Eco. Env. & Cons. 27 (3) : 2021; pp. (1113-1118)
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ISSN 0971–765X

Resource partitioning between *Agrotis ipsilon* and *Spodoptera litura* larvae with respect to host plant *Nicotiana tabacum*

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(Received 28 November, 2020; Accepted 4 January, 2021)

ABSTRACT

Resource partitioning is a phenomenon in which two or more species depend on same host plant separate their food obtaining area. This process has been evolved to reduce competition between the involved species so that their survivality will increase. Two species of Noctuidae family *Agrotis ipsilon* and *Spodoptera litura* feed upon same plant that is tobacco plant but they separate their portion of feeding. Larvae of two species are collected from field, reared and identified from their adult form. Feeding habit of two species are observed in the field and also in the laboratory by giving them natural food source. From the observation the conclusion that comes that the black cut worm or *Agrotis ipsilon* feeds on stem of tobacco plant and *Spodoptera litura* feeds on leaves of tobacco plant. Though the season for *Spodoptera litura* ranges from mid December to last of January and the season for *Agrotis ipsilon is from* mid January to mid February. So there is an overlapping time in their season of life cycle. To overcome the competition two species use two different parts of same plant as their food source.

Key words: *Pest, Resource partitioning, Host plant, Polyphagous, Lepidopteran*

Introduction

Organisms compete for resources, that is often limited which leads to either intense competition between the species or coexistence with each other. One such way of co-existence between two competing species is through resource partitioning. The term resource partitioning may be defined as "the division of limited resources by species to help sustain in an ecological niche without competition". Knowledge on the allocation of different resources within a particular ecological niche is vital to unveil the level/complexity of ecological interactions occurring between diverse species.

Food resource partitioning has been well observed in many faunal groups (Schoener, 1974). Phytophagous insect communities have been well documented in describing resource partitioning (Southwood, 1961; Olper, 1974; Strong, 1974 a,b). Resource partitioning (Lamp *et al.*, 2017) has also been illustrated in some lepidopteran (Noctuidae) species (Gilbert and Singer, 1976). From the study of Shapiro and Carde (1970) it was concluded that such host plant similarities among butterflies create a competition among the species ultimately leading to ecological shift (Gall *et al.*, 2017). However, understanding and pinpointing the partitioning of food source is very difficult and complex (Rarthcke, 1976; Colwell, 1973).

Two Lepidopteran species, namely *Spodoptera litura* and *Agrotis ipsilon* having wide host range share many of their host plants. *Spodoptera litura* has

a wide host range (>120 plants), majority of which is cultivated crop. Similar is the host preferences of another Lepidopteran species, i.e. *Agrotis ipsilon.* Also known as black cutworm, *Agrotis ipsilon* expands its host range through majority of the consumed vegetables. Both the species cause tremendous damage to the crop, thus resulting in heavy economic losses.

Both the above-mentioned species are present throughout the sub-Himalayan India, attacking varied groups of cultivated crops. In Coochbehar district, both the species attack tobacco cultivation causing huge economic losses. This study aims to provide an insight into the habitat preference of these two Lepidopteran species on the cultivated tobaco plants throughout Coochbehar district of West Bengal. Understanding the feeding process of these moths will also help in assessment of the damages caused by these species to the crop plant.

Materials and Method

Materials required

i. Fresh Tobacco leaves ii. Fresh Tobacco stems iii. Transparent plastic container iv. Cotton cloth v. rubber band vi. Water vii. Scissor viii. Forceps ix. Entomological pin xi. Incubator xii. Thermocol block xiii. Butter paper xiv. Canon EOS 700D camera

Methodology

Habitat preferences study

Three different sites were selected, namely Mathavanga, Dinhata and Shitalkhuchi. All the information related to the sites are provided in Table 1.

The larvae of all the Lepidopteran moths were collected from the tobacco fields in plastic containers and brought to the laboratory. The larvae were identified up to species level following standard identification keys (Beardsley, 1982). Larvae identified as *Spodoptera litura* and *Agrotis ipsilon* were selected for further studies. Each *Spodoptera litura/Agrotis ipsilon* larva was placed in a plastic jar and covered with a cotton cloth. Three different experimental sets of larvae were prepared, i) provided with leaves only, ii) provided with stems only, iii) provided with both stems and leaves. The leaves and stems were replaced every day with a fresh batch. Five different replicates were set for each experimental set.

Life cycle study of the moths

This survey work was carried for three years from 2017 to 2019. Larvae instars were collected from the field. Then they were kept inside a transparent plastic jar covering the mouth of the jar with a cotton cloth. They were then reared up to adults. The climatic parameters were also studied throughout the specified time to assess the role climatic variation on the studied moth species.

Results

Host Preference studies

The differentiation in food consumption between two genera was observed by rearing them in the laboratory and from their food consumption preference.1stinstars of *Spodoptera litura* was found to prefer young Tobacco leaves or newly formed leaves preferring the edges of leaves. Second instars were similar to that of first instars regarding their feeding habit. Third, fourth and fifth instars of *Spodoptera litura* preferred feeding upon matured leaves of Tobacco plant. *Spodoptera litura* larvae did not show any kind of aggression among them. Whereas all instars of *Agrotis ipsilon* preferred stem from the basal part of the Tobacco plant even when both leaves and stems were provided to them.

Life cycle

As the study was done for three continuous years, it was observed that *Spodoptera litura* occurs in Tobacco field in the mid of December and *Agrotis ipsilon* occurs in third week of January in Coochbehar district. Though time is different but

Table 1. Coordinates of survey area

Site cutivated	Geographical coordinate	Species collected	Other crops
Mathavanga (golakganj)	26.2752° N, 89.2041° E	*Spodoptera litura and Agrotis ipsilon*	Maize, potato, rice
Dinhata (Krishi mela)	26.1306° N, 89.4479° E	*Spodoptera litura and Agrotis ipsilon*	Maize, potato, rice
Shitalkhuchi	26.1691° N, 89.1801° E	*Spodoptera litura and Agrotis ipsilon*	Maize, potato, rice

Table 2. Laboratory observation of moulting by providing 3 types of food combination

Name of the species	Food	Survivality
Agrotis ipsilon	Only leaf	Nil
Agrotis ipsilon	Leaf + stem	Larva to pupa to adult
Agrotisipsilon	Only stem	Larva to pupa to adult
Spodoptera litura	Only leaf	Larva to pupa to adult
Spodoptera litura	Leaf + stem	Larva to pupa to adult
Spodoptera litura	Only stem	Nil

still there is an overlapping time of occurrence of larvae between two species. The larva transformed into a pupa like cotton mass attached to ventral surface of the leaf. Pupa was sessile and did not eat food. After 16 days adults emerge out from the pupa.

In December 2017 throughout the month the weather was clear sunny day, humidity average 80% with 60% minimum in a day and 100% maximum. Average temperature throughout the month was 21°C (min. 14°C and max 28°C). December 2018 and 2019 was more or less similar with that of 2017 but December 2018 was warmer. For 2018 and 2019 January was cooler than December with an average temperature of 17 degree January 2018 was foggy or low cloudy but January 2019 was clear sunny (http://www.timeanddate.com/weather/india/cooch-behar/historic?month=12&year=2017). All three sites are characterized by a long summer of almost six months, a small winter of two months of January and December, and a short monsoon in the middle of summer *i.e.,* from mid-June to mid-August. And the main feature of these two moths is they could only be collected in winter. No moths could be collected in summer or rainy season.

Table 3. Field observation of moulting by providing 3 types of food combination

Name of the instar stage Agrotis ipsilon	Food
1st instar	Stems of basal part of plant
2nd	Stems of basal part of plant
3rd	Stems of basal part of plant
4th	Stems of basal part of plant
5th	Stems of basal part of plant
Spodoptera litura	
1st instar	Newly formed leaf
2nd instar	Newly formed leaf
3rd instar	Matured leaf
4th instar	Matured leaf
5th instar	Matured leaf

Fig. 1 a. Larva newly hatched, b: larva in intermediate condition, c: matured larva, d: pupa, e and f: adult of *Spodoptera litura*

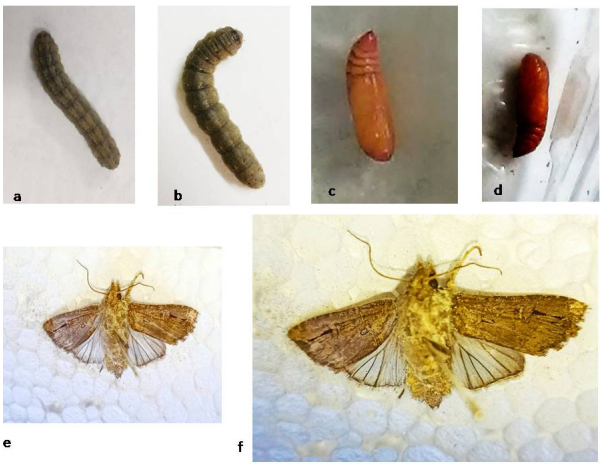

Fig. 2. a &b. Larval stage, c and d : pupa , e and f : adult of *Agrotis ipsilon*

Discussion

These two moth species in the mentioned area not very much competitive as they do not depend upon the same food source though the host plant is same so interspecific more correctly intergeneric competition is not much intense here. As a result, there is no

niche overlapping for both trophic niche and habitat niche. So, it can be said that there is already a pre-existing niche shift. This partitioning of resource is achieved through three different niche dimension: plant species, plant habitat and plant growth or growth condition.

In polyphagous herbivorous insects the feeding strategy is rarely described (Levin's and Mac Arthur, 1969; Wiklund, 1971). Here it is observed that how the two genera interact for obtaining food from same plant. Regarding this discussion Colwell, 1973 has proposed two theories, in the first one, an insect population uses parts of a single or small number of closely related plant groups as its larval food and is known as resource specialist (Restrepo *et al.,* 2019); in the other theory, an insect population uses two or more dissimilar or related plant species and known as patch generalist (Mills *et al.,* 2020) (Bellone *et al.,* 2020).

As these two genera are polyphagous in nature they definitely can recognize which host plants is most suitable for them (Levine and MacArthur, 1969). If we compare monophagy (Wiklund *et al.,* 2018) and polyphagy we can come to the conclusion that monophagy and polyphagy (Pan *et al.,* 2019) occurs depending upon the insects gut morphology and gut physiology (Benson, 1977), plant's geographical location, presence of predator *etc.* The basis on which host preference depend is the oviposition by the insect and its survival i.e., the survivality of the larva. As per this strategy the insect shows tendency to choose host plant in which it can acquire all its necessity. There are many factors which determines the host plant selection.

Noctuidae species which spend much time searching for oviposition will lose a chance to find the normal host quickly. This finding of novel host *i.e.,* host with maximum oviposition site will decrease its chance to find its normal host. So "pursuit time" can cause reduction in finding normal host.

Another factor which is very crucial for survival of the moth is polyphagy. A plant with low larval survival but with high plant abundance can be chosen as host (Benson, 1977). There are various factors involved in host plant selection, the larvae either has to pay costs or may gain benefits from it. If the new host's leaves are nutritious then the larva will gain an advantage, if not then it will be very difficult for the larvae to adopt with the new host. Thus, if the habitat range is large then it's easy to get right host plant for the larvae. But if there is a competition between two pest species then it becomes very difficult to choose the right host plant. But here in this case two species co-exist as they have separated their food niche.

However, since these species share same hosts, they have developed some level of partitioning. *Spodoptera litura* larvae are known to feed only upon the leaves of the plants. Others species of *Spodoptera* also feed upon leaves of various plants as rice or potato. Whereas, *Agrotis ipsilon* larvae feed inside the stem, showing a borer like activity and feeding upon the juicy part inside the stem (Busching *et al.,* 1977). The *Spodoptera litura* larvae shows a looping movement on the leaves (Montezano *et al.,* 2018; Abdullah *et al.,* 2019).

When there is no competitive effects insect will adapt to an optimal level with its host (Wiklund, 1977). Competitive process may cause a negative effect in species survival (Sensu MacArthur 1972). Host plant selection in a fluctuating environment is difficult than in case of constant environment. Many host plants are common for both *Agrotis ipsilon* and *Spodoptera litura* such as potato, rice, maize *etc*. Resource plant abundance in a particular season has no role in competition between two pest species as *Agrotis ipsilon* and *Spodoptera litura* have no two different food niches on same host.

Climatic pattern changes with time and so the topography and ecological factors. Effect of climate change with time on the species interaction, i.e., interaction between insect and its host plantis also having been studied. Natural disaster which causes maximum crop loss in a certain region can also be reason for pest and its host plant interaction (Graae *et al.,* 2018). Effect of climatic and species composition oscillation can be represented geographically.

From the study it can be said that climatic change does not have much impact on population of those two species though climate has an indirect effect on pest population, because plant growth and survivality depends upon climatic condition. In three areas *Spodoptera litura* reaches its abundance in the end of January. Another important feature about these two species is these two species prefer dry cold weather rather than moist warm weather. As it is seen that *Spodoptera litura* is predominating from mid December to mid January so it can be said that the insect prefer a cooler environment than *Agrotis ipsilon* as *Agrotis ipsilon* is predominating from end of January to mid of February. In summer and rainy season it is very difficult to find any of the two spe-

cies.

The geographic and topographic patterns and the historical impact on these geographic structures are different in these three regions. If we compare Golokganj of Mathavanga subdivision, Stalkhuchi and Dinhata sub division there are lots of differences in the soil quality (Shiduzzaman *et al.*, 2018), vegetation, climatic condition, humidity, temperature are different in these three regions. Due to these geographical and climatic differences insect species composition also varies (Benson, 1977)

By observing the faunal composition in these regions it can be assumed that the faunal composition in some places is caused due to historical accidents but not in all regions. The species abundance is high in Golokganj region rather in Dinhata 1 (Sengupta *et al.*, 1971) or Shitalkhuchi (Ghosh *et al.*, 2018) though the host plant species is same.

Host plant interaction for *Agrotis ipsilon* and *Spodoptera litura* are available for many areas of Indian sub-continent. From several studies of host plant interaction in *Agrotisipsilon* and *Spodoptera litura* it is known that Tobacco is one of the favourite host plants of both the species. These areas of Coochbehar are richly cultivated with Tobacco so these areas are highly productive also for *Agrotis ipsilon* and *Spodoptera litura*.

There is a large difference between larval and adult feeding habit. This study focused on the feeding strategies of two larval species. In three regions, Mathavanga, Dinhata and Sitalkhuchi both the species shows a resource specialist tendency. Though it is known that rice is also host for *Agrotisi psilon* (http://entnemdept.ufl.edu/creatures/veg/black_cutworm.htm) but there was no *Agrotis ipsilon* population in Aman rice or winter rice field of same area. And corn or maize is also an alternative host for *Spodoptera litura* (https://wiki.bugwood.org/Spodoptera_litura) but there was no *Spodoptera litura* larvae in neighboring Tobacco field at same time. So from the study it can be said that here in this region both *Spodoptera litura* and *Agrotis ipsilon* are resource specialist. As these two genera are depending upon same host so they must partition their resource. As a result one is leaf eater another feeds on juicy stem. Or it can also be said that their guilds are different.

This study provides an insight into the feeding preferences to two pests of tobacco plant. It might help in assessing the economic damages caused by these pest species to the crop. Also, more knowledge on such preferences might help in efficient planning to minimize the damages caused by these pests on tobacco plants. The knowledge gained on the life cycle and abundance of these pests with reference to climatic variations, might help in efficient control of these pest species before they start causing damage to the crops.

Acknowledgement

Author's appreciation extends to Mr. Pradipto Kumar Roy. Whose encouragement has been especially valuable, and his early insights launched the greater part of this paper.

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