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STUDIES ON SOME NATURAL ENEMIES OF PUNCTUREVINE *TRIBULUS TERRESTRIS* OCCURRING IN KARNATAKA STATE, INDIA

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ABSTRACT

During a survey for natural enemies of *Tribulus terrestris* L. in Bangalore and nearby areas in South India a leaf-feeding mite, *Eriophyes tribuli* Keifer, was the most abundant species, followed by a gelechiid leaf-miner, *Ephysteris subdiminutella* Stn., and a lycaenid defoliator, *Zizeeria maha* Kollar. Larvae of two weevils. *Microlarinus angustulus* Mshl. and *M. rhinocylloides* Hch., fed and developed in fruits. A pyralid, *Tegostoma comparalis* Hb., attacking leaf-buds, leaves and tender fruits was very localized in occurrence. All these except the polyphagous *Z. maha* warrant further study and host-specificity testing for evaluation as biocontrol agents.

INTRODUCTION

The puncturevine *Tribulus terrestris* L. (Zygophyllaceae; Caltrop family) is a cosmopolitan, prostrate to decumbent, terrestrial annual weed which is native to north Africa and the Mediterranean region. It grows along roadsides, tank (dam) and river bunds, on pastures and crop fields, playgrounds and other recreation sites and also on forest land. Its spiny fruits are injurious to man and livestock, puncturing their skin and sometimes even the stomach linings of animals that ingest them. The closely related perennial species *T. cistoides* L., a native of tropical America, is less widely distributed. Besides the direct injury inflicted, both species are known to cause photosensitization and nitrate poisoning in livestock. *T. terrestris* can extract soil moisture from great depths and compete severely with crops under very dry conditions (Holm *et al.* 1977).

Mechanical control of *Tribulus* is impractical because the plants have strong taproots and the seeds germinate erratically throughout the year. Since the weed is found mostly in places where the land is of low value, chemical control is uneconomical and only of temporary benefit. The seeds are dispersed by animals, water, vehicles, etc. Biological control offers a promising alternative measure which has already been used successfully in Hawaii, continental U.S.A. and the West Indies. However, so far only two species of weevils, the fruit-infesting *Microlarinus lareynii* Jacquelin du Val and the stem- and crown-mining *M. lypriformis* Wollaston, have been used. They were discovered in India in 1957 and 1958 and later also found in Europe where they were studied in detail and their host-specificity was tested before material from Sicily was shipped to the U.S.A. in 1961 for field release and evaluation. They have exercised an appreciable degree of control of puncturevine over much of the south-western U.S.A. (Andres 1978). *M. lypriformis* has spread naturally from the U.S.A. to Jamaica and Mexico (Bennett 1979). Introduction of these two species into Hawaii in 1962 resulted in rapid and dramatic control of *T. terrestris* and *T. cistoides* (Maddox 1976). Although both weevils were introduced into St. Kitts, West Indies, only *M. lypriformis* became established but it gave highly successful control of *T. cistoides*. It was also successfully introduced into the island of Nevis, West Indies (Bennett 1971).

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In 1975 Dr Lloyd A. Andres, Biological Control of Weeds Laboratory, United States Department of Agriculture, Albany, California, and one of us (T.S.) found some puncturevines heavily infested by mites on a roadside area near Bangalore. As a result the U.S.D.A. supported a one-year survey for natural enemies of *T. terrestris* in Bangalore and nearby areas in Karnataka State, with a view to finding additional candidates for use in areas where *M. lareynii* and *M. lypriformis* do not provide adequate control. The results of this survey are presented here.

METHODS AND MATERIALS

Entire *T. terrestris* plants were collected, in plastic bags, for observations on insects and mites associated with them. They were also thoroughly examined for disease symptoms. Also, monthly samples, each of five plants, were taken at random at three localities for estimation of the relative abundance of the more important organisms. This was done mainly to facilitate future collection work.

Potted plants obtained from the field as seedlings were used in the laboratory for breeding and studying some of the insects.

RESULTS

The following species of insects and mites were recorded. Biological notes are given for those that could be bred in the laboratory.

Ephysteris subdiminutella Stn. (Lepidoptera:Gelechiidae)

Povolny (1966) placed this species in a new sub-genus, *Ochrodia*, and listed its synonyms as *Phthorimaea ochrodeta* Meyr., *Ph. crocoleuca* Meyr., *Ph. extorris* Meyr., and *Gelechia jamaicensis* Wlsng. Another member of this genus, *E. chersaea* Meyr., is injurious to sugarcane (Jarvis 1924). *E. subdiminutella* is a leaf-feeder with considerable damage potential and is common in most localities. It is multivoltine and active throughout the year.

Biology

Mating usually takes place within 24 hours of emergence. After a pre-oviposition period of one to two days eggs are laid singly in the axils of buds and on stems, branches, midribs and veins of leaflets, preferentially on the lower side of leaflets, and also occasionally on the basal parts of flowers and tender fruits. The maximum recorded number of eggs per leaflet was 13. Females laid 56 to 214 eggs (average 128 for nine females). Eggs hatched in three to six days. The four larval stages and the pupal period lasted three, two, three, six and eight days, respectively.

The newly hatched larvae mine the leaflets, and feed on the mesophyll, leaving semi-transparent films of epidermis, which become brittle. The larvae continue to feed in mines during the first two stages and occasionally also in the third, then leave the mines and feed externally on the foliage. The late third and fourth stage larvae feed on the leaf buds. The larvae keep moving to fresh foliage, making galleries. The full-grown larva, which is creamy yellow, pupates in a cottony cocoon in the terminal leaf-folds. A potted plant exposed to ovipositing *E. subdiminutella* for 24 hours was killed in 12 days before the larvae completed the third stage.

The moths are quick fliers. Females lived for 7 to 13 days and males for 7 to 30 days.

This gelechiid was attacked by a larval parasite, *Apanteles* sp. (Hymenoptera: Braconidae), in late February and in August, the maximum parasitism reaching about 40 per cent.

Dichomeris **sp. (Lepidoptera:Gelechiidae)**

This defoliator was reared only once from material collected at Doddakurugodu. Several species of *Dichomeris* are known to attack crops of economic importance.

Zizeeria maha **Kollar (Lepidoptera:Lycaenidae)**

The host-range of this polyphagous multivoltine species includes *Oxalis corniculata* L. (Oxalidaceae), *Tephrosia pauciflora* Grah. (Papilionaceae), *Nelsonia* sp. and *Strobilanthes* sp. (Acanthaceae) (Wynter-Blyth 1957). It was frequently found on *T. terrestris*, being more common from November to January.

Biology

The eggs, which are laid singly, are bluish-grey, somewhat spherical and firmly attached to leaflets. Observations were started using eggs collected in the field in late January. The eggs hatched in about five days. The greenish larvae feed on leaves and tender fruits. The pupa is naked, usually either fixed to a branch or found in the soil beneath the plant. The five larval stages, prepupal and pupal periods lasted five, three, five, six three, one and eight to nine days, respectively.

Larvae were occasionally parasitized by *Apanteles* sp. and by *Aplomya laeviventris* Wulp. (Diptera:Tachinidae). *Brachymeria margaroniae* Joseph *et al.* (Hymenoptera:Chalcididae) attacked the pupae.

The adults are very active on sunny days, mostly flying very low and resting often on grass blades and *Tribulus* plants. The newly hatched larvae gnaw the upper epidermal layer, making circular blotches. The larvae and pupae are usually found in the soil beneath the plant. An entire plant was defoliated when five or six full-grown larvae were allowed to feed on it until they pupated.

Tegostoma comparalis **Hb. (Lepidoptera:Pyralidae)**

This defoliator is reported from the Mediterranean sub-region, North-west Himalayas, and South India (Poona and Coimbatore) (Hampson 1896) and Rungs (1952) has recorded it from Morocco. It was active from April to September, becoming abundant in July-August at Anaganahalli and around Mysore.

Biology

Mating occurs within 24 hours of emergence, when pairs are confined in clear plastic cages. Eggs were deposited mostly on the walls of the cages although excised shoots of *T. terrestris* were provided for oviposition. Fertile eggs were obtained on the third day after mating. Each female laid 119 to 132 eggs.

The pearly white eggs collected from cages were held in small plastic containers for hatching. They turned yellowish with the development of the embryo and hatched in six to seven days. Newly hatched larvae mine the leaves but after the first moult, the larva feeds externally on the leaves, often hiding in galleries or leaf-webs. The five larval stages occupied four, three to four, two to four, two to five and five days, respectively. After the final moult the full-grown larvae normally form mud cells in the ground in which they pupate. The pre-pupal

period lasted three to four days inside the mud cells. The adults emerged after seven to ten days. Heavy infestation leads to defoliation, eventually weakening the plant.

The pupae were attacked by an unidentified ichneumonid.

Agrotis spinifera **Hb. (Lepidoptera:Noctuidae)**

A. spinifera is polyphagous, feeding on tobacco in Africa (Zacher 1917), maize and onion in Uganda (Hargreaves 1921) and gram in India (Fletcher 1920). It was noticed feeding on *T. terrestris* in Bangalore, Doddakurugodu, Hoskote and Kodigehalli from January to April. The larvae fed on the foliage causing significant damage from January to February although they were present only in small numbers. They are nocturnal, hiding in the soil beneath the host plant during the day. The pupa is robust and naked. In February the pupal period of field-collected larvae ranged from 15 to 16 days.

Trichoptilius congrualis **Walk. (Lepidoptera:Pterophoridae)**

This leaf feeder was reared only once from material collected at Doddakurugodu.

Microlarinus angustulus **Mshl. and** *Microlarinus rhinocylloides* **Hch. (Coleoptera: Curculionidae)**

These weevils were collected on *T. terrestris* in Anaganahalli, Charanahalli, Doddakurugodu, Hoskote, Jayapura, Mysore, Shivaganga, Udbur, Viswes-warapura and Vazamangala, practically throughout the year. The adults feed on stems and fruits while the larvae feed in fruits. The oval, orange-red eggs are embedded in feeding bloches at the bases of fruits and covered with greyish yellow faecal cement. The faecal cement of *M. lareynii* is reported to be greyish black and that of *M. lypriformis* black (Andres and Angalet 1963). The newly hatched larvae burrow into the fruits where they feed and pupate. Two or three segments of the fruit are destroyed by a single larva.

The larvae were parasitized by a *Bracon* sp. (Hymenoptera:Braconidae).

Baris **sp. (Coleoptera:Curculionidae)**

This was occasionally noticed feeding in stems and roots of *T. terrestris* in the Doddakurugodu area. Several species of *Baris* are known to attack vegetables and fruits.

Frankliniella schultzei **(Trybom) (Thysanoptera:Thripidae)**

This is a polyphagous species that attacks several economically important plants. It fed on flowers and leaf buds and occasionally on leaves of *T. terrestris* at all localities, becoming abundant in October.

Ferrisia virgata **group (Hemiptera:Pseudococcidae)**

Nymphs and adults of a species of mealybug belonging to the *Ferrisia virgata* group were found attacking the leaves, stems and fruits in several localities. Dr D.J. Williams, Commonwealth Institute of Entomology, London, who examined our specimens, has commented that on the basis of protein analysis at least five species are involved in this group, which cannot as yet be separated satisfactorily from slide preparations.

At Thindlu, a sample of five plants yielded 156 mealy bugs in March, 1976.

Eriophyes tribuli **Keifer (Acari:Eriophyidae)**

This mite was widespread, being present throughout the year at all localities

surveyed. Infestation remained high from mid-January to mid-May. Feeding was mostly on leaf and flower buds, but occasionally on stems and leaves. Constant feeding caused a browning of the plants, which were already small and stunted when the mites became abundant.

To gain a preliminary assessment of the effect of this mite on *T. terrestris* 300 adults were released on a caged, healthy, potted plant free from other insects and mites. The lateral shoots dried up after a month and eventually the entire plant. The experiment was repeated by releasing 200 adults on another plant. This also dried up, but there was no heavy build-up of the mite population.

Tenuipalpus **sp. (Acari:Tenuipalpidae)**

All stages of this mite were seen feeding on leaves and stems. This species has been identified as a new one near *Tenuipalpus eremitus* Chaudhri, a polyphagous mite described from Pakistan (Dr Swaraj Ghai, pers. comm.).

Abundance of insects on *T. terrestris*

The relative abundance of the eriophyid mite and four important insect enemies of the weed was estimated at three different habitats, viz., roadside at Hoskote, tank bund at Doddakurugodu and waste land at Thindlu (Table 1). At all three *E. tribuli* was the most abundant. The next was *E. subdiminutella*, which inflicted significant damage at two of them. *Z. maha* ranked third. The activity of *E. subdiminutella* was highest at the roadside habitat while at Thindlu it was lowest. At Doddakurugodu, where the tank bund is parallel to the road but at a higher elevation, both *E. subdiminutella* and *Z. maha* occurred in more or less equal numbers but showed slight seasonal differences. At Thindlu *E. tribuli* remained the most abundant whereas *Z. maha* and particularly *E. subdiminutella* were scarce. The *Microlarinus* spp. were present at all localities but in much smaller numbers. *Tegostoma comparalis* was not seen in these localities.

Several other insects taken on *T. terrestris* during the present survey were either polyphagous or found in insignificant numbers with unknown status.

DISCUSSION

Of the natural enemies recorded in the areas surveyed *E. tribuli, E. subdiminutella, Z. maha, T. comparalis* and *Microlarinus* spp. appear to be important. *E. subdiminutella* appears to be the most promising biocontrol agent as it attacks the growing tips and foliage and thereby arrests growth and fruit-set. However, since at least one species of this genus feeds on a cultivated plant (*E. chersaea* Meyr. on sugarcane in Queensland [Jarvis 1924]) a detailed investigation of the host-specificity of *E. subdiminutella* is especially necessary before it can be recommended. *Z. maha* is polyphagous and so not suitable. *T. comparalis*, although local in Karnataka, causes sufficient damage wherever it is found, and it warrants further study. *M. angustulus* and *M. rhinocylloides* belong to a genus restricted to Zygophyllaceae, and merit detailed investigation in India and field evaluation to assess their potential in comparison with *M. lareynii* and *M. lypriformis*. However, interference by native parasites and predators may reduce their value in other areas as has happened with the two species already widely used (Goeden and Louda 1976).

Considering that puncturevine is not native to India the presence of *M. lareynii* and *M. lypriformis* in southern Europe, of *E. tribuli* in Sudan and that of all the three in India show that some of the natural enemies may have spread naturally with the weed from its centre of origin. Further distribution records of

Table 1. Abundance of immature and adult insects and mites on five plants of *Tribulus terrestris* at three locations.

Date	*Eriophyes tribuli*	*Zizeeria maha*	*Ephysteris subdiminutella*	*Microlarinus* spp.
		HOSKOTE		
1975				
24.xii	603	39	44	15
1976				
25.ii	853	8	242	26
28.iv	2805	5	10	0
27.v	4137	0	39	0
26.vi	1419	6	56	0
28.vii	1177	6	104	2
27.viii	462	1	22	11
24.ix	1363	6	52	86
		DODDAKURUGODU		
1975				
11.xi	536	36	0	97
11.xii	162	115	14	20
1976				
13.ii	958	140	26	20
18.ii	4714	59	55	14
12.iii	1737	21	145	6
21.iv	4077	0	12	0
12.v	1979	0	10	0
11.vi	756	7	56	3
14.vii	629	19	86	1
14.ix	383	37	78	20
		THINDLU		
1975				
13.x	0	4	0	45
11.xi	353	70	0	4
1976				
12.i	1475	29	0	0
11.iii	28438	10	0	0
11.iv	12218	2	0	0
11.v	10726	3	4	0
10.vi	697	14	0	2
13.vii	1266	23	1	0
12.viii	4223	28	2	0
10.ix	908	8	0	29
11.x	30	8	46	60

such species will be useful for selecting populations with desired ecological preferences and their introduction in other areas to increase the chances of establishment.

Cromroy (1978) has discussed the value of eriophyid mites as biological weed control agents. Like most other species of this group *E. tribuli* is likely to prove to be highly host-specific. It was described by Keifer (1974) from *T. terrestris* collected at Shambat near Khartoum, Sudan. The indications from our studies are that the mite when present in large numbers subjects *Tribulus* to appreciable physiological stress. In combined action with other natural enemies it has the potential to reduce the vigour, stunt vegetative growth and lower the reproductive potential of the weed. For these reasons it is recommended for further study as another promising candidate biocontrol agent detected during the survey.

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