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Ecological Monophagy in the Polyphagous Nymphalid Butterfly *Hypolimnas bolina*

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ABSTRACT

The polyphagous great eggfly *Hypolimnas bolina* Linneaus (Lepidoptera: Nymphalidae) with the reported larval hosts in the plant families Acanthaceae, Amaranthaceae, Aroidea, Asteraceae, Convolvulaceae, Malvaceae, Portulacaceae, Tiliaceae, and Urticaceae, exhibited host plant preference in the biotope of the Andhra University at Visakhapatnam (17°42'N - 83° 20'E), South India. The females tested *Asystasia gangetica*, *Dipteracanthus prostratus* (Acanthaceae), *Pupalia lappacea* (Amaranthaceae), *Sida cordata* (Malvaceae), and *Triumfetta pentandra* (Tiliaceae) but oviposited selectively on *S. cordata.* Total larval development time, length and weight of fifth instar, pupal weight and, the growth and nutritional parameters like consumption index (CI), growth rate (GR), approximate digestibility (AD), efficiency of conversion of ingested food to body substance (ECI) and efficiency of conversion of digested food to body substance (ECD) were studied to assess the relative suitability of the five plant species as host plants. The hatchlings raised on *S. cordata* were used in all the tests conducted in the laboratory with 28 ± 2^0C temperature, 80 ± 10% relative humidity and the natural light conditions of 12 - 14 h duration. The five plant species were found to be physiologically suitable for the growth and the development of larvae but they differed significantly in their effects on the nine parameters studied. Giving five credits to the top performer and reducing one credit in the subsequent host, the established order of their suitability with their total credits was *A. gangetica* (32) > *P. lappacea* (30) > *D. prostratus* (27) > *T. pentandra* (26) > *S. cordata* (20). Evidently the criteria of larval performance were not involved in host selection. The prostrate habit of *S. cordata* and its occurrence in open places with exposure to sun and the female's behaviour of laying eggs close to the ground were implicated as the ecological and behavioural factors in the selection of the host plant for oviposition. This kind of specialization is described as ecological monophagy.

Key words: Hypolimnas bolina, *Sida cordata*, oviposition, ecological monophagy.

INTRODUCTION

The eggfly genus *Hypolimnas* Huebner (Lepidoptera: Nymphalidae) is represented by three species in India. These include *H. bolina* L., *H. misippus* L. and *H. anomala* Wallace (Varsheny, 1994). While the latter species is confined to Andaman and Nicobar islands, the former two are distributed in the mainland (Wynter-Blyth, 1957). These are noted for their marked sexual dimorphism. Though the males of these species are not easily distinguishable from each other, the females are markedly distinct from each other, and are clearly noticeable while they are ovipositing. Available records of their larval host plants indicate that they are polyphagous. Their host plants are many belonging to unrelated families like Acanthaceae, Amaranthaceae, Aroidea, Asteraceae, Convolvulaceae, Malvaceae, Portulacaceae, Tiliaceae, and Urticaceae (Bell, 1910; Sevastopulo, 1973; Kunte, 2000 and 2006; Rajagopalan, 2005). Although some of the plant species of these families are available on the Andhra University campus, Visakhapatnam (17° 42'N - 83° 20'E), South India, interestingly, the great eggfly *H. bolina* was found to search and test *Asystasia gangetica* (L.) T. Anderson, *Dipteracanthus prostratus* (Poiret) Nees (Acanthaceae), *Pupalia lappacea* (L.) Juss (Amaranthaceae), *Sida cordata* (Burm. f.) Borssum (= *Sida veronicaefolia*) (Malvaceae), and *Triumfetta* pentandra A. Rich (Tiliaceae) but ovipositing only on *S. cordata*. As such *H. bolina* displayed host plant preference for ovipositing. Such host choice behaviour of the breeding females of butterflies in local plant use has not been studied in India (Kunte, 2000).

Normally, offspring performance, mostly the developmental time, provides suitable answer to the female's oviposition preference. But there was no unequivocal correspondence between oviposition preference and offspring performance in all the researches so far reported (Singer, 1984; Janz *et al.,* 1994). The necessary conclusion then was that the relationship is more complicated than a simple correlation between female preference and some aspect of performance like developmental time. Therefore, Janz *et al.* (1994) concluded that it is ideal to take all parts of the insect life cycle into account in any study aimed at understanding the host plant choice of the female. Here it is attempted to find out the consequences of rearing the larvae on both the actual and potential host plants and look for the factors determining the female choice of the host plant species for oviposition.

MATERIAL AND METHODS

The life cycle of *H. bolina* on the oviposition host plant *S. cordata* was studied in the laboratory in a temperature regime of 28 ± 2°C, relative humidity of 80 ± 10% and the natural light conditions varying in duration from 12 h during November - January to 14 h during June - July. Data were collected on the number of instars developed, their duration, length and weight, and also the pupal duration and weight. Instarwise larval performance was also studied in terms of food consumption, growth and utilization following Waldbauer (1968). Such data were collected by rearing the larvae on the actual host (*S. cordata*) and the potential hosts (*A. gangetica*, *D. prostratus*, *P. lappacea*, *T. pentandra*). The data obtained were subjected to statistical analysis of variance (ANOVA) in one way classification as the variables are independent.

A thorough search made of the early life stages of *H. bolina* on the oviposition host *Sida cordata* indicated that these life stages occur mostly during the period August - October, the period recording most of the annual rainfall. During this period, the ovipositing females were observed from close quarters and the leaves with the freshly laid eggs were plucked carefully. The date and time of collection were noted. The material was then transferred to petridishes of 10 cm diameter and 1.5 cm depth, the inside of which was lined with moist filter paper to provide moist conditions. Such petridishes were brought to the laboratory and kept in clean, roomy cage (60 x 50 x 30 cm) fitted with wire gauge. The eggs thus kept were examined at 6 h intervals daily to record the hatching time. After hatching, the larvae were transferred to clean petridishes, and were fed daily with weighed quantity of fresh young leaves. The initial and final length and weight of different instars, and the total food consumed, weight of the faeces were taken to calculate food consumption index (CI), growth rate (GR), approximate digestibility (AD), efficiency of conversion of ingested food to body substance (ECI) and efficiency of conversion of digested food to body substance (ECD). The time of formation of pupa, duration, its weight, and adult eclosion were recorded. These data were repeated for each of the potential host plants included in the study. The hatchlings from the eggs laid on the oviposition hosts were used for the purpose. Since most of the food consumption occurred in the final instar (instar V), the weight and length measurements, growth, food consumption and utilization indices of this instar were used for comparison of the larval performance on the actual and potential hosts.

RESULTS AND DISCUSSION

The effects of different host plants studied with respect to the nine parameters of offspring performance (Table 1.) differed significantly as indicated by the ANOVA (Table 2.). A rank or suitability order of host plants could be established in respect of each of the nine parameters by giving five credits to the top performer in respect of each parameter and reducing one credit for each subsequent host plant species. The larval developmental time varied between 19.20 days in *A. gangetica* and 40.20 days in *T. pentandra*; the order of suitability of the five host plants indicated by this parameter was *A. gangetica* > *P. lappacea* > *D. prostratus* > *S. cordata* > *T. pentandra*. The length of larva ranged from 40.00 - 50.50 mm, and the rank order of host plants indicated was *P. lappacea* > *A. gangetica* > *S. cordata* > *D. prostratus* > *T. pentandra*. The mean weight of larva was maximum (1739.60 mg) with *P. lappacea*, followed by *T. pentandra* (1396.30 mg), *D. prostratus* (1171.10 mg), *A. gangetica* (1132.90 mg) and *S. cordata* (754.20 mg). Pupal weight was the highest in *T. pentandra* (839.10 mg) followed by *P. lappacea*, *A. gengetica*, *D. prostratus* and *S. cordata*. Similar variations were observed in the effects of different host plants on the food utilization and nutritional capability of the larva (Table 1). To cite the instance of approximate digestibility (AD) of host leaves, the values varied from 31.44% with *P. lappacea* to 61.80% with *S. cordata*; the order of relative performance in this respect was S. *cordata* > *D. prostratus* > *A. gangetica* > *T. pentandra* > *P. lappacea*.

Based on the total of credits accomplished by each host plant species the order of suitability of host plant species with the respective total credits was: *A. gangetica* (32) > *P. lappacea* (30) > *D. prostratus* (27) > *T. pentandra* (26) > *S. cordata* (20). Interestingly, it was *S. cordata* the least in the order of suitability that was actually chosen by *H. bolina* for oviposition and subsequent larval feeding. The other more optimal host plant species were totally ignored for oviposition in the natural environment. This observation is in line with the remarks of Dethier (1954) that the oviposition behaviour of many species of butterflies may be far from optimal.

Table 1. Larval development time (days), length, weight, growth rate (GR), consumption index (CI), approximate digestibility (AD), efficiency of conversion of ingested food (ECI), efficiency of conversion of digested food (ECD) of instar V, and pupal weight of *Hypolimnas bolina* fed with actual and potential host leaves.

Host plant species	N	Larval devt. time (d)	Length of instar V (mm)	Wt. of instar V (mg)	Pupal Wt. (mg)	GR (mg / day)	CI (mg / day)	AD (%)	ECI (%)	ECD (%)
1. *S. cordata*♦	5	37.00 (2) ± 0.44	43.30 (3) ± 0.73	754.20 (1) ± 2.31	517.10 (1) ± 5.63	0.10 (1) ± 0.01	0.67 (4) ± 0.01	61.80 (5) ± 0.83	15.60 (2) ± 0.30	25.25 (1) ± 0.54
2. *A. gangetica**	5	19.20 (5) ± 1.07	50.00 (4) ± 0.27	1132.90 (2) ± 3.38	729.30 (3) ± 1.03	0.29 (5) ± 0.00	1.36 (1) ± 0.02	56.28 (3) ± 1.48	21.34 (4) ± 0.59	41.49 (5) ± 0.80
3. *P. lappacea**	5	23.60 (4) ± 0.51	50.50 (5) ± 0.84	1739.60 (5) ± 4.68	731.30 (4) ± 1.55	0.18 (4) ± 0.01	1.49 (2) ± 0.01	31.44 (1) ± 3.08	12.67 (1) ± 0.50	40.31 (4) ± 1.26
4. *T. pentandra**	5	40.20 (1) ± 0.58	40.00 (1) ± 1.30	1396.60 (4) ± 4.74	839.10 (5) ± 1.35	0.13 (2) ± 0.00	0.61 (3) ± 0.02	54.12 (2) ± 1.17	21.59 (5) ± 0.83	37.89 (3) ± 0.85
5. *D. prostratus**	5	35.60 (3) ± 1.70	40.30 (2) ± 0.95	1171.10 (3) ± 1.93	674.00 (2) ± 2.03	0.16 (3) ± 0.01	0.94 (5) ± 0.02	56.58 (4) ± 2.09	17.07 (3) ± 0.94	30.11 (2) ± 1.10

• Actual host; * Potential host; Numbers in parenthesis are the credits given to each host plant species.

The observed hierarchy order of host plants suggest that the selection of oviposition host plant by *H. bolina* was not based on larval performance. It may be involving some ecological and behavioural factors. There were reports of the role of ecological factors such as shady, sunny environment, plant's apparency, density, inflorescence size, phenology etc. in host selection rather than larval performance (Jermy, 1984; Singer, 1984; Scriber, 1986; Jaenike, 1990; *Janz et al.*, 1994; Mayhew, 1997). The females of *H. bolina* were found to walk while searching for oviposition sites; an observation also made by Bell (1910). Some authors reported that the larvae of *H. bolina* defoliated the low growing species of Urticaceae (Wynter-Blyth, 1957; Kushwaha *et al.,* 1963). It is thus suggestive that the females of *H. bolina* with low flying habit are bahaviourally adapted to lay eggs close to the ground; a bahaviour also reported with some populations of *Euphydryas editha* (Singer, 1971). In the Australian tropics, *H. bolina* preferred freshly emerged seedlings of less than 10 mm height of *Synedrella nodiflora* (Asteraceae) for ovipositing ignoring all the vertically grown up potential host plants including *S. nodiflora* (Kemp, 1998). The oviposition host plant species *S. cordata* under study is a much branched herb, and the branches grow prostrate, having cordate leaves sparingly clothed with stellate hairs, and occurring in open waste places; *D. prostratus* is also a prostrate herb but occurs in shady places. Of the other host plants, *A. gangetica* is a trailing herb and the others grow erect. Perhaps, the low growing and prostrate habit of *S. cordata* and the sunny environment provided suitable oviposition sites. Since the temperature at ground level would be relatively higher than those above, the larvae of *H. bolina* appears to be heliophilic. The butterflies whose larvae are heliophilic prefer to oviposit in sunny open areas (Urquhart, 1960; Rausher, 1979). The sunny exposures promote faster development of the larvae than those lacking radiant input and allow the production of additional broods per season (Grossmueller and Lederhouse, 1985; Turlure and Van Dyck, 2009). The kind of local food plant specialization exhibited by *H. bolina* may be described as ecological monophagy (Scriber, 1986). Such host specialization is considered to be advantageous since it enables most efficient exploitation of the host plant (Singer, 1984). This host specificity not only influences the food supply of larvae but also stimulates the female adults to lay eggs (Moore and Menash, 2000). All the plant species included in the study came out as physiologically suitable to the growth of larvae of *H. bolina*. It therefore suggests that in any geographical region *H. bolina* may have a wider range of potential host plants suitable for larval growth than the range of plants actually used for oviposition. Such a facility as expressed by Wiklund (1975) enables the larvae to maximize the probability of their survival on the plant their mother chooses for them.

Table 2. Analysis of variance of different parameters of larvae and pupae in relation to host plants.

Parameter		SS	df	MS	F	P
Larval development time	Between groups	1678.640	04	419.660	161.410	0.000
	Within groups	52.000	20	2.600		
Length of instar V	Between groups	525.340	04	131.330	131.360	0.000
	Within groups	78.400	20	3.920		
Weight of instar V	Between groups	2631684.000	04	657920.880	14047.333	0.000
	Within groups	936.720	20	46.836		
Pupal weight	Between groups	276492.400	04	69123.090	1679.380	0.000
	Within groups	823.200	20	41.160		
Growth rate (GR)	Between groups	0.1050	04	0.02635	71.216	0.000
	Within groups	0.0074	20	0.00037		
Consumption index (CI)	Between groups	3.1670	04	0.792	442.263	0.000
	Within groups	0.0358	20	0.00179		
Approximate digestibility (AD)	Between groups	2811.509	04	702.88	38.844	0.000
	Within groups	361.893	20	18.095		
Efficiency of conversion of ingested food (ECI)	Between groups	292.395	04	73.099	32.332	0.000
	Within groups	45.218	20	2.261		
Efficiency of Conversion of digested food (ECD)	Between groups	1061.810	04	86.756	59.290	0.000
	Within groups	89.544	20	4.477		

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