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The medicinal annual legume *Senna (= Cassia) tora* (L.) Roxb. and its insect associations in Kerala, India

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ABSTRACT: Plant-animal interaction is an important biotic interaction of evolutionary significance in the tropics. Although we have a rich biodiversity, our knowledge of the natural history of species and their biotic interaction is poor. In this study, we highlight the insect community that interacts with an important medicinal herb, *Senna tora* in Kerala. We have studied the herbivorous insects of the plant and their parasitoids. Thirty four species of insects are identified as major herbivores of *S. tora*. The parasitoid community recorded comprises of 19 species. The caterpillar of *Eurema hecabe* was the most dominant herbivore of *S. tora* and it completes its entire life cycle on the plant. The results of the study indicate that *S. tora* is a potential plant to be used in habitat management for conservation biological control.

KEYWORDS: Herbivory, *Senna tora*, parasitoid insects, insect-plant interaction

INTRODUCTION

Plant-animal interaction is an important biotic interaction of evolutionary significance. Herbivory is an important interaction that can limit the recruitment of plants in different climatic zones and eco-regions. Herbivory by insects, however, lead to a fourth level trophic (biotic) interaction between the herbivorous insects and their natural enemies. Gathering the baseline information on animals associated with plants and their role in plant recruitment, although important, is less studied from Indian region; such information is particularly useful for the cultivation and propagation of plants of medicinal importance. Here we report our findings on the flower visitors, herbivorous insects, and their natural enemies of a common medicinal herb, *Senna* (=*Cassia*) *tora* (L.) Roxb. (Family Leguminosae) (The Plant List, 2013) with two broad objectives: 1) what is the diversity and associated roles of herbivorous insects

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on *S. tora*? and 2) how important the plant species is in maintaining the natural insect parasitoid diversity locally?

Senna tora L. is an important wild legume with food, forage and medicinal potential. Volatile oils extracted from the seeds of *S. tora* have a strong antioxidant activity, and they may be valued highly in the treatment of hyperlipidemia, hypertension, oculopathy and inflammatory disease (Zhang *et al.,* 2007a). The whole plant is used in ayurveda as medicine for several ailments that include skin infections and psoriasis. The roasted seeds of *S. tora* are often used as a substitute for coffee among some humans. It grows in dry soil throughout the tropical part of India. It is an annual foetid herb, and reaches the height of up to 90 cm. The plant is an important choice in butterfly gardens as some species of butterflies are known to have larvae that feed on the leaves of *C. tora* (Mathew and Mary, 2007)

MATERIALS AND METHODS

The study was carried out in the University of Calicut Campus (11°7'N, 75°5'E). In India *Senna tora* occur as a rainy season weed. It is an annual foetid herb, and grows up to a height of 30–90 cm. Leaves are pinnate, up to 10 cm long rachis grooved, conical gland between each of two lowest pairs of leaflet, leaflets in three pairs, opposite, obovate, oblong and base oblique. Flowers are found in pair in axils of leaves, petals five, pale yellow. Fruit is a pod. About 30-50 rhombhedral shaped seeds are found in the pods. Usually they flower after the monsoon rains (in Indian conditions).

The study site is characterized by the abundance of mango trees (*Mangifera indica*). *Senna tora* plants (n =121) were tagged using aluminum labels and monitored for insect activity since its leaf flush, which continued throughout the flowering and fruiting season of the plant. Hourly observations were carried out from 06 00 h –18 00 h and insect species were recorded, and their specific roles observed and documented. Insects that were found to chew and suck the leaves of *S. tora* and continue to feed for more than 30 seconds and those who fed on stem and pods were classified as herbivores. Insect visitors to the flowers of *S. tora* were recorded. The adult insect visitors were closely examined for any oviposition on the plant. The herbivorous insects were collected by hand picking, killed, labeled and preserved and then identified with the help of experts,

The parasitoids were collected using an aspirator. Pseudococcid species are major pests of the plant, and the infested parts of the plant such as stem and pod, were collected and enclosed in glass beakers covered with muslin cloth. The parasitoids that emerged from these pseudococcids were collected, identified, labeled and preserved. Pods of the plant were also collected and the number of weevils that emerged was recorded. All specimens are kept in the Entomology Museum of Department of Zoology, University of Calicut.

RESULTS

Thirty four (morpho) species of herbivorous insects were observed on different plant parts (leaves, stems, flowers and pods) of *S. tora*. The parasitoids comprised 19 species of hymenopterans. *Eurema hecabe* (Linnaeus) (Lepidoptera: Pieridae), commonly known as common (or two-spot) grass yellow, was the most frequent floral visitor on *S. tora* flowers, and fed on the nectar, and deposited eggs on the underside or on the margin of the leaf blades. The number of eggs per leaf varied between 2 and 6 (average 3.4 eggs, N = 56), and the number of eggs per plant varied between 12 and 28 (average 16 eggs, N = 21). *Spindasis vulcanus* Fabricius (Lepidoptera: Lycaenidae) and *Ypthima ypthimoides* (Moore) (Lepidoptera: Nymphalidae) were also seen visiting *C. tora.*

Insects of three orders, Coleoptera, Orthoptera and Hemiptera visited and used the floral resources of the plant. Fourteen (morpho) species of beetles (Order : Coleoptera) were observed feeding on different parts of the plant. The family Chrysomelidae with eight species was the most common (Table 1). The mango leaf cutting weevil, *Deporaus marginatus* Pascoe was found in large numbers feeding on the pods of *S. tora*. In the present study, at least 65.39% of the total pods (N = 1033) examined were infested by the weevil. A curculionid weevil, *Myllocerus viridanus* Fabricius also caused severe damage to this plant by feeding on its leaves. One unidentified species each of Anobiidae and Tenebrionidae and two unidentified species of Coccinellidae also occasionally visited the plants and ate the leaves and pods (Table 1). Fourteen species of Orthoptera were observed feeding on this plant (Table 1) with twelve species belonging to the family Acrididae.

Nineteen species of parasitic wasps visited or were reared from the herbivores of *S. tora* leaves and pods during the present study. Pseudococcid sp.1 infested the stems, while Pseudococcidae sp. 2 infested the pods. *Coccophagus* sp. (Hymenoptera: Aphelinidae), *Apanteles opacus* (Ashmead) (Hymenoptera: Braconidae) and *Philosindia* sp. (Hymenoptera: Encyrtid) were recorded as parasitoids of the pseudococcids. Other parasitoids visiting *S. tora* are listed in Table 2. Among the nineteen species of parasitoids the majority (5 species) belonged to family Braconidae. These include one unidentified species of Encyrtidae, two unidentified species of Platygastridae and three unidentified species of Eurytomidae.

DISCUSSION

The common grass yellow which was the dominant lepidopteran visiting *S. tora* is among the most polyphagous of butterflies in its larval stages. All its host plants are leguminous and belong to the families Mimosaceae, Caesalpiniaceae and Fabaceae (Kunte, 2000).

The mango leaf cutting weevil, *Deporaus marginatus* Pascoe, which has been reported as a pest of mango (Nair, 1975), was found in large numbers feeding on the pods of *S. tora*. The observation is interesting as the study was carried out in an area where there is an abundance of mango trees.

Table 1. List of herbivorous insects collected from *Senna tora*

Insect	Family
Coleoptera	
Alticine sp.	Chrysomelidae
Aulacophora atripennis (Fabricius)	Chrysomelidae
Aulacophora foveicollis Lucas	Chrysomelidae
Cassida circumdata Herbst	Chrysomelidae
Criocerine sp.	Chrysomelidae
Cryptocephaline sp.	Chrysomelidae
Hispine sp.	Chrysomelidae
Monolepta signata Oliv.	Chrysomelidae
Myllocerus viridanus Fabricius	Curculionidae
Deporaus marginatus Pascoe	Curculionidae
Epilachna sp. 1	Coccinellidae
Coccinellide sp. 2	Coccinellidae
Anobiid sp. 1	Anobiidae
Tenebrionid sp. 1	Tenebrionidae
Hemiptera	
Idioscopus niveosparsus (Lethierry)	Cicadellidae
Pseudococcid sp.1	Pseudococcidae
Pseudococcid sp.2	Pseudococcidae
Lepidoptera	
Eurema hecabe L.	Pieridae
Spindasis vulcanus Fabricius	Lycaenidae
Ypthima ypthimoides Moore	Nymphalidae
Orthoptera	
Acrida exaltata Walker	Acrididae
Cercina sp.	Acrididae
Dnopherula sp. 1	Acrididae
Dnopherula sp. 2	Acrididae
Dnopherula sp. 3	Acrididae
Neorthacris acuticeps (Bolivar)	Acrididae
Neorthacris sp.	Acrididae
Orthacris sp.	Acrididae
Parabida sp.	Acrididae
Phyllochoreia sp.	Acrididae
Poekilocerus sp.	Acrididae
Zygophlaeoba sp.	Acrididae
Atractomorpha sp.1	Pyrgomorphidae
Atractomorpha sp.2	Pyrgomorphidae

Table 2. Parasitoids collected from *Senna tora*

Parasitic Hymenoptera	Family
Coccophagus sp.	Aphelinidae
Apanteles expulsus Turner	Braconidae
Apanteles opacus Ashmead	Braconidae
Apanteles sp.	Braconidae
Cotesia sp.	Braconidae
Orgilus sp.	Braconidae
Hockeria sp.	Chalcididae
Tropimeris monodon Boucek	Chalcididae
Sympiesis sp.	Eulophidae
Encyrtid sp.	Encyrtidae
Philosindia sp.	Encyrtidae
Eurytoma sp. 1	Eurytomidae
Eurytoma amaranthusa Narendran	Eurytomidae
Eurytoma dentata Mayr	Eurytomidae
Eurytoma sp. 2	Eurytomidae
Eurytoma sp. 3	Eurytomidae
Calotelea sp.	Scelionidae
Platygastrid sp.1	Platygastridae
Platygastrid sp. 2	Platygastridae

The factors which contribute to association of thirty four species of insect herbivores and nineteen species of hymenopteran parasitoids with *S. tora*, observed in the present study are to be investigated further. It has been observed that plants extensively communicate with organisms in the environment through volatiles and these volatiles can be induced by herbivory (Pichersky and Gershenzon, 2002). Plants synthesize and emit blends of volatile compounds from their damaged and undamaged tissues, which act as important host-location cues for parasitic insects. The volatile terpenoids and other compounds emitted from leaves in response to insect damage allow insect parasitoids and predators to distinguish between infested and non-infested plants and this helps in locating hosts or prey (Pare and Tumlinson, 1999; Tumlinson 1998). The production by phylogenetically diverse plant species and the exploitation by parasitoids of highly specific chemical signals keyed to individual herbivore species, indicates that the interaction between the plants and the natural enemies of the herbivores that attack them is more complex than previously realized (Dicke *et al*, 2003; Turlings and Wäckers, 2004). The leaves of *S. tora* contains the hexahydroxy flavones and other glycosides (Chakrabarty and Chawla, 1983) which may be acting as important host location cues for the herbivorous as well as the parasitic insects.

Oil from *S. tora* seeds was found to contain chrysophanic acid and sterulic acid (Desai and Shukla, 1978). Also 13 phenolic glycosides were isolated from the pods of *S. tora* (Sinha *et al*. 2001). In our study the larvae of the mango leaf cutting weevil, *D. marginatus* Pascoe, were found to be feeding on the pods of this plant and pupating in small, orange, oval chambers. The beetle may have acquired adaptations to overcome the effects of these secondary plant metabolites.

The study found that at least one reported pest species, *D. marginatus* and several beneficial parasitoid species, along with many insects species associated with *S. tora.* It has been observed that pollinators and natural enemies depend on plant-provided resources such as nectar, pollen, alternate prey, refuge and shelter, and nesting materials (Landis *et al*., 2000; Ricketts *et al*., 2008, Klein *et al*., 2007, Zhang *et al*., 2007b, Tscharntke *et al*., 2008, Wackers *et al*., 2008). The species richness and abundance of plant communities which offer these resources are important to population dynamics of beneficial insects, present in cropped field surrounding cultivated lands (Landis *et al*., 2000). Bowie *et al*. (1999) has noted that mass-flowering crops such as canola (*Brassica napus* L.) provide floral resources to natural enemies.

The seeds and pods of the plant may be an important alternate host for the mango pest, *D. marginatus* during the non-leaf flush season of mango trees, which would keep its population viable in nature. The parasitoids, hitherto unknown of their target hosts, may also be benefited by the diversity of the egg, larvae and pupae of herbivorous insects associated with the plant. However, it is known that *S. tora* is an important foraging plant for some butterflies and moths (Atluri *et al.,* 2004, Mathew and Mary, 2007) and is being introduced into the butterfly gardens. At least one study (Agrawal, 2002) reported a psychid moth (Lepidoptera) causing at least 20% defoliation in *S. tora*. Here we report that the mango leaf cutting weevil could also check the recruitment of *S. tora* by consuming the seeds.

Many studies have shown that patches of non-crop vegetation within agricultural landscapes do play an important role in maintaining beneficial insect communities near agricultural fields before, during, and after periods when insect-derived ecosystem services are valuable to crops (Landis *et al.,* 2000, Coll and Guershon 2002, Bianchi *et al.,* 2006, Isaacs *et al.,* 2009). The presence of nineteen species of parasitoids associated with *S.tora* points to the importance of this plant in maintaining beneficial insect communities in the ecosystem.

It is proposed that *Senna tora* may be used in habitat management as the goal of habitat management is to create a suitable ecological infrastructure within the agricultural landscape to provide resources such as food for adult natural enemies, Habitat management can be considered a subset of conservation biological control methods that alters habitats to improve availability of the resources required by natural enemies for optimal performance and providing a habitat in which alternative hosts or prey are present (Landis *et al.,* 2000).

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