FIRST REPORT OF PHYTOPHAGY BY AN ENTOMOPHAGOUS LEPIDOPTERAN CATERPILLAR *SPALGIS EPIUS* (WESTWOOD) (LYCAENIDAE)

ASHIRWAD TRIPATHY

Entomology Branch, Forest Protection Division, Forest Research Institute, P.O. New Forest, Dehradun, Uttarakhand 248006, India

Email: ashirwadaspire351@gmail.com

Reviewer: Piet van der Poel

INTRODUCTION

Lycaenid larvae generally feed on plant material, but some rely on other insects for nutrition during all stages or part of their development. This includes ant eggs, larvae and pupae, as well as ant regurgitations. It also includes Hemiptera (the True Bugs), hemipteran honeydew and other lycaenid larvae or larvae of the same species (Pierce *et al*., 2002).

Three genera of Miletinae, that is, *Spalgis* Moore, 1879; *Taraka* Doherty, 1889 and *Feniseca* Grote, 1869 feed on Hemiptera tended by ants (Dinesh *et al*., 2010). Additionally, aphytophagy is occasionally observed in phytophagous butterfly larvae; this behaviour is observed in the Erebidae, Bombycidae, Geometridae, Noctuidae, Saturniidae and Sphingidae moths and Lycaenidae, Nymphalidae, Papilionidae, Pieridae, and Riodinidae butterfly families (Dethier, 1937). Lycaenids feed primarily on angiosperms, conifers, cycads, ferns, fungi, lichens, homopterans (mealybugs, scale insects, aphids, and so forth) and ant larvae (Atsatt, 1981). Additionally, they can feed on a variety of prey (Greenideid aphids and leafhoppers) at the same location (Lohman & Samarita, 2009).Caterpillar entomophagy is divided into four categories: cannibalism, occasional predatism, habitual predatism, and parasitism (Balduf, 1938). Cannibalism in Lepidoptera has been reported in three species of Lycaenidae (Tripathy, 2020)

MATERIAL AND METHODS

The present study was carried out in the Baramunda region of Bhubaneswar from April to May 2018. Bhubaneswar (20°17’14’’N; 85°47’27’’E) is located on the coastal belt of Odisha, India. The larvae were examined under lab conditions at the College of Forestry, OUAT, Bhubaneswar.

The larvae of *Spalgis epius* were collected from *Hibiscus rosa-sinensis*, which was infested with mealy bugs, *Coccidohystrix insolita* (Green, 1908). The larvae were kept in the lab at 25°C and at 70-78% humidity. *Spalgis epius* is an entomophagous insect that feeds on the aphids, coccids and pseudococcids. Due to this fact, the feeding behaviour of the larvae was studied in artificial conditions. A total of sixty-eight (n=68) larvae of 2^{nd}(n=22) 3^{rd}(n=24) and 4^{th}(n=22) instar were collected from the field from which seven to eight (n=7-8) larvae from each instar except 1^{st} instar (due to very small size) were placed in a plastic box (9.5cm x 8.5cm) with ‘unlimited food’ (i.e., coccid with all the stages such as eggs, nymphs

and the adults), 'limited food' and 'no food condition' respectively. The food here is given in the form of green leaves over which coccids are present to assess *S. epius* feeding behaviour. This was done to explore the cannibalistic behaviour and to know whether this entomophagous insect eats a leaf or not during stress like 'limited' or 'no food'.

During this experiment it was found that when the food was limited or no food was given to 3rd instar larva, instead of dying, the larva pupated with a smaller pupa and eventually a small adult emerged from it. But the pupal duration increased and matches with the emergence time of the adult from the pupa made from the 4th instar larva. This is represented by the word 'pupate' in figure 1.

Adults of *S. epius* that emerged were deposited in the collection of the Odisha University of Agriculture and Technology, Bhubaneswar, Odisha.

RESULTS

It was found that phytophagy (leaf-eating behaviour) of entomophagous *S. epius* larvae occurs in stress conditions. When food is limited and larvae are numerous, 3rd and 4th instars will eat leaves. When food and larva are both limited no leaf-eating behaviour is shown. This shows that when intraspecific competition for food occurs, they either eat leaves or eat their own kind (cannibalism). Here, cannibalistic behaviour is seen only in the 2nd instar larvae in no food conditions (Table 1: fig. f). The 2nd instar larvae did not show any phytophagy behaviour. Also, the 2nd instar larvae were found to eat scale insect eggs placed near the 3rd instar larvae on its dorsal surface during 'no food conditions'. Some of the 3rd instar larvae showed phytophagy and the remaining larvae pupated during 'no food conditions' (Table 1) while 4th instar larva always pupated during 'no food conditions'.The larvae that pupated during the 2nd and 3rd instars produced adults rather smaller than the smallest known adult specimens of this species. Evans (1932) gave a wingspan, measured from the centre of the thorax to the apex of the forewing, doubled, as 20-30 mm for the species. In the present study, the smallest individuals measured had a wingspan of 16 mm (Figure 2).

DISCUSSION

Coccidae species consume a considerable amount of plant sap, which results in decreased plant vigour, poor development, dieback of twigs and branches, early leaf drop, and eventual death of the entire plant (Gill & Kosztarab, 1997). Natural enemies such as ants, mantis, lacewings, ladybird beetles, and specific parasitoids have been observed attacking these scale insects as a biocontrol measure (Sathe *et al*., 2014). *S. epius* has been identified as the primary biocontrol agent for two notable mealybug species, *Planococcus citri* Risso, 1813 and *Maconellicoccus hirsutus* Green, 1908 (Dinesh & Venkatesha, 2011a).

Leaf eating behaviour or phytophagy of the entomophagous caterpillar of *S.epius* can be explained by its phylogeny. The genera *Spalgis*, *Taraka* and *Feniseca* of the sub-family Miletinae of the family Lycaenidae are aphytophagous and feed on ant-tended Hemiptera (Dinesh *et al*., 2010).The subfamily Miletinae is divided into four tribes Miletini, Spalgini, Lachnocnemini, Liphyrini, and all are carnivorous. The leaf-eating behaviour arises due to ancestral genes. The subfamily Lipteninae, a close relative of Miletinae, feeds on lichens (Real & Brown, 2012); some species of Aphnaeinae feed on fungi in ant galleries (Real & Brown, 2012). Due to this, they have the innate ability to eat leaves, but now they are modified to feed only on hemipterans. However, in stress conditions

for their survival, they consume a small portion of a leaf (Table 1: fig. b) but not a whole leaf, as their mandibles are modified to eat hemipterans. Aphytophagy is occasionally observed in phytophagous butterfly larvae (Dethier, 1937), but the reverse was not recorded till now in Lepidoptera, though some studies in the order Heteroptera shown phytophagy by predatory Heteroptera (Naranjo & Gibson, 1966; Holtz *et al*., 2011). Phytophagy by predators helps to complete a nutritional aspect in that particular stage of development (Naranjo & Gibson, 1966; Holtz *et al*., 2011). This behaviour is also observed in predatory coccinellids, especially Coccinellini (Escalona *et al*., 2017).

Similarly, some researchers found that phytophagy may be perfectly substitutable for carnivory in several species (Kiman & Yeargan, 1985).On the other hand, some carnivory is substitutable during certain developmental stages (Stoner, 1970). This is the first record of any Lepidopteran larva, which is entomophagous in nature, showing phytophagy.

CONCLUSION

The present study revealed a new kind of change in feeding behaviour in Lepidopteran larva. The occasional shift from phytophagy to aphytophagy in some groups of moths and butterflies was recorded earlier. However, the shift from aphytophagy to phytophagy was not recorded in any Lepidopteran larva. So, this is the first-ever record of a carnivorous larva feeding on a leaves during stress conditions.

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Table 1: showing the phytophagy and cannibalism in different food availability conditions by *Spalgis epius* larva

Stages	**Phytophagy**			**Cannibalism**		
	No Food	**Limited Food**	**Unlimited Food**	**No Food**	**Limited Food**	**Unlimited Food**
2nd instar	-	-	-	√	-	-
3rd instar	√ (pupate)	√	-	-	-	-
4th instar	- (pupate)	√	-	-	-	-

Fig a- ventral side of *Spalgis epius* larva indicating the minute mandibles. **b-** phytophagy was shown by the *S. epius* (3rd instar) larva during 'no food condition'. **c-** *S. epius* larva feeding on the scale insects in the rearing box. **d-** arrow (yellow) indicating the larva in the natural field condition feeding on the scale insects. **e-** larva after feeding placing the left-over of the scale insects to its dorsal surface to camouflage in its natural environment. **f-** cannibalism by 2nd instar larva during 'no food condition'.

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Stages	**Mean Pupal size(cm)**		**Mean Pre pupal stage duration(days)**	**Mean Adult length(head to tail)**	**Mean Adult wing span**
	length	**width**			
2nd instar	0.514±0.012	0.31±0.008	2.3±0.48	0.5±0.008	1.607±0.008
3rd instar	0.607±0.008	0.41±0.01	2.1±0.31	0.9±0.004	2.207±0.008
4th instar (control)	0.7±0.004	0.5±0.003	0.97±0.06	1.08±0.11	2.586±0.032

Figure 1: comparative measurement of pupal and adult size. Mean and SD from n=10

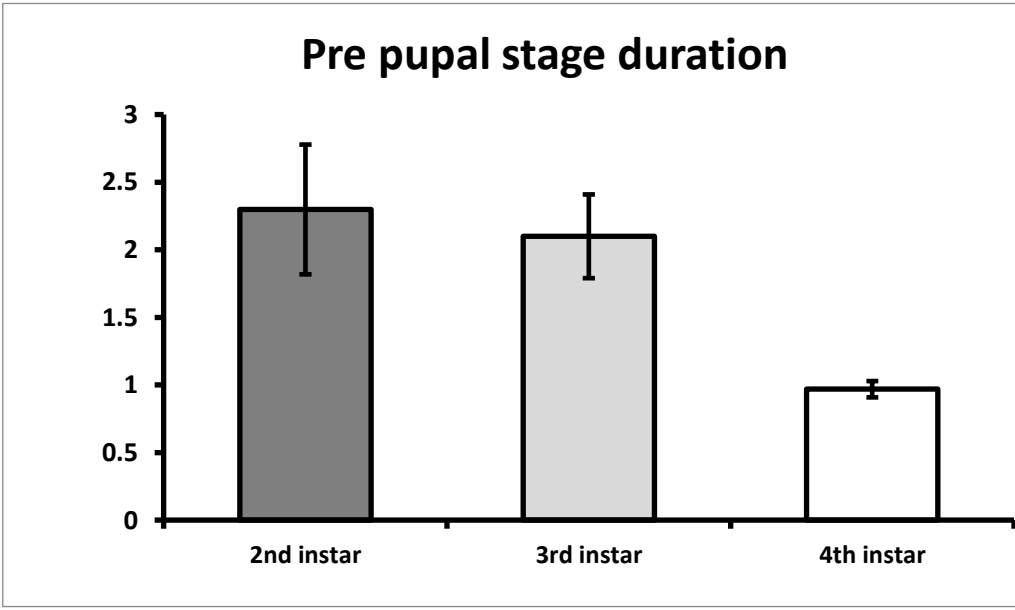
Pre pupal stage duration
3
2.5
2
1.5
1
0.5
0
2nd instar
3rd instar
4th instar

Figure 2