

PARASITIC WEED PLANTS AND THEIR NATURAL ENEMIES WITH SPECIAL
REFERENCE TO PAKISTAN—A REVIEW

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Introduction. The important parasitic weeds in Pakistan include *Cuscuta* spp. (Convolvulaceae); *Loranthus* spp. (Loranthaceae); *Arceuthobium* spp. and *Viscum* spp. (Viscaceae); *Striga* spp. (Scrophulariaceae); and *Orobancha* spp. (Orobanchaceae). They affect a wide variety of plants, some economically important. *Loranthus* spp. infest about 274 hosts which include citrus, limes, tea, rubber, fruit, forage, park and many other broad-leaved trees (Mushtaque and Baloch, 1979). The dwarf mistletoes, *Arceuthobium* spp., attack coniferous forest trees (e.g., pines, fir, spruce, junipers, larch) while *Viscum* spp. infest deciduous trees in parks, boulevard plantings, natural forests and orchards (e.g., olives, apples, almonds, cherries) (Gill and Hawksworth, 1961). Witchweeds, *Striga* spp., mostly damage graminaceous plants (e.g., sorghum, corn, sugarcane, pearl millet) (Greathead and Milner, 1971) while broomrapes, *Orobancha* spp., attack crucifers, eucurbits, potato, egg-plant, tomato, sunflower, carrot, celery, lettuce and legumes (Kasaian, 1971). The dodders, *Cuscuta* spp., parasitise a large number of plants including trees, herbs, shrubs, cultivated crops (mostly legumes) and weeds (Baloch, *et al.*, 1967a).

The destructive effects of parasitic weeds on their host-plants include reduced vigour and poor growth-rates, poor fruit and seed set, top die-back, predisposition to attack by insects and diseases and premature death (Gill and Hawksworth, 1961).

Control of parasitic weeds by mechanical means is laborious and expensive, chemicals are costly and fraught with danger to the host-plants. Specific and effective biocontrol agents, if available, would be more suitable since they do not have any dangerous side-effects and are self-perpetuating. A number of workers have reported natural enemies attacking parasitic weeds, but the information is scattered in various journals and unpublished reports and is not easily accessible. Therefore an attempt has been made to bring together all the available information on the possibilities for biocontrol of parasitic weeds with particular reference to Pakistan but, where relevant, references from other parts of the world are included.

The Parasitic Weed Species. 1. *CUSCUTA* SPP. *Cuscuta* spp., their distribution and host-plants in Pakistan, insects attacking them and detailed studies on the phenology, ecology, host-specificity, etc., of the promising enemies have been reported by Baloch (1968) and Baloch, *et al.*, (1967 a and b, 1969, 1970 and 1975). Promising insect enemies in Pakistan include an agromyzid, *Melanagromyza cuscutae* Hering, a tortricid, *Herpystis cuscutae* Bradley, and five species of weevils in the genus *Smicronyx*.

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Melanagromyza cuscuteae attacks thick-vined species (vine thickness 1-2 mm.). It is found throughout the country and becomes active in March-April in warmer and in June July in cooler areas. Periods of excessive heat and cold are passed as puparia within the dry vines. Eggs are laid in tender and newly sprouting vines and the maggots feed in these, causing them to dry up. At peak population density (March-April and September-October) damage to the host may be severe. *M. cuscuteae* is parasitised by *Opius* sp. and *Dacnusa* sp. (Braconidae), *Eupelmus* sp. (Eupelmidae), *Bruchophagus* sp. (Eurytomidae) and *Eucoilidea* sp. (Cynipidae). These parasites destroy up to 70% of the fly puparia (Baloch, 1968). It is highly specific to *Cuscuta* spp. and even the ovarian development ceases if the females are not allowed to feed on the exudates which ooze out after insertion of ovipositor. As a result of these investigations, *M. cuscuteae* was released in Barbados for the control of *Cuscuta americana* and *C. indecora*. However, it failed to establish on these species possibly because the thin vines of these species were unsuitable.

Herpystis cuscuteae attacks the fruits of *Cuscuta reflexa* and *C. reflexa* var. *brachystigma* in the central, northern and northwestern parts of Pakistan. Its active period depends on the host and climatic conditions. In the northern area, activity begins in September, the population increases gradually reaching a peak in December-January, declining thereafter, and the insect disappears from the field by the end of February. When fruits are not available eggs are laid on vines and the larvae bore into those parts which twine around the host plant. With the commencement of fruit-formation, infestation becomes confined to the seeds. *H. cuscuteae* attacks *Cuscuta* spp. parasitising a number of host-plants but its highest incidence occurs on dodders infesting *Adhatoda vasica* and *Dodonaea viscosa* (Baloch, et al., 1969). In the laboratory young larvae are capable of feeding and development on peas, celery and field-bindweed but none of them is known to be attacked in nature.

The genus *Smicronyx* attacks plants of the families Convolvulaceae Scrophulariaceae and Orobanchaceae but the species belonging to the subgenus *Smicronyx* have only been recorded from *Cuscuta* spp. (Anderson, 1962). The *Smicronyx* complex infesting *Cuscuta* spp. in Pakistan comprises *S. roridus* Mshl. (= *cuscuteae* Mshl.) and four new species described by Anderson (1974) as *S. ghanii*, *S. parafasciatus*, *S. ushoensis* and *S. rufovittatus*.

Smicronyx roridus is the most common species, found throughout the country on thick-vined *Cuscuta* spp. only. Adults are usually present throughout the year in small numbers but high populations of all stages are found during April-May and September-October. It remains inactive during the hot and cold periods of the year. Eggs are laid singly in tender and newly sprouting vines. Galls start forming one day after oviposition and become fully developed four days later when the eggs begin to hatch. The vine on either side of the gall dries up but the gall itself remains green until the larva inside reaches maturity. The fully-grown larva cuts a hole in the gall, drops to the ground and pupates in the soil. There are four generations a year (Baloch, 1968). Up to 40% larvae are parasitised by *Bracon* sp. during peak population density.

The remaining four species of *Smicronyx* feed only on flowers and fruits of thin-vined dodders (vine thickness 0.3-0.7 mm.) except for a biological race of *S. parafasciatus*

which attacks the thick-vined *C. reflexa* and *C. reflexa* var. *brachystigma*. The weevils and their hosts are confined to the cooler areas of the foothills and hills (400-2,400 m) in the northern parts of Pakistan (Baloch, *et al.* 1970 and 1975).

All these species have one generation a year except *S. rufovittatus* which has 5-6. All of them overwinter as adults under plant trash and as mature larvae in the soil. Overwintered adults of *S. ghanii* and *S. ushoensis* become reproductively active in early July, those of *S. rufovittatus* and *S. parafasciatus* in April and late August, respectively. Activity continues until the end of September (except *S. parafasciatus* which remains active up to late November to early December) when they enter hibernation.

S. ghanii infests *Cuscuta planiflora* and *C. europaea* var. *indica* while *S. parafasciatus* attacks these two species and *C. pulchella* in the Swat and Chitral valleys. *S. ushoensis* was found only on an unidentified species of *Cuscuta* in the Usho area of Swat and *S. rufovittatus* on *C. campestris* at Nowshera in the North-West Frontier Province. *S. ushoensis* and the two races of *S. parafasciatus* are restricted to the species of dodder on which they were recorded in nature.

From the USSR: Marikovskii and Ivannikov (1966) report *M. cuscuteae*, *S. roridus* and *Eupoecilia ambiguella* Hub. (Phalonidae) attacking *Cuscuta* spp. in Kazakhstan where *M. cuscuteae* is parasitised by *Eurytoma* sp. (Eurytomidae) and *Sphegigaster* sp. (Pteromalidae); Stojanovik (1961) mentions *Smicronyx jungermanniae* Reich. as reared exclusively from *C. pentagona* in northern Siberia, while adults of *Smicronyx seriepilosus* Tourn. also feed on this same species. Lekic (1969) also reports *S. jungermanniae* on *Cuscuta europaea* and *C. trifolii* as well as *C. pentagona*. He considers it the most important natural enemy, especially in abandoned habitats and further reports *S. seriepilosus* from *Campestris* in one locality. *Smicronyx menozzii* Solari infests *Cuscuta australis* in Italy but has very little controlling effect (Frili, 1966). Its larvae are parasitised by *Bracon praestans* Tobias (Braconidae). *Smicronyx sculpticollis* Casey attacks *Cuscuta cephalanthi* in the U.S.A. and is also reported on *C. gronovii* from Long Island (Weiss and West, 1921).

Rudakov (1961) reported 60-100% die-back of *Cuscuta cupulata* in alfalfa fields in the U.S.S.R. due to infection by *Alternaria cuscutacidae*. Pure cultures of this organism are reported to have infected all parts of dodders but were harmless to the host-plants. It killed some vines within 5-8 days and the whole clump in 18-20 days. Leach (1958) records a disease caused by *Colletotrichum destructivum* in the U.S.A. In green house tests it infected *Cuscuta epithymum* and *C. campestris* but not their host alfalfa, although it is recorded as a host of this organism so that he concluded that the infecting dodders may be different from that attacking alfalfa.

II. *LORANTHUS* SPP. The species and their importance as parasitic weeds, natural enemies associated with them in Pakistan and detailed studies on promising natural enemies were reported by Baloch and Mohyuddin (1969) and Mushtaque and Baloch (1979). They reared 26 insects and a mite of which a trypetid, *Ceratitella asiatica* Hardy, a chrysomelid, *Demarchus pubipennis* Jacoby, A pyralid, *Euzopherodes ephestialis* Hmps., a

gelechiid, *Anarsia sagmatica* Meyr., a yponomeutid, *Zelleria loryanthivora* Meyr., and a pierid, *Delias eucharis* Drury, appear to be stenophagous.

According to Hardy (1967) there are four known species in the genus *Ceratitella* of which three (*asiatica* Hardy, *bifasciata* Hardy and *loranthi* (Froggatt)) have been reared from mistletoes only (*Loranthus* and *Amylothea*) while the fourth (*unifasciata* Hardy) has no recorded host. *C. asiatica* attacks the fruits of *Loranthus* spp. below 900 m. Its activity is very well synchronized with the fruiting period of its host, December-March. The larvae eat the contents of the seeds and pupate there. High populations occur in March, after which the fly enters diapause as puparia or as adults. It has two generations a year and is host-specific. It was introduced into Trinidad against *Phthirusa* spp. (Loranthaceae) but failed to survive either in laboratory breedings or in field releases, suggesting that it may be highly host-specific and cannot accept other mistletoes, although *Phthirusa* is closely related to *Loranthus*.

Larvae and adults of *Demarchus pubipennis* defoliate the host when the population is at a peak in June. It becomes active in Late April or early May and at the end of November mature larvae hibernate in the soil. Like *Ceratitella asiatica*, it occurs below 900 m and has four generations a year. Oviposition takes place on leaves in feeding pits which are then covered by faecal matter. Odak, et al. (1969) report *D. pubipennis* as a pest of pigeon pea, *Cajanus cajan*, in India. However, the species attacking *Loranthus* in Pakistan is host-specific and the record from pigeon pea is either a misidentification or of a strain or biological race different from that on *Loranthus* spp. Seventy percent of larvae are parasitised by *Tachinophytopsis ghanii* Mesnil (Tachinidae) in August.

Euzopheroles ephesiadis also damages leaves and is found throughout the distribution area of its host in northern Pakistan. Oviposition by the overwintering generation commences in late April or early May and there are 5-6 generations before activity ceases at the end of November. The peak population is reached in July when there may be as many as 25 larvae per leaf. Hibernation takes place as mature larvae either between stitched leaves or plant debris. The eggs are laid on the leaves preferably on rough spots and the larvae feed between stitched leaves. The larvae are parasitised by *Phanerotoma* sp. (Braconidae). *E. ephesiadis* is specific to the genus *Loranthus*.

Anarsia sagmatica, a flower-feeder, is well synchronized with the flowering period of its host. Breeding takes place from October to March when it aestivates as mature larvae. High numbers are found in December-January, which is the coldest season. The eggs are laid on flower-stalks or flowers and larvae initially feed on tender shoots but eventually on the flowers completely destroying them. There are four generations a year. The larvae are parasitised by *Paralitomastix varicornis* (Nees) (Encyrtidae). In confinement the young larvae are capable of feeding and development on lettuce and radish so that further studies are needed to determine whether these plants would be attacked under natural conditions.

Zelleria loryanthivora and *Delias eucharis* have not been investigated in detail. The former is a flower-feeder and its phenology and damage are similar to that of *A. sagmatica*.

It is also known to feed on flower-buds of *Loranthus* in India during February-March. *D. eucharis* is a leaf-feeder and is reported by Beeson (1941) as a pest of *Pterospermum acerifolium* (Sterculiaceae) as well as from *Loranthus cordifolius* in India but neither Maxwell-Lefroy and Howlett (1909) nor Bingham (1907) mention any other host and the latter positively states that he did not find it attacking any other host. A pyralid, *Cyanaphycis bradleyella* Roesler, damages leaves of *Loranthus* spp. at Tret and Kahuta in the Rawalpindi district and at Azad Pattan in Kashmir in low numbers in association with *E. ephestialis*. As this is the first host record for this insect its host range is not known.

Elsewhere in the world, Gill and Hawksworth (1961) cite records of damage to shoots by the butterflies *D. eucharis* and *Ogyris* sp. in India and Australia; to fruits by the fruitflies *Cryptodacus silvai* Costa Lima in Brazil and *Ceratitis loranthi* (Froggatt) in Australia; scale insects in Australia; and gall-forming insects in Java, Indonesia. They also list a number of fungi from mistletoes, of which a number are from *Loranthus*.

III. *ARCEUTHOBIMUM* SPP. Baloch, *et al.* (1976) report on the species of dwarf mistletoes and their natural enemies in Pakistan. The weed species are *Arceuthobium minutissimum*, a minute species (about 8 mm long) but a very serious parasite of *Pinus griffithii* at Kalam and Utror in the Swat valley and at Naran in the Kaghan valley in northern Pakistan and *A. oxycedri*, a larger species (about 20 cm long) which affects 70% of *juniperus excelsa* (= *J. macropoda*) in the Susnamana forest of the Ziarat valley in western Pakistan. Natural enemies having a definite association with dwarf mistletoes and promising as biocontrol agents include a pyralid *Dioryctria taiella* Amsel and a blastobasid *Prosinitis florivora* Meyr. on *A. oxycedri* and a geometrid *Comostola inops* Prout on *A. minutissimum*.

Dioryctria taiella is the most important enemy of *A. oxycedri*. It overwinters in the third to sixth larval instars from September resuming activity in late April when the larvae continue to feed until the end of May or early June. Pupation usually takes place on juniper twigs or under bark near the host, but occasionally also among the bunchy shoots of the mistletoe. Adults emerge during mid-June to mid-July, oviposition commences in late June to late July and first generation larvae appear on the host in early July to early August. They continue to feed until early October. The larvae and pupae are parasitised by three species of ichneumonids.

Young larvae feed, both internally and externally, mainly at the bases of shoot. As they grow, they move upwards, construct cases by stitching together shoots with silken webs and hibernate in them. There are usually one or two larvae per shoot but that is enough to kill it.

Several species in the genus *Dioryctria* are known pests of important forest trees, but *D. taiella* is apparently specific to dwarf mistletoes as it has not been observed to feed on other vegetation in the area and did not complete its development even on other mistletoes.

Prosinitis florivora, the second effective natural enemy of *A. oxycedri*, is also univoltine. Overwintering larvae resume activity in April and pupate during May. Adults

emerge in June and the larvae appear on the host during July. Feeding continues until September when the mature larvae overwinter under the bark of *Juniperus excelsa*. Like *D. taiella*, the larvae usually feed at the base of shoots as borers and external feeders, but sometimes they also attack the terminal shoots, flowers and seeds.

The host range of *P. florivora* has not been experimentally determined but it has not been observed to feed on *J. excelsa* or any other plant although Meyrick (1969) reports it as a pest of mango in India. This record is considered to be either a misidentification, or possibly the insects attacking mango and dwarf mistletoe belong to different strains or biological races.

Comostola inops, the only insect which attacks *Arceuthobium minutissimum*, is also univoltine. It is scarce at Utror in the Swat valley, but at Naran in the Kaghan valley is quite abundant. At the second locality overwintering takes place as third to fourth instar larvae. Activity is resumed in late April and pupation takes place near the growing points of the mistletoe host, *Pinus griffithii*, in early August. Young larvae appear in early September and continue to feed until the end of November. The host range is not known but, like *P. florivora*, it has not been found feeding on the host tree.

Gill and Hawksworth (1961) mention few insects and fungi associated with *Arceuthobium* spp. elsewhere but in a more recent review (Stevens and Hawksworth, 1970) 22 insects and 8 mites attacking dwarf mistletoes mainly in the USA, Canada, Mexico and Europe are reported. Of the insects, the moths *Filatima natalis* (Heinrich), *Dasypygia alternosquamella* Heinrich and *Mitoura spinetorum* (Hewitson) and the bug *Neoborella alternosquamella* Heinrich and *Mitoura spinetorum* (Hewitson) and the bug *Neoborella tumida* Knight are considered as host specific. A bark beetle, *Pityophthorus arceuthobii* Wood, has also been recorded feeding on dwarf mistletoes in Mexico (Wood, 1971).

IV. *VISCUM* SPP. Two species of *Viscum* occur in Pakistan, viz.: *V. album* on *Juglans regia* and *Aesculus indica* in the Murree Hills, *Populus ciliata* in the Swat valley and *Prunus persica* in Kashmir; *V. cruciatum* on *Olea cuspidata* in the Swat valley.

In Pakistan natural enemies definitely associated with *V. album* were not found but *V. cruciatum* leaves are mined by a pyralid gen. et sp. nr. *Ectomyelois*, and a chrysomelid, *Cassida obtusata* Bhm., also damages leaves. The first is of unknown status but the other is a minor pest of sweet potato and other Convolvulaceae in Java (Franssen, 1934.)

Gill and Hawksworth (1961) report on insects and diseases recorded from *Viscum* spp. and *Phoradendron* spp. elsewhere.

V. *STRIGA* SPP. Agha, et al. (1965) reported on *Striga* spp. and insects associated with them in Pakistan. There are two species of *Striga*, *S. asiatica* (= *S. lutea*) and *S. euphrasioides*, both attacking roots of *Sorghum vulgare*. Important insect enemies include a nymphalid *Gunonia (Precis) orithya* L. which is quite common and inflicts considerable damage to the host and a pterophorid *Platyptilia* sp. nr. *molopias* Meyr. which is very rare. *G. orithya* feeds on a number of other plants but nothing is known about the host-specificity

of *Platyptilia* sp. The larvae and pupae of *G. orithya* are parasitised by *Sturmia bella* Mg. and *S. flavohalterata* Bisch. (Tachinidae).

Greathead and Milner (1971) studied insects associated with four species of *Striga* (*hermonthica*, *asiatica*, *forbesii* and *gesnerioides*) in East Africa and discussed the possibilities for biocontrol. They consider the seed-pod galling weevils, *Smicronyx* spp., and the root-, and stem-mining agromyzid, *Ophiomyia strigalis* Spencer, as the most promising candidates. *O. strigalis* is the most common insect affecting witchweeds in Kenya, attacking more than 90% of plants in some areas and there is a stem-galling hymenopteron, *Eurytoma* sp., of minor importance (Davidson, 1963). Sankaran and Rao (1966) found *Smicronyx albobariegatus* Faust and the noctuid *Euloastra argentisparsa* Hmps. to be the most destructive and specific insects of *Striga euphrasioides*, *S. densiflora* and *S. asiatica* in India. Sankaran *et al.* (1969) found brown and green forms of *E. argentisparsa* of which the green seemed more important.

Meister and Eplee (1971) list five fungi on *S. asiatica* in the U.S.A.; *Curvularia geniculata*, *Fusarium solani*, *F. roseum*, *Rhizoctonia solani* and *Sclerotium rolfsii*. They are effective only when the plants are less than 10 weeks old or when the relative humidity remains above 90% for more than four days. The host range of these fungi is not known except that *S. rolfsii* also attacks maize. Nag Raj (1966) records *Cercospora* sp., *Oidium* sp. and *Phoma* sp. on *S. asiatica* and *S. densiflora* in India and Nag Raj, *et al.* (1970) report the isolation of *Macrophoma* sp. from *S. asiatica* and *Phyllosticta* sp. from *Striga guayanensis*.

VI. *OROBANCHE* SPP. Natural enemies of broomrapes in Pakistan have not yet been investigated. According to Nasir and Ali (1972) there are 20 species of *Orobanche* in this country of which *O. aegyptiaca* on solanaceous plants and melons, *O. cernua* on tobacco and *O. alba* on labiates are the important. Quddus, *et al.* (1969) record *O. aegyptiaca* on 22 crop and weed hosts in western Pakistan.

Manjunath and Nagarkatti (1977) reviewed the literature on the natural enemies of broomrapes including those found in India i.e., 24 insects and a fungus (*Sclerotium rolfsii* on *O. cernua*), of which only the agromyzid *Phytomyza orobanchia* Kalt. appeared to be important. However, the insects which warrant further studies are the flies *Phorbia* (*Chortophila*) sp. and *Siphonella sulcicollis* var. *lacteipennis* Duda, the weevil *Smicronyx cyaneus* Gyll. and the psilid *Megachetum* (*Cyhtiza*) *atriseta* Mg. on *Orobanche speciosa* in Italy. *P. orobanchia* is wide-spread in Yugoslavia, mainly on *Orobancha cumana* in sunflower fields and also on *Orobancha ramosa* in tomato, tobacco and hemp fields. It has 3 generations per year and infests the broomrapes throughout their growing season (Lekic, 1969). *P. orobanchia* also damages *O. crenata* and *O. minor* as secondary hosts and is capable of remaining in hibernation up to 3 yers. It is parasitised by *Sphegigaster orobanchiae* Kurd. (21.4%), *Opius* sp. (5%), *Cyrtogaster vulgaris* Wlk. (7.4%), *Callitula bicolor* Spin. (2.8%), *Stenomelina gracilis* (1.6%), *Thinodytes cyzicus* (Wlk.) (0.8%) and *Opius similoides* (4.1%) (Lekic, 1974). *P. orobanchia* is also recorded in Egypt feeding on *O. crenata* (Hamad, *et al.*, 1967). Further details of the biology, ecology, effectiveness as a controlling agent, methods of redistribution, etc., of *P. orobanchia* in the U.S.S.R. and eastern Europe are described by Antonets (1970), Kott (1969), Lekic (1970), Bronshtein (1968), Khilabustina (1969), Kapralov (1974), Sushchinskii (1969) and Kasasian (1971).

Stankevich (1971) reports *Colletotrichum lagenarium* causing anthracnose in *O. aegyptiaca* on water-melons in the U.S.S.R. He considers that the *Orobanchae* strain is a specialised form and possibly a useful biocontrol agent as it differs in the dimension of its spores, diameter of hyphae, etc. from the form which attacks water-melons. Also in the U.S.S.R. *Fusarium orobanchae* is reported to have caused 11% reduction of broomrape infestation in experiments (Khalimov, 1970) and Panchenko (1974) reports 4 species of *Fusarium* attacking *O. aegyptiaca* in Astrakhan province of the U.S.S.R. of which *F. oxysporum* var. *orthoceras* is reported to reduce broomrape shoots by 90-97%. A reduction of infestation of *Orobanchae* spp. by about 86-100% in tobacco fields and 84-88% in water-melon fields is reported to have been achieved by the use of 'Product F' (a preparation of *F. oxysporum*) at the rate of 0.5-1.00 g. per plant (Kott, 1969). The infectivity is said to have lasted 80 days and was most effective at high moisture levels.

VII. **CONCLUSIONS AND RECOMMENDATIONS.** Although natural enemies of species of *Cuscuta*, *Loranthus*, *Arceuthobium*, *Striga* and *Orobanchae* have been investigated in some detail, there are still many areas in the world where these parasitic weeds are known but the native natural enemies have not yet been studied. Therefore, it is important that surveys be made of such areas in order to determine if any promising biocontrol agents exist. The possibilities of biological control of *Viscum* spp. have not been studied and its natural enemy complex needs to be determined.

Host-specific natural enemies of *Cuscuta* spp. include *Melanagromyza cuscatae*, *Herpystis cuscatae*, *Smicronyx* spp. and a disease caused by *Alternaria cuscutancidae* in Pakistan, Yugoslavia, the U.S.A. and the U.S.S.R. *M. cuscatae* and *Smicronyx roridus* are widespread in all these areas, while the other insects seem to be restricted to where they were recorded. Thus, there is scope for the redistribution of natural enemies within these countries.

Natural enemies of *Loranthus* spp. have been investigated in detail only in Pakistan, where the promising species are *Ceratitella asiatica*, *Demarchus pubipennis* and *Euzopherodes ephestialis*. Host ranges of *Zelleria loranthivora*, *Cyanaphycis bradleyella* and *Delias eucharis* are not definitely known but these are probably also host-specific. Since *Loranthus* spp. are widely distributed and their natural enemy complex is not known, the species recorded in Pakistan should not be introduced unless a thorough local investigation confirms their absence.

Apparently promising insect enemies of *Arceuthobium* spp. have been studied in Pakistan and the U.S.A. They include *Dioryctria taiella* and *Prosinitis florivora* on *A. oxycedri*, and *Comostola inops* on *A. minutissimum* in Pakistan, and *Filatima natalis*, *Dasyppa alternosquamella*, *Mitoura spinetorum* and *Neoborella tumida* on *Arceuthobium* spp. in the U.S.A. Thus, there is scope for the exchange of natural enemies between these two countries and their introduction elsewhere.

Host-specific, promising enemies of *Striga* spp. include *Smicronyx* spp. *Ophiomya strigalis* and *Eulocastra argentisparsa* in Africa and India. They are not known from Pakistan and so could be introduced in an attempt at biological control.

Natural enemies of *Orobancha* spp. have been investigated in India, Italy, the U.S.S.R. and Yugoslavia. The only promising agent with a proven specificity and also the most exploited biocontrol agent is *Phytomyza orobanchia*. The disease caused by *Fusarium orobanchae* is also a specific and effective agent and is produced commercially in the U.S.S.R. The fly occurs in negligible numbers in India and possibly Pakistan. Some insects occur in Italy but their host range is still unknown. Therefore, there is need for further research in most countries but *P. orobanchia* and *F. orobanchae* can be safely used.

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