesting a carbohydrate diet and those feeding on water, a significantly greater number of eggs were laid by the females fed on

TABLE I

Number of eggs laid[1] *by fattened mated females of* E. fabia *fed on different carbohydrate diets or distilled water during their adult lives*[2]

Adult food	Mean number of eggs laid
Raffinose	604.6 a
Galactose	509.8 ab
Sucrose	445.4 b
Fructose	420.4 bd
Glucose	317.4 cd
Distilled water	164.8 e
Mean	410.4
LSD (1%)	155.1
(5%)	114.5

[1]Data pooled from 5 females.

[2]Any two means followed by the same letter do not differ significantly at the 1% or 5% level by the Least Significant Difference (LSD) test (Paterson 1939).

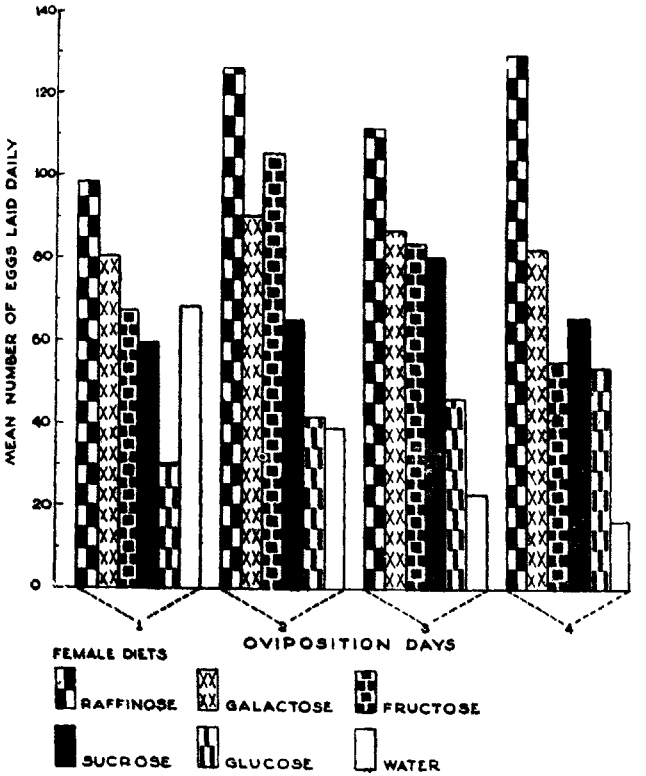

Fig. 1. Histogrammic representation of the oviposition rate, during the first 4 days of egg laying, in *E. fabia* fed on different carbohydrates or distilled water in their adult life (data pooled from 5 replicates).

any one of the test sugars than on water (Table I). Amongst the various carbohydrates, raffinose diet helped the individuals to deposit maximum number of eggs but this was significantly different ($P<0.01$) from the egg yield values obtained only from moths imbibing sucrose, fructose or glucose. Females drinking solely glucose solution laid relatively fewer eggs than those feeding on galactose ($P<0.01$) or on sucrose ($P<0.05$).

Interesting variations also occurred in the rate of oviposition during a 4-day egg laying period in these moths (Fig. 1). With the exception of water-fed females, the egg deposition rates of all other individuals always registered an increase during the 2nd twenty-four hour period of oviposition and this rise became steadily more and more on the 3rd and 4th successive days of oviposition specifically in the case of glucosefed moths. Water-ingesting insects showed their maximal rate of egg laying on the 1st day of oviposition itself. This, however, declined continuously during the subsequent 3 days of oviposition, the magnitude of this fall being very pronounced between the 1st and 2nd day of oviposition.

The number of eggs laid by mated females emerging from well nourished group reared larvae and pupae was markedly reduced and showed a significant difference

TABLE II

*Egg deposition, during the first 6 days of oviposition, by mated females from two different regimens**

Regimen	Number of females tested	Mean number of eggs laid (±SE)
Fattened mated females	12	452 ± 17.86†
Mated females emerging from group-reared larvae and pupae	5	384 ± 21.28

*Data subjected to *t*-test for groups with different numbers of individuals (Snedecor 1961).
†Significantly different at the 5% level from the value below in the column.

from the egg deposition counts taken from fattened mated females ($P<0.05$) (Table II). That the population density occurring during immature stages of a mated female, developed even under congenial nutritional conditions, can also seriously impair its oviposition—a feature not recorded so far in insect reproduction—is evident from this finding.

DISCUSSION

This investigation has revealed certain hitherto unknown, interesting and undoubtedly important factors affecting the reproductive capacity of *E. fabia* on okra fruit. These are discussed at some length here.

The fact that significantly more eggs were deposited when the adult moths were fed on a sugar solution instead of plain water, although they were all reared under identical conditions and did not show any marked difference in longevity or in length of oviposition period, clearly indicates that carbohydrate nutrition is very essential in promoting the egg laying capacity of mated females as in the butterfly *Colias philodice eurytheme* (Stern and Smith 1960), plausibly through better utilisation of dietary protein reserves in yolk formation during egg production (Engelmann 1970). The greatest contrast in the aggregate number of eggs deposited between moths fed on raffinose as compared with glucose further implies that, like in the syrphid *Sphaerophoria scutellaris* (Lal and Haque 1955), different sugars variably regulate the reproductive potential of these insects. The higher egg output by females ingesting fructose or galactose instead of glucose, notwithstanding that all the three sugars are monosaccharides, lends additional support to this interpretation. The maximum egg output by moths fed on raffinose can then reasonably be assumed to be due to the combined effect of fructose, galactose and glucose (all of which will be obtained from the ingested raffinose subsequent to its complete hydrolysis) on the reproduction of these pests. This implication that adult females of *E. fabia* are capable of fully utilising raffinose, though meaningful, requires substantiation by direct evidence through conventional studies on the digestive physiology of this insect. However, if proved correct, it becomes all the more interesting when compared with the physiological inability of this species to utilise completely this trisaccharide during its larval stage (Krishna and Pandey 1974).

Although the need for a carbohydrate nutrient during the female adult's life to realise full fecundity has now been experimentally established in *E. fabia,* we still do not know whether variations in the effect of different sugars ingested by the adult on its oviposition are due to superior nutritional value of some of these saccharides or on account of disparities in food quantities consumed. Also the question whether this moth in nature obtains through feeding all the necessary sugars, quality— and/or quantity-wise, from the foliage or flowers of one or more of the plants naturally infested by it or it is impelled by instinct to visit certain other plants falling outside its normal host range to fulfill its carbohydrate requirements for reproduction is still open.

The variability in oviposition rates in relation to differences in the adult foods of the fattened mated females is then considered. We interpret this feature in our findings as the outcome of the interaction of the varying nutritional as well as other genetically controlled innate factors with the adult regime to constitute a distinct, though pliable, imaginal programming of the reproductive processes of the female which inevitably gets superimposed on the already determined preimaginal reproductive programming of the same individual during its larval and pupal regimes. Thus the augumented egg output on the 2nd day of oviposition in all the sugar-fed mated moths and its further shoot-up on the 3rd and 4th egg laying days in glucose-ingesting individuals show the periods of accelerated egg maturation rates influenced by adult foods, during a 4-day oviposition phase (when more than 55 per cent of the total eggs laid are deposited), in these females. The initially sharp and continuous decline in the oviposition rate of water-fed individuals, subsequent to attaining the peak on the first day of egg laying, is evidently due to the swift and progressive falling off of the imaginal egg maturation rate following deprivation of a carbohydrate diet during their adult lives. The possibility that all egg maturation throughout the adult life of these females occurs mainly at the expense of their larval nutritional reserves is implicit in the previous statement.

It must be mentioned here that our earlier published account on the mean daily oviposition of seed-reared, fattened mated females fed on sucrose during their adult period (Vishwapremi and Krishna 1974*b*) stated the occurrence of "its peak value on the first day of egg laying". This is slightly at variance with our present findings. Presumably our not using the ANALAR quality of sucrose, unlike in the present experiments, in the sugar diet of the females studied earlier led to this small discrepancy.

The fecundity of the mated females in terms of total eggs laid was adversely affected when their larvae and pupae grew in groups even amidst abundant food. Perhaps collisions, interference with feeding etc., as suggested by Engelmann (1970) to explain the low egg output in *Drosophila melanogaster* females living in groups (Pearl 1932), occurred in the aggregated larvae and created stresses which precociously affected the physiological processes associated with egg production in the resultant females leading to a severe reduction in their total egg yield. In the light of this postulation it may not be unreasonable to suggest that the presence generally of only one mature larva inside an okra fruit in plants in nature is a behaviourally associated adaptive feature of this insect to overcome the unfavourable characteristics of a crowded environment.

Differences in larval diet (Vishwapremi and Krishna 1974*b*) or in adult food or in the larval environmental experience associated with population density caused no observable change in the length of the preoviposition period of the mated females. From this it is inferred that variations in larval or adult nutrition or in larval density is of no functional significance so far as the time of entrance into the reproductive period (Hillyer and Thorsteinson 1969) in these moths are concerned.

Thus the present findings collectively constitute an important step in the further understanding of the various complex and intricate factors affecting the reproduction of *E. fabia* on okra plant. These results in conjunction with our earlier observations (Vishwapremi and Krishna 1974*b*) assume greater significance, than either set of information alone, in relation to formulation of future integrated control programmes where this accumulated valuable knowledge can be judiciously exploited to check the multiplication of this pest.

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