BIOLOGICAL CONTROL OF WEEDS IN INDIA
A REVIEW OF INTRODUCTIONS AND CURRENT INVESTIGATIONS OF NATURAL ENEMIES[1]

T. Sankaran

Commonwealth Institute of Biological Control
Indian Station, Bangalore-6, India

Introduction

The first outstanding success in biological control of weeds in India dates back to the mid-19th century when *Dactylopius ceylonicus* Green (= *D. indicus* Green), introduced from Brazil in 1795 for commercial production of cochineal dye, had run wild and spread on *Opuntia vulgaris* Miller (= *O. monacantha* Haworth) in central and north India and completely destroyed this cactus over large areas. This was, of course, not a deliberate introduction of a natural enemy for weed control but the results were entirely beneficial and clearly demonstrated the potentialities and economic gains of biological weed control. Actually, *D. ceylonicus* had been mistaken for the true cochineal insect, *D. coccus* Costa, and imported but was later found to be a distinct species and described under a very inappropriate specific name! Being restricted to *O. vulgaris* it proved a failure when artificially distributed in south India to control *Opuntia dillenii* (Ker-Gawler) Haworth. Therefore, *D. opuntiae* Lichtenstein (= *D. tomentosus* (Lamarck)), a North American species, was deliberately introduced from Ceylon in 1926 and this also gave spectacular control of *O. dillenii* and of the related *Opuntia elatior* Miller. An estimated 100,000 acres were cleared of *O. dillenii* (Narayanan, 1954). Areas which were wholly impenetrable on account of cactus bushes became fit for cultivation within five or six years (Pruthi, 1969).

In 1921 the seed-fly *Ophiomyia lantanae* (Frogg.) was obtained from Hawaii (origin Mexico) and liberated in south India to control *Lantana camara* L., a Central and South American weed first introduced into India in 1809. It became established but failed to control the weed. Twenty years later the Tingid bug *Teleonemia scrupulosa* Stal, native to the New World, was imported from Australia for trial against lantana on an experimental scale but not released since it was feared that the bug might attack teak and certain other economic plants on which it lived for several weeks under laboratory conditions (Roonwal, 1952). However, the bug 'escaped' and has now spread to a distance of some 300 km from the laboratory at Dehra Dun in Uttar Pradesh. There is a recent report that in some places lantana has been killed outright by the bug but that in others the infested plants appeared to have become weak. It is, however, noteworthy that the bug has not been recorded as a pest of teak or of any other plants, including some which were attacked in the laboratory (Joshi, 1969).

The grass carp *Ctenopharyngodon idella* Val, a native of Siberia, Manchuria and China, was introduced from Japan in 1959 to control submerged aquatic weeds in fish ponds and it has since been distributed to different parts of the country (Jhingran, 1968).

Apart from these sporadic attempts in the past biological control of weeds has received scant attention in India in spite of the fact that there

---

[1]Presented at the 2nd International Symposium on Biological Control of Weeds, Rome, Italy, Oct. 4-7, 1971, and supported by a research grant under U.S. PL-480.

occur here several well-known alien weeds, both terrestrial and aquatic, which have been studied in their native areas from the biocontrol point of view and for which promising and host-specific natural enemies are known and worth introducing. There are certain weed situations eg., forest areas, tea, rubber and other commercial plantations, hydro-electric reservoirs, large lakes and public waterways where no economical mechanical or herbicidal control methods are feasible and biological control should be seriously considered and attempted on an adequate scale.

At the C.I.B.C. Indian Station investigations on insects attacking several species of native and alien weeds have been in progress over the past seven years to study and evaluate the indigenous natural enemies with a view to their possible use in biological control in other areas, and to explore the possibilities of introducing host-specific exotic natural enemies to control the alien weeds. Further introductions of natural enemies to control some weeds have started and others are still under consideration. These are briefly considered here under the individual weed species.

Crofton weed, *Eupatorium adenophorum* Sprengel (Compositae) - This weed, a native of Mexico, is widespread in the hilly areas of south and north India, forming dense thickets up to some 10 ft. high on valuable grazing land and encroaching upon teak, rubber, tea and other commercial plantations. The Mexican Trypetid gall-fly *Procecidochares utilis* Stone, which has successfully controlled the weed in Hawaii, parts of Australia and in New Zealand, was imported from New Zealand in 1963 and in the following years released in the Nilgiris, Darjeeling and Kalimpong areas. The fly became quickly established and is gradually extending its distribution in these areas. Although in many places all the plants examined are attacked and individual plants are heavily galled the overall control is by no means impressive. In Hawaii *P. utilis* is reported to be successful only in relatively lower rainfall areas (less than 50 inches annually). It is desirable to spread the gall-fly to other areas in India where *E. adenophorum* is a problem in low rainfall areas. As in Hawaii and Australia the gall-fly is attacked by native parasites in India, two of which have been identified as *Dimeromicrus kiesenwetteri* (Mayr.) (Torymidae) and *Syntomopus* sp. (Pteromalidae). Larvae of *Heliothis armigera* (Hb.) (Noctuidae) have been seen feeding on galls, which may contain *Procecidochares* larvae and pupae. All these reduce the efficiency of the gall-fly.

Siam weed, *Eupatorium odoratum* L. (Compositae) - This neotropical plant is a serious weed in orchards and commercial plantations in south and north-east India. *Ammalo insulata* (Walker) obtained from the West Indies through the C.I.B.C. Station there has been successfully bred in quarantine in the laboratory at Bangalore and tested on a number of economic plants in addition to those screened at Trinidad. These tests have shown that this Arctiid is specific to *E. odoratum*. Therefore, field releases are warranted.

Lantana, *Lantana camara* L. (Verbenaceae) - Additional insect enemies of lantana are now being introduced. Recently *Diastema tigris* Guenee (Noctuidae), *Syngamia haemorrhoidalis* Guenee (Pyralidae) and *Uroplata girardi* Pic. (Hispidae) were imported and further importations of these and other lantana insects are contemplated. *T. scrupulosa* has been collected in Uttar Pradesh and released in Andhra Pradesh but it is too early to say whether permanent establishment has occurred.

Witchweeds, *Striga* spp. (Scrophulariaceae) - Witchweeds are native to the tropical and subtropical areas of the Old World but one species has spread to the U.S.A. where it parasitises corn. *Striga densiflora* (Benth.), *S.*

euphrasioides (Don) Saldanha and *S. lutea* Lour. are common root-parasites of graminaceous crops in India. Insects attacking these species have been studied. A gall-forming weevil, *Smicronyx albovariegatus* Fst., attacks the three *Striga* spp. but most of the galls are produced on the root, stem and branches and do not impair the vigour or reproductive potential of the host plant. Fruit-galls are scarce. Larvae of the Noctuid *Eulocastra argentisparsa* Hmps. feed on the ripening seeds in the fruit-pods but their population in the field is always low. *Compsilura concinnata* Meig. (Tachinidae), a *Temelucha* sp. (Ichneumonidae) and microsporidia attack the larvae of *E. argentisparsa*. The Commonwealth Institute of Entomology, London, has critically re-examined the *Eulocastra* specimens reared on *Striga* and reported that the green and brown forms are not conspecific as identified earlier (Sankaran *et al*, 1969) but belong to two distinct species, *E. argentisparsa* and *E. undulata* Snellen, respectively. Larvae of the former feed on the seeds while those of the latter feed on leaves. An *Apanteles* sp. has been reared from *E. undulata* larvae. Larvae of both species failed to feed on *Antirrhinum majus* L., *Limnophila heterophylla* Benth. and *Bacopa monnieri* (L.) Pennel while those of *E. undulata* have also been tested on *Linaria* sp. and *Veronica* sp. (all Scrophulariaceae) with the same results. To-date no alternative food plants are known and no species of *Eulocastra* has been recorded in the entomological literature as a pest of any economic plant. Laboratory breeding of *Eulocastra* using uprooted *Striga* plants is easy but the seasonal incidence of witchweeds is a major limitation in this work. Efforts are being made to develop an artificial diet for the larvae. Milner (1967) has investigated the natural enemies of *Striga* spp. in East Africa and suggested the introduction of the Agromyzid stem- and root-miner *Ophiomya strigalis* Spencer into India.

Nut-sedge, *Cyperus rotundus* L. (Cyperaceae) - This cosmopolitan weed has a large number of insect enemies in India. However, most of these are polyphagous. A rhizome- and stem-boring weevil, *Athesapeuta cyperi* Mshl., and two Tortricid stem-borers, *Bactra* (*Nannobactra*) *minima minima* Meyr. and *Bactra* (*Chiloides*) *venosana* (Zeller) are common species which are promising as biocontrol agents. The biology and destructive potential of *B. minima minima* have been studied. Infested *Cyperus* plants are killed but where the rhizomes are only partially destroyed they are capable of giving rise to fresh growth. However, both *Athesapeuta* and *Bactra* appear to keep the weed under some biotic pressure in India and are suitable for introduction into other areas where they may prove to be more effective. They are not known to be harmful to any cultivated plant.

Water hyacinth, *Eichhornia crassipes* (Mart.) Solms (Pontederiaceae) and Water ferns, *Salvinia* spp. (Salviniaceae) - These are economically the most important aquatic weeds in India. A recent survey has shown that *Salvinia natans* (L.) Allioni occurs very extensively in the Kashmir Valley, covering roadside irrigation canals and spreading on the famous Dal Lake in Srinagar and this may, if left uncontrolled, become as serious a problem as in Kerala where a species which was previously thought to be *S. auriculata* Aubl. but which Cook and Gut (1970) have recently shown to be a sterile hybrid with, perhaps, *S. auriculata* as one of the parent species, has proved to be a serious threat to rice cultivation, inland water transportation, hydro-electric installations and irrigation systems. This was first noticed in Kerala in about 1964 but has since spread over thousands of acres. *Salvinia cucullata* Roxb. and *S. natans* are the predominant species in north-east India. An extensive search has revealed that none of these *Salvinia* spp. has any important indigenous natural enemy. Therefore, the Kerala State Electricity Board has sought the help of C.I.B.C. in introducing *Salvinia* insects from the South American region where *S. auriculata* is native and its natural enemies have been investigated by Bennett (1968).

Several species of insects have been recorded on *E. crassipes* in India. The commonest of them is a semi-aquatic grasshopper, *Gesonula punctifrons* Stal, which also breeds on *Arum*, *Colocasia* and *Monochoria*. None of these indigenous insect species, which have transferred to water hyacinth since the weed was introduced into this country over fifty years ago, is capable of controlling the infestations. Attempts are now in progress to build up in quarantine at Bangalore cultures of *Arzama densa* (Wlk.) (Noctuidae), *Acigona ignitalis* Hmps. (Pyralidae), *Epipagis albiguttalis* Hmps. (Pyralidae), *Neochetina eichhorniae* Warner (Curculionidae), and *Orthogalumna terebrantis* Wallwork (Galumnidae), all of neotropical origin, for additional screening tests in the laboratory and for field evaluation. A bacterial disease which hampered the laboratory cultures of the first three species is now being eliminated by breeding the newly hatched larvae on *Eichhornia* plants which are kept in water treated with streptomycin sulphate. Attempts are also being made to eliminate spirochetes and a bacillus infecting the larvae of *Neochetina*.

Willow primrose, *Ludwigia adscendens* (L.) Hara (= *Jussiaea repens* L.) (Onagraceae) - This common weed in rice fields and shallow slow-moving irrigation canals etc. is severely defoliated by *Haltica caerulea* Olivier in many areas. Of the wide range of economic plants tested with this Halticid some ornamental species in the Onagraceae (*Fuchsia* spp. and *Clarkia elegans* Dougl.) were found to be suitable for oviposition and larval feeding. Therefore, attention is now being given to *Nanophyes* sp. nr. *nigritulus* Boh. (Curculionidae) which breeds in the developing fruits and arrests seed-formation, and to *Mompha* sp. nr. *shrankella* Hb. (Momphidae) the larvae of which mine the leaves and later bore into the shoots and cause wilting. These two species have failed to breed on the above ornamental plants and appear to be suitable for trial against the same or related *Ludwigia* spp. in other areas.

Other aquatic weeds - Larvae of *Nymphula crisonalis* Wlk., *N. diminutalis* Wlk. and *N. responsalis* Wlk. feed on *Potamogeton nodosus* Poir. The first two Pyralid species also attack *Nymphoides indicum* (L.) O Kuntze (Menyanthaceae). Larvae of all the three species have been tested on rice seedlings, but did not feed. A *Bagous* sp. (Curculionidae) attacks *N. indicum* and another congeneric species has been recorded feeding on *Nymphaea nouchali* Brum. f. and *N. stellata* Willd. (Nymphaeaceae). Larvae of a Noctuid, *Namangana pectinicornis* Hmps., cause extensive damage to *Pistia stratiotes* L. in several areas in India. This species is worth studying further and evaluating for introduction elsewhere. The South American Alligator-weed, *Alternanthera philoxeroides* (Mart.) Griseb. which was previously known only in north-east India has now spread to the south. Indigenous insect enemies, *Psara basalis* Wlk. and *P. stultalis* Wlk. (Pyralidae) and a *Cassida* sp. (Cassididae), defoliate this weed and the related *A. sessilis* (L.) DC but are of little control value. Biological control of the Alligator-weed by introducing *Agasicles* sp. and other host-specific insect enemies from South America is worth considering before the weed spreads to other areas and becomes a menace like *Eichhornia* and *Salvinia*.

Discussion

There are several alien weeds in India for which the possibilities of biological control appear very good. However, for want of adequate financial support, which is only too readily made available for the extension of the use of pesticides in spite of the limitations and hazards involved, the biological method of controlling weeds, as also of insect and other pests, is either neglected or at best considered only as a last resort. A concerted and well-planned programme of introduction of natural enemies of *Lantana*

camara, *Eupatorium odoratum*, *Orobanche* sp., *Eichhornia crassipes*, *Salvinia* spp. and *Alternanthera philoxeroides* could be started immediately since these have been investigated in other countries, with exploratory surveys and initial research already completed.

With other alien weeds like *Mikania* spp. and *Parthenium hysterophorus* L. a survey for host-specific natural enemies should be made in their native habitats. Insects attacking *Striga*, *Cyperus*, *Pistia*, *Ludwigia* etc. which have been studied in India may be of value in the control of these weeds in other areas where the insects do not occur. In recent years our knowledge of the factors governing host-specificity of insects suitable for weed control has greatly advanced, and as pointed out by Zwölfer and Harris (1971) the risks of an introduced weed insect transferring to a new host and becoming a pest have been discussed and discounted by several authorities. This knowledge and the experience gained in other countries would be helpful to the agricultural departments and research institutions and universities in India in fully exploiting the possibilities of biological control.

References

Bennett, F.D. 1968. Investigations on insects as controlling agents for *Salvinia auriculata* Aubl. and *Eichhornia crassipes* (Mart.) Solms., two aquatic weeds of neotropical origin. C.I.B.C. West Indian Station, Trinidad, 9 pp.

Cook, C.D.K. and Gut, B. 1970. Report on the *Salvinia* (African Pyle) problem in Kerala. Botanischer Garten der Universität Zürich, 5 pp.

Jhingran, V.G. 1968. Progress of inland fisheries research in India. Everyman's Science 3 (1): 38-47.

Joshi, D.P. 1969. Eradication of *Lantana camara* by *Lantana* bug. Indian Forester 95 (2): 152-154.

Milner, J.E.D. 1967. Report on a survey of the natural enemies of *Striga* spp. (Scrophulariaceae) in East Africa. C.I.B.C., East African Station, Kampala, 57 pp.

Narayanan, E.S. 1954. (Discussion on biological control of weeds). Rep. Sixth Commonw. ent. Conf., London, p. 100.

Pruthi, H.S. 1969. Textbook of Agricultural Entomology. Indian Council of Agricultural Research, New Delhi, 977 pp.

Roonwal, M.L. 1952. The natural establishment and dispersal of an imported insect in India - The Lantana bug, *Teleonemia scrupulosa* Stal (= *lantanae* Distant; Hemiptera, Tingidae), with a description of its egg, nymphs and adult. J. zool. Soc. India 4 (1): 1-16.

Sankaran, T., Rajendran, M.K. and Ranganath Bhat, Y. 1969. The biology of *Eulocastra argentisparsa* Hampson (Lep.: Noctuidae) with special reference to the occurrence of dimorphism. Tech. Bull. Commonw. Inst. biol. Control 11: 31-43.

Zwölfer, H. and Harris, P. 1971. Host specificity determination of insects for biological control of weeds. Ann. Rev. Ent. 16: 159-178.

DISCUSSION

LITTLE I would like to ask Dr. Sankaran if he has ever given thought to this question. I've traveled extensively and seen water hyacinth almost everywhere. It has been extraordinarly widely distributed thanks to deliberate human distribution. It has also been subjected to a wide range of fauna which could potentially attack it in a large number of countries, and yet in my experience I've never ever seen any stand of water hyacinth substantially attacked by anything. You see the occasional leaf nibbled but I have never seer really substantial attack. Does that mean that water hyacinth like other successful weeds has some inbuilt resistance to insect attack in the form of some sort of repellency, or some sort of unpalatableness to insects? Is this something that might be worth looking at as a possible value that could be squeezed from hyacinth. It is a remarkable feature of some of these very successful weeds that they do not seem to be attacked by insects or fungi. Have you ever thought of looking into this to see if you can extract some sort of essence that is responsible for this lack of natural enemies?

SANKARAN We know the water hyacinth situation in India, and there are several insects attacking it, but they are not able to control it. The grasshopper is the most common insect that I've seen and in some areas large patches of water hyacinth are attacked by this grasshopper but it is not able to control the hyacinth.

According to reports I've seen in South America some insects do exercise a significant amount of control. Whether the same control can be reproduced in other areas by introducing these native insects from the New World is actually for the future to demonstrate, after there have been sufficient field releases of these insects on adequate scale.

BENNETT Certainly, in South America there is quite a rich fauna associated with Eichornia crassipes but it is not clear if insects are the main factors for the scarcity of water hyacinth in natural situations. Certainly, where man-made lakes have been developed in South and Central America water hyacinth has become a major problem. In some of these the insect fauna has not been investigated in detail but on Brokopondo Lake certain of the components were absent when Dr. Zwölfer and I visited it. Whether or not at some stage they will arrive on their own account or will have to be introduced deliberately remains to be seen. The point brought out yesterday was that lack of competition from high plants and of other plants in the area means that control of water hyacinth, which has great powers of recovery by producing new plants as the older ones are destroyed, can only be accomplished by agents that really put a lot of continuous pressure on the plant. Certain insects, in South America do have natural enemies and therefore may be more effective in areas other than where they are indigenous.

LITTLE Dr. Bennett, do you think this apparent resistance to insect attack is a real thing or not?

BENNETT This has been brought out in a number of discussions yesterday and will be referred to later in papers. Certainly it does occur but I will not comment further at this time.

HARRIS I think aquatic plants may present a problem for insects as they are so watery that an insect would have to eat a lot to get enough to thrive on. I understand if you feed a cow on water hyacinth, it starves to death. It would be interesting to know how insects overcome this problem.

CERLING I would like to ask: Is nutsedge, Cyperus rotundus, native to India?

SANKARAN I don't think so, probably it is a cosmopolitan species. I really do not know where it comes from.

GERLING How bad a pest is it in India?

SANKARAN It is as bad as in other areas.

GERLING You mentioned these insects, that is why I asked.

SANKARAN We have seen that in areas where Bactra infestations occur, the nutgrass plants do not grow to any great height. They are normally a few inches to less than a foot high. But, on the other hand, where these insects do not occur the nutgrass plants grow luxuriantly.

ANDRES What other species of Cyperus do you have in India?

SANKARAN We have quite a large number of Cyperaceae in India and not all of them are economically important, or maybe they have not been studied in detail like Cyperus rotundus. Recently we had to check up the Cyperaceae in South India in connection with a problem in the Pacific where Cyperus aromaticus is a serious weed. We were asked to look for Cyperus aromaticus in South India in order to study its insect enemies. C. aromaticus has been listed in the Flora of India, but to date, we have not been able to locate it anywhere. There is a publication on the Cyperaceae of Mysore State where our laboratory is located.

ANDRES Do you know if Bactra attacks these other species, and were you able to find it?

SANKARAN No, we have not found Bactra in any other Cyperus spp. but we have not made a survey for many other Cyperaceae. I think that is a point we should follow-up in our future investigations.

BALOCH We have the same species of Bactra in Pakistan. We found them in Cyperus bulbosus and Cyperus eleusinoides. They feed in them under natural conditions.

END OF DISCUSSION

* * *