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Natural Enemies of *Convolvulus arvensis* In Western Mediterranean Europe

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Because of interest in biological control for *Convolvulus arvensis* L. in the USA, a survey of its fauna was conducted in Mediterranean Europe. In all, 140 species of insects, three species of mites and three pathogenic fungi were found attacking *C. arvensis* and other closely related members of the Convolvulaceae. Most organisms were associated with the leaves, but, considering the amount of root material available, very few were found on the roots. About half of the arthropods are widespread and important *C. arvensis* herbivores, but most are polyphagous and many are known crop pests. None is strictly monophagous on *C. arvensis*. The seasonal progression of plant growth and the presence of the more important arthropods associated with various plant parts are described. After considering literature records of their host specificity and field observations of plant damage and biology, 15 species most widespread and damaging to *C. arvensis* were tested for their ability to live on sweet potato. *Galeruca rufa, Eriophyes* sp. and *Spermophagus sericeus* were considered to have the greatest potential as biocontrol agents, while six other insects and one fungus may be of value.

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Natural Enemies of *Convolvulus arvensis* in Western Mediterranean Europe[1/2]

INTRODUCTION

Convolvulus arvensis L., field bindweed, is a prostrate or climbing perennial herb with shoots up to 100 cm long and glabrous to pubescent herbage. Leaves are oblong-sagittate to ovate, obtuse to rounded at the apex, 1.5–3.5 cm long with short, slender petioles. White or pink funnel shaped flowers, 1.5–2.5 cm long, are axillary and usually solitary on filiform peduncles bearing two bracts well below a 3 mm-long calyx (Munz and Keck, 1959). An extensive underground system of roots and rhizomes may cover an area up to 6 m in diameter (Frazier, 1943) and extend down 9 m below the soil surface (Phillips, 1978). Reproduction is by seeds or vegetative sprouting from the lateral roots. Seeds have a hard outer coat and may remain viable and germinate in soil for up to 30 years (Timmons, 1949). Different populations of *C. arvensis* show variation in form, seed proteins, and flowering habits (Garcia-Baudin and Darmency, 1979) and in resistance to herbicides (Whitworth, 1964). The chromosome number has been reported as 2n = 48 (Garcia-Baudin and Darmency, 1979) and 2n = 50 (Wolcott, 1937).

Convolvulus arvensis is a member of the tribe Convolvuleae of the Convolvulaceae. Of the 200 or 300 species of *Convolvulus,* 118, including *C. arvensis,* occur in the Mediterranean region and adjoining part of Western Asia which is considered to be a principal area of distribution of the genus (Sa'ad, 1967). While *C. arvensis* may have originated in this area, it is now found throughout the temperate regions of the world, especially at lower elevations. Field bindweed's relatives in the Convolvulaceae include *Ipomoea batatas* (L.) Lam. sweet potato, a widely grown plant that is a staple food in the diet of much of the world's population. Ornamental morning glories are also *Ipomoea* spp. The closest relatives of *C. arvensis* are in the genus *Calystegia.* These are all wild plants, and one, *Calystegia sepium* (L.) R. Br., is an important weed in eastern North America.

Field bindweed is the 14th most important weed in the USA (Jansen et al., 1972) and is considered by Holm et al. (1977) to be the 12th most important weed in the world. It is mainly a pest of cultivated crops and ornamentals but is also found along roadsides, in fallow fields, and on other noncultivated land (Holm et al., 1977). In the USA it occurs throughout the country except for the very southernmost portions (USDA, 1971). It is less important in the more humid eastern part and a more serious weed in the arid West (Meyer, 1978).

Because *Convolvulus arvensis* is an important weed and very difficult to control by chemical or cultural methods, there has been great interest in using biological controls. Mohyuddin (1969a) lists the insects from *Calystegia* spp. and *Convolvulus* spp. found by him in Ontario, Canada, and by others in different parts of the world. Mohyuddin's papers and other literature dealing with insects attacking *Convolvulus* spp. in North America were summarized by Baloch (1974) who also found 34 insects in Pakistan feed-

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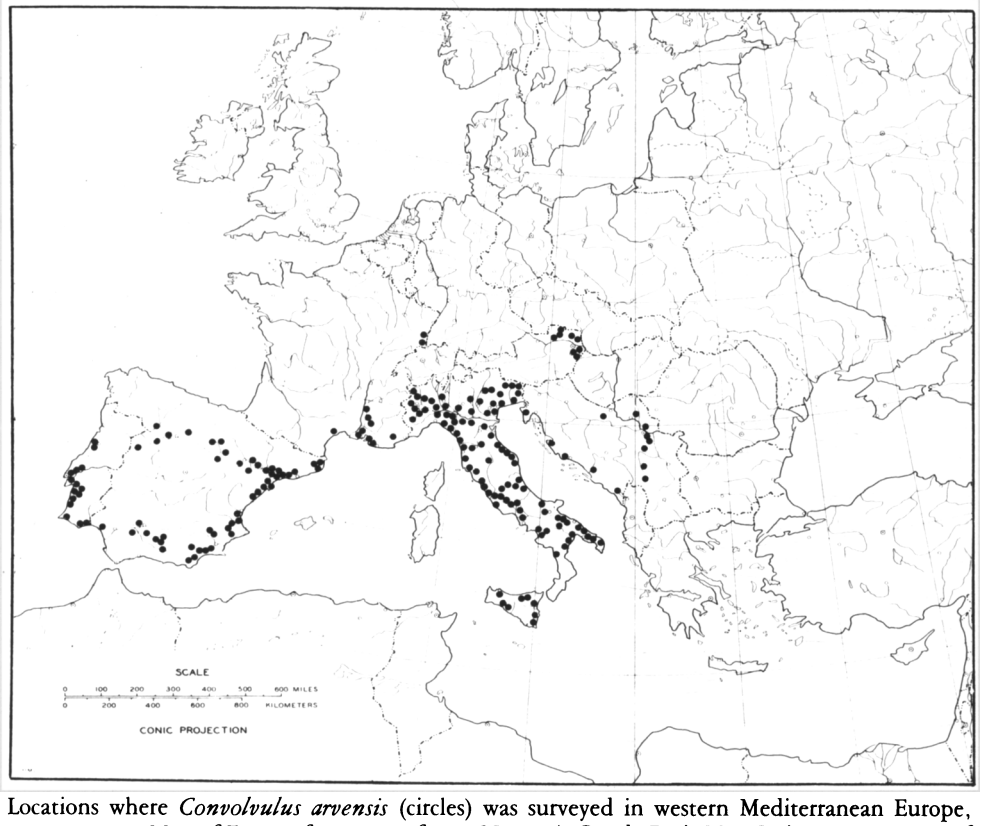
[2] The contents of this report reflect the views of the authors who are responsible for the facts and the accuracy of the data presented herein. The contents do not necessarily reflect the official views or policies of the State of California or the Federal Highway Administration. This report does not constitute a standard, specification, or regulation.

ing on bindweeds and studied these (1977a,b) as possible biological control agents. As part of a cooperative project between the University of California and the USDA, Mediterranean Europe has been explored for natural enemies of this plant since 1970. Until this part of the project ended in 1977, it was headquartered at the USDA Biological Control of Weeds Laboratory in Rome, Italy, and most of the collecting was done in Italy and to the west. The organisms found on *Convolvulus arvensis* and the results of preliminary tests for feeding and survival on *Ipomoea batatas* by those arthropods appearing to have the most potential as biocontrol agents are reported here.

METHODS

Collection sites used during this research are shown in the figure. Italy was surveyed the most intensively and at all times of the year, by Buckingham during 1970 to 1971 and by Rosenthal from 1972 to 1977. Collections from other countries plus the other research was carried out by Rosenthal. France was visited in April, 1973, and during June and September, 1974, Eastern Austria in June, 1974, and Yugoslavia in June, 1975. In 1975 three trips were made to the Iberian Peninsula during the early (May–June), middle (July), and late (September–October) portions of the *C. arvensis* growing season.



Locations where *Convolvulus arvensis* (circles) was surveyed in western Mediterranean Europe, 1970 to 1977. Map of Europe from part of map No. 104, Goode Basic Map Series, Department of Geography, University of Chicago, Chicago, Illinois. Copyright by the University of Chicago, Department of Geography.

Collections were made every 10 to 50 km, depending on the amount of variation in geography and land use. Collecting sites were grassy or weedy roadsides, fallow fields, *C. arvensis*-infested cropland planted with grain, row crops, fruit trees or grapes, and vacant town lots. The field bindweed stands surveyed varied from heavy infestations covering large areas to very light infestations consisting of only a few scattered crowns. Other members of the Convolvulaceae besides *C. arvensis* were sought and carefully searched wherever they were encountered. *Calystegia sepium, Convolvulus cantabrica* L., *C. althaeoides* L. and *Ipomoea purpurea* (L.) Roth were especially common. Small fields of *I. batatas* were found in Lecce, Italy.

At each collecting site plants were inspected for damage, and organisms were aspirated or hand picked from them. Since many species drop from the plant when disturbed, insects under the plants were collected also. From 1975 to 1977, half-hour inspections were made, so that the amount of plant damage and the numbers of organisms found at different locations and at different seasons could more easily be compared. Whole crowns, with as much root material as possible, were dug out of the soil and the stems and roots were either dissected in the field for boring insects or were kept in plastic bags and dissected later. When available, seeds were collected and kept for insect emergence. Additional time was spent at the survey sites to collect, by hand picking or with a sweep net, larger numbers of species selected for use in laboratory studies. Collected insects were fed and reared (if immature) on *C. arvensis*. Herbarium specimens of diseased plants were prepared for later identification. Most locations were surveyed during the day, but some collections were nocturnal. Parasites reared from the various insect collections are mentioned in the text.

Ipomoea batatas as the most important economic crop species in the Convolvulaceae was used for feeding and development tests to eliminate insects and mites that could use this plant as a host. Sweet potato feeders represent serious potential pests and are not acceptable as biological control agents in the USA. Insects and mites not known to be pests, and that appeared to be especially damaging to *C. arvensis,* were tested if common enough or if adequate numbers could be reared in the laboratory. With the exceptions described below, the host specificity laboratory tests were done in half-pint (236.6 ml) cardboard cartons using the methods of Rosenthal and Carter (1977). Tests were conducted in a temperature cabinet adjusted for a 14-h photoperiod with fluctuating temperatures of 65 ° F (18.3 ° C) during the dark phase and 80 ° F (26.7 ° C) during the light phase. Two insects were tested in each cage on a bouquet of the test plant material held in a water-filled vial with a cotton plug. Numbers of each insect species tested are given in Results. Amount of feeding was measured using a square millimeter grid, and results were given as percentage of feeding on the *C. arvensis* control during a 5-day period. After 5 days, survivors were fed on test plants until they either matured or died. Survival was compared with that of unfed controls.

RESULTS AND DISCUSSION

General

The 139 species of phytophagous arthropods collected on *C. arvensis* and its close relatives in southwestern-south central Europe as listed in the table.[3] Pollinators are other flower visitors are not included, unless they or their progeny were capable of

[3]See appendix starting on page 15.

damaging the flowers or other plant parts. In the table, organisms are listed taxonomically, with orders and families arranged in the sequence used by Borrer, DeLong, and Triplehorn (1976) and genera and species arranged alphabetically. Details on collection dates and localities are available from the senior author.

Taxonomically these species are distributed in 36 families in seven orders of insects and in two families of mites. The Coleoptera are the most numerous (59 species), especially the Chrysomelidae (24 species), the Curculionidae (14 species) and the Bruchidae (five species). The Lepidoptera are almost as common (51 species), but the only family with many representatives is the Noctuidae (20 species). The third most numerous order is the Homoptera with 15 species. There are six species of Hemiptera, all Pentatomidae. Only two species of Thysanoptera and one species each of Collembola and Diptera were found. Besides these insects and the three species of mites, two fungal pathogens, *Erysiphe convolvuli* DC. ex St. Amans and *Alternaria tenuissima* (Fr.) Wiltshire, were found attacking *Convolvulus arvensis* leaves, while the fungus *Puccinia convolvuli* Cast. was seen on *Calystegia sepium* leaves.

Most of the herbivores—105 (75.5%) external leaf feeders and 5 (3.6%) leaf miners —are associated with *C. arvensis* foliage. Twenty four (17.4%) insects feed on the flowers, seeds or seed capsules and 11 (7.9%) on, or within, the stems and roots. Considering the tremendous amount of root material produced by *C. arvensis,* it is surprising that more organisms do not utilize roots as a food source. However, the low percentage of root and stem feeders in the Mediterranean is not unusual for field bindweed. In Pakistan, only four (11.8%) of the arthropods attack the roots and stems (Baloch, 1974); in Canada there was only one stem feeder out of 23 insects and mites associated with *Convolvulus* spp. and *Calystegia* spp. (Mohyuddin, 1969a), and only five (4%) of the arthropods from Mohyuddin's world list were root or stem feeders (Mohyuddin, 1969a). The most useful biological control agents for field bindweed would be organisms attacking the roots, preventing seed production, or defoliating the plant during its whole growing season. Because of the absence of arthropods associated with *C. arvensis* roots in North America, a root feeder would be especially useful.

Of the insects and mites that could be identified to species, 76 (71.7%) are known to be polyphagous. Of these polyphagous arthropods, 43 of the insects and two of the mites are agricultural pests. Another 15 are only known from members of the Convolvulaceae, and one of these oligophagous insects, *Bedellia somnulentella* (Zeller), is a pest of sweet potato (Parella and Kok, 1977). Eight of the latter appear to limit their feeding to species of *Convolvulus* and *Calystegia,* and *Melanagromyza albocilia* Hendel may only live in *Convolvulus* spp. None is strictly monophagous on *C. arvensis.* Information about the feeding habits of the others could not be found.

Sixty seven species (48.2%) of arthropods were only rarely encountered on *C. arvensis.* Many of these could only be identified to genus, and many others are polyphagous insects for which *C. arvensis* is not an important host. An exception is the leaf mining pyralid, *Titanio normalis* Hübner, reared from *C. althaeoides* in Spain and from *C. cantabrica* in Italy. *Titanio normalis* has previously been recorded only from *C. arvensis* and *C. cantabrica* (Hering, 1957). Forty eight (34.5%) species are common or abundant throughout one or more countries and another 24 (17.3%) are locally common over a smaller area or at scattered locations. Of these 72 widespread herbivores, not all are equally abundant or damaging to the plant at all times of the year.

About 20 defoliators are obviously destructive to *C. arvensis,* but some of these, *Tetranychus* spp., *Bedellia somnulentella, Spodoptera littoralis,* and *Agrius convolvuli* L., are crop pests. The feeding of *Eriophyes* sp., and the Chrysomelidae, leaf miners, Ptero-

phoridae and leafrolling caterpillars is distinctive, but several larger external leaf-feeding Lepidoptera usually occur in the same location making it difficult to assign the amount of defoliation due to any one species. The Homoptera and Hemiptera cause little apparent damage to field bindweed, even though they are numerous. *Spermophagous sericeus* (Geoffroy) was the only insect found destroying a large proportion of the seeds. While *Longitarsus* spp. adults are numerous and *Melanagromyza albocilia* is widespread, roots and stems of *C. arvensis* show little damage from their attack.

Plant growth cycle and seasonal appearance of organisms

In Italy, *C. arvensis* sprouts appear above ground beginning in March, but few arthropods are seen on the leaves and stems before May. Exceptions to this among more common insects and mites are *Philaenus spumarius* (L.) and adults of *Galeruca rufa* Germar, which become active in March, and *Eriophyes* sp., *Oidaematophorus monodactylus* (L.), *Longitarsus pellucidus* Foudras adults and *Trachys puncticollis* Abeille var. *obscurella* Oben. adults which begin feeding in April.

Field bindweed foliage grows most rapidly from May to July; this is also the time of year when most of the flowers and seeds are produced. The most common and obviously damaging arthropods found on the leaves at this time are the Chrysomelidae, notably *Hypocassida meridionalis* (Suffrian), *H. subferruginea* Schrank and *Galeruca rufa;* the Pterophoridae *Oidaematophorus monodactylus* and *Pterophorus pentadactyla* (L.); the leaf rolling Lepidoptera *Chrysocrambus linetellus* (F.), *Pyrausta cespitalis* (Denis and Schiffermüller), *Sitochroa verticalis* (L.), *Hydriris ornatalis* (Duponchel) and *Brachmia triannulella* (Herrich-Schaffer); the leaf mining Lepidoptera *Bedellia somnulentella* and *Stigmella* sp. and the buprestid *Trachys puncticollis* var. *obscurella.* Other leaf feeders active at this season include *Eriophyes* sp. and the caterpillars of *Tyta luctuosa* (Denis and Schiffermüller), *Aedia leucomelas* (L.) and *Emmelia trabealis* (Scopoli). The Homoptera *Philaenus spumarius* and *Selenocephalus pallens* Lindberg are common on the stems, while root-feeding Pseudococcidae are found in some locations. *Spermophagus sericeus* is abundant in the flowers and seeds, and Pentatomidae are commonly sucking on the developing seed capsules. During the hot, dry Mediterranean summer, field bindweed above-ground growth largely dies back, but Pseudococcidae are still found on the roots, and *Galeruca rufa* and an occasional caterpillar may be seen feeding on the remaining foliage. The Tetranychidae may heavily attack the leaves at this time. The fungus *Erysiphe convolvuli* is common from July on and is associated with the drying of *C. arvensis* foliage.

After the first rains in late summer there is another spurt of above-ground *C. arvensis* growth. During the fall, nutrients are stored in underground plant parts that will overwinter. The most prevalent herbivores at this season are the leaf-feeding Lepidoptera *Hydriris ornatalis, Bedellia somnulentella, Stigmella* sp., *Aedia leucomelas, Emmelia trabealis, Tyta luctosa* and *Agrius convolvuli. Erysiphe convolvuli* continues to be common on the foliage. *Eriophyes* sp., *Cicadella viridis* (L.), *Trachy puncticollis* var. *obscurella, S. sericeus* and the leaf-feeding Chrysomelidae are also present. *Longitarsus pellucidus* begins ovipositing in the fall and the larvae begin attacking the roots. *Melanagromyza albocilia* larvae and pupae are found in the stems and roots both early and late in the growing season and even in midwinter.

Collections on the Iberian Peninsula were not begun until May, so the early spring development of field bindweed and its associated fauna were not observed. However, in

the late spring and summer the fauna seems similar to that of Italy. Chrysomelidae are active, but two common Italian species, *Hypocassida meridionalis* and *Galeruca rufa,* which also occur in France, were not found in Spain or Portugal. *Trachys puncticollis* var. *obscurella's* distribution also does not extend south into the Iberian Peninsula, although the same leaf mining Lepidoptera found in Italy are numerous there. Other defoliators present are *Longitarsus pellucidus* and *L. nasturtii* (F.) or nr. adults in late spring and the Lepidoptera *Oidaematophorus monodactylus, Pterophorus pentadactyla, Hydriris ornatalis, Sitochroa verticalis, Aedia leucomelas, Emmelia trabealis* and *Tyta luctuosa.* A case-bearing caterpillar, probably *Dissoctena granigerella* Staudinger, destroys the flowers of *Convolvulus althaeoides* and *C. arvensis* in southern Portugal and the adjoining part of Spain. It was found feeding only on these plants, as expected from the hosts recorded by Lhomme (1923–49), although Staudinger (1859) said it feeds on various plants. The Pentatomidae are common on the developing seed capsules. Bruchidae adults in the genera *Bruchidius* and *Spermophagus* are numerous in the flowers, but only *Spermophagus* larvae, especially those of *S. sericeus,* actually develop in *Convolvulus* seeds. Pseudococcidae occur on *C. arvensis* roots in cultivated fields and citrus groves along the eastern coast of Spain. In the warmer parts of southern Spain the powdery mildew, *Erysiphe convolvuli,* is found as early as May, but it is not generally common until July.

As in Italy, the most noticeable Iberian defoliators in the fall are caterpillars. In Spain and Portugal two to three times as many caterpillars fed on leaves in September and October as there were at the same locations earlier in the years. These large Lepidoptera populations extensively defoliate the plants. The same species found in the summer are prevalent during the fall with the addition of *Agrius convolvuli, Onebala lamprostoma* (Zeller) and *Spodoptera littoralis* (Boisduval). *Longitarsus pellucidus, S. sericeus* and *Erysiphe convolvuli* continue to be present. *Melanagromyza albocilia* was not found on the Iberian peninsula.

Most promising organisms for biological control

Root and stem feeders. Longitarsus pellucidus is a widespread and abundant leaf feeder as an adult, but the root feeding larvae were not encountered often, and their ability to damage *C. arvensis* is unknown. It is recorded from a number of wild and cultivated plants, but is mainly associated with members of the Convolvulaceae (Jolivet, 1967). In our field collections, it was found on species of *Convolvulus* and *Calystegia.* As it was the most common root feeder on *Convolvulus arvensis* (and a root-destroying organism would seem to be the best biological control agent for this plant), it was studied in spite of its polyphagous record in the literature. In laboratory tests during August, 1973, 20 adults fed only 40 percent as much on sweet potato leaves as 20 others did on field bindweed. They survived well when sweet potato was their only food, but reproduction on either plant did not occur during this experiment. Attempts to rear larvae in the laboratory were unsuccessful, so their ability to complete development or reproduce on sweet potato was not established. The hymenopterous parasite *Microctonus* sp. (Braconidae) was reared from an adult *Longitarsus* sp.

Melanagromyza albocilia bores mainly in the center of the stem, but its burrows may extend down into the roots. At the upper end of the burrow a hole is opened to the outside, and the insect pupates near this hole. Infested plants showed no damage externally but were physically weakened at the point where the emergence hole was formed.

Because of its size and method of feeding, this fly appears to cause little harm to its host. Although these flies were found at many collecting sites in Italy, they were not found in large numbers. Perhaps this was due either to natural enemies or because their presence could only be detected when the plants were dissected, so their host specificity was not studied. *Melanagromyza albocilia* was only found in *C. arvensis* and *C. althaeoides* stems and is considered to be a specific feeder by Spencer (1973). A related species, *M. convolvuli* Spencer, was studied in Pakistan by Baloch (1977a) who found this species able to complete development on *Ipomoea batatas* and *I. purpurea.* The cecidomyid *Lasioptera convolvuli* Felt is known from the stems of *C. arvensis* and *Calystegia sepium* in North America (Mohyuddin, 1969a).

Seed feeders. The most important seed feeding insects found on *C. arvensis* were the Bruchidae. Four species of *Spermophagus* were reared from *C. arvensis* seeds. The most common one was *S. sericeus.* This genus is associated with Convolvulaceae, and *S. sericeus* is known from seeds of *Convolvulus* and *Calystegia* (Southgate, 1979). It was reared from field-collected seeds of *Convolvulus arvensis, C. althaeoides,* and *Calystegia sepium.* Usually only a small percentage of seeds were attacked, but a 40 percent infestation was found at Rome, and 65 percent of the seeds collected near Venice were infested. In the laboratory during June, 1972, adults oviposited on developing seed capsules of *Convolvulus tricolor, Ipomoea purpurea* and *Ipomoea* sp. In Greece, however, *S. sericeus* larvae only developed in the seeds of *Convolvulus* and *Calystegia* (Rosenthal and Lambrou, in preparation). The hymenopterous parasites *Bruchophagus* sp. (Eurytomidae), *Dinarmus acutus* Thomson (Pteromalidae) of *S. sericeus* were found in Italy. *Megacerus discoidus* (Say) occurs in seeds of *Calystegia sepium, Convolvulus arvensis, Ipomoea tiliacea* (Willd.) Choisy and *I. leptophylla* Torr. in North America (Teran and Kingsolver, 1977) and was considered by Mohyuddin (1969a) as the most promising candidate for biocontrol of *C. arvensis* from Canada. In California, *M. impiger* (Horn) is in the seeds of *Calystegia* spp. and, rarely, in the seeds of *Convolvulus arvensis* (Schlising, 1980). Further study of *M. discoidus* and *M. impiger* should be conducted before *S. sericeus* is introduced into North America.

Defoliators. Because it is widespread and active from March until November, i.e., the whole *C. arvensis* growing season, *Galeruca rufa* is the most important defoliator of that plant in Italy. In 1973 during laboratory tests, 40 adults, 20 newly hatched larvae and 20 medium-sized larvae, tested separately, fed no more than 20 percent as much on *Ipomoea batatas* as equal numbers of others fed on *C. arvensis,* and the larvae could not complete development on *I. batatas.* From field observations and more extensive host specificity studies using a larger number of plant species, *G. rufa's* host range appears restricted to species of *Convolvulus* and *Calystegia* (Rosenthal and Carter, 1977). In 1977 *G. rufa* was tested further because one record was found listing *Salvia aethiopis* L. as a host (Bogavac and Mitič-Muźina, 1972). Here, 30 adults and 30 half grown larvae barely fed on *S. aethiopis* and *Mentha piperita* L., a commercially grown mint, and 30 newly hatched larvae did not feed at all on the mints compared with the same number of insects that did feed on *C. arvensis.* No larvae developed on Labiatae either in this laboratory experiment or in field cages when 60 newly hatched larvae were placed on each plant species. From these tests, *S. aethiopis* does not appear to be a true host of *G. rufa.* In field cage studies during 1977, moderate populations of *G. rufa* caused defoliation that was severe enough to lower *C. arvensis* flower production and kill seedlings (Rosenthal and Hostettler, 1980). Besides the two fungal pathogens and the parasite, since described as *Asecodes galerucae* Askew (Askew and Viggiani, 1978), recorded by Rosenthal and Carter (1977), a microsporidian protozoan, *Nosema* sp., infects the adults.

The Cassidinae are also important *C. arvensis* defoliators. The most abundant and widespread species in southwestern Europe is *Hypocassida subferruginea,* however, *H. meridionalis* and *C. rubiginosa* Müller are also common. *Cassida atrata* F. was common at several locations and defoliated small infestations near Rome. From literature records, *C. rubiginosa* is a polyphagous pest (Balachowsky, 1963; Jolivet, 1967), *C. atrata* is known from *Salvia* (Porta, 1923–32) and both *H. meridionalis* and *H. subferruginea* are recorded as specific to species of *Convolvulus* and *Calystegia* (Jolivet, 1967). During 1972, six *H. subferruginea* adults fed 16.4 percent as much on sweet potato as six others fed on field bindweed. Six adults given a choice of the two plants ate 32.5 percent as much sweet potato as field bindweed and laid all of their eggs on the sweet potato. Twenty eight newly hatched larvae fed only 6 percent as much on sweet potato as controls did on *C. arvensis;* only four survived the 5-day test, and none of them completed development on sweet potato. During 1975, 30 newly hatched larvae of *Cassida atrata* ate 6.6 percent as much *I. batatas* as controls ate of *Convolvulus arvensis* and did not complete development on *I. batatas.* In the field, *H. subferruginea* was collected on *C. arvensis, C. althaeoides,* and *Calystegia sepium,* while *Cassida atrata* was found on *Convolvulus arvensis* and *Calystegia sepium.* Cassidinae are common on *Convolvulus arvensis* in other parts of the world. Baloch (1974, 1977b) found *Cassida indicola* Duv., *C. enervis* Boheman, *Aspidomorpha indica* Boheman, *Glyphocassis trilineata* (Hope) and *Metriona australica* (Boheman) in Pakistan. In Canada, Mohyuddin (1969b) studied *Chelymorpha cassidea* (F.), *Metriona bicolor* (F.), and *Chirida guttata* (Oliver) and listed (Mohyuddin, 1969a) nine more from different parts of the world. The eight species studied by Baloch and Mohyuddin all commonly breed on *Ipomoea batatas,* and, as real or potential sweet potato pests, are of no value for biological control.

Feeding by *Eriophyes* sp. causes leaf distortion and galling. Attack begins in the buds, and heavily infested shoots become stunted and deformed stubs. During 1972, *Eriophyes* infested *C. arvensis* leaves were attached to 10 small sweet potato plants, grown from cuttings, and to 10 *C. arvensis* seedlings. In 3 days when sufficient mites had moved onto the plants excess numbers were removed leaving 25 mites/plant. Six days later there was an average of 46.1 mites on each of 7 live *C. arvensis* seedlings, one plant was so badly galled the mites couldn't be counted, and 2 plants had been killed by the mites. The sweet potato plants were free of *Eriophyes* except for 2 that had 1 and 8 mites, respectively. After 6 more days, only 1 mite remained on sweet potato and there had been no reproduction on it. On the field bindweed seedlings there were 33.7 mites/plant, 5 plants were dead and the others heavily galled. There were numerous *Eriophyes* eggs or spermatophores on *C. arvensis.* In the field, Eriophyidae damage was seen on *C. althaeoides* as well as on *C. arvensis. Eriophyes convolvuli* (Nalepa) is known from *C. arvensis* in Europe (Buhr, 1964), but no gall mites are known to attack it in North America.

The other significant external leaf feeders are all Lepidoptera. One or more species of Pterophoridae, the 3 Noctuidae *Tyta luctuosa, Emmelia trabealis* and *Aedia leucomelas* and the Pyralid *Hydriris ornatalis* were found at most collecting sites. The Pterophoridae are most common in spring and early summer while the others are most numerous in the fall and, especially the Noctuidae, occur even where *C. arvensis* populations are low and widely dispersed.

The most common species of Pterophoridae are *Oidaematophorus monodactylus* and *Pterophorus pentadactyla*—the latter considered specific to *Convolvulus* spp. by Meyrick (1927) and Beirne (1952), but polyphagous by Hrubý (1964) and Mohyuddin (1969a). Newly hatched larvae were tested for feeding on sweet potato during 1973: 20 larvae

ate 28.4 percent as much sweet potato as 20 others did of field bindweed. They could not live more than 2 weeks or complete development on sweet potato. In the field they were collected on *C. arvensis* and *Calystegia sepium.* The dipterous parasite *Ligeria angusticornis* (LW) (Tachinidae) was reared from a *P. pentadactyla* larva feeding on field bindweed. *Oidomatophorus monodactylus* was also common on these two plants. The latter is a widely distributed species that occurs in North America and attacks sweet potato (Mohyuddin, 1969b).

During 1973 *Tyta luctuosa* larvae were tested for feeding and development on *I. batatas:* 20 newly hatched larvae and 15 medium sized larvae fed 4.3 percent and 8.6 percent as much, respectively, on *I. batatas* as the comparable individuals on *C. arvensis.* Test mortality was high when the larvae were fed *I. batatas,* and no larvae completed development. Since then *T. luctuosa* has been studied further; its host range was found to be restricted to species of *Convolvulus* and *Calystegia* (Rosenthal, 1978). *Aedia leucomelas* (Spuler, 1908) and *Emmelia trabealis* (Allan, 1949) are also recorded only from species of *Convolvulus* and *Calystegia.* In 1975, 20 large larvae of *A. leucomelas* fed heavily on sweet potato in the laboratory before going into winter diapause. That same fall, larvae were common on sweet potato plants growing in the laboratory garden in Rome. As these plants had been caged all summer, larvae had been living on *I. batatas* from the time they hatched or were very small. In 1973, 20 newly hatched *E. trabealis* larvae ate 65.7 percent as much sweet potato as 20 others ate of *C. arvensis;* 85 percent survived the test when fed sweet potato, and one completed development on that plant.

Hydriris ornatalis is a leaf roller known to be oligophagous on members of the Convolvulaceae (Lhomme, 1923–49). During 1975, 20 larvae ate 155 percent as much *I. batatas* as 20 others ate of *C. arvensis;* survival was good on both plants, and half of the larvae fed *I. batatas* completed development. *Hydriris ornatalis* adults were also reared from *I. batatas* growing in the laboratory garden. While this species has a wide world distribution, it has never been reported as a sweet potato pest.

Chrysocrambus linetellus is another Pyralidae that was common on *C. arvensis* and *Calystegia sepium* in Italy and Austria. While references to the adult are common in the taxonomic literature, the larval biology is unknown (Bleszynski, 1965). In 1974, 10 large larvae and 10 newly hatched larvae ate 51.3 and 77.3 percent respectively, as much of *I. batatas* as the controls ate of *Convolvulus arvensis;* survival was good on *I. batatas* and 40 percent of the larvae were able to complete development.

Brachmia triannulella is a Gelechiidae known only from *C. arvensis* and *Calystegia sepium* (Mohyuddin, 1969a). This distinctive larva was commonly seen in rolled leaves of these plants. During 1975, 20 newly hatched larvae and 10 medium-sized larvae fed 29.6 and 119.5 percent respectively, as much on sweet potato as the controls on *C. arvensis.* Survival was good on sweet potato; 30 percent of the new larvae and 80 percent of the older larvae fed sweet potato pupated. The ichneumonid parasite *Triclistus* sp. was reared from a *B. triannulella* pupa. *Onebala lamprostoma* was common during September and October along the coastal plain of eastern Spain. The larvae tie one or more leaves into a tight shelter, then feed within the leaves as blotch miners. While most of the larvae were found on *C. althaeoides* they were also collected from *C. arvensis.* They are only recorded in the literature from *C. althaeoides* (Walsingham, 1908) and *C. microphyllus* (Baloch, 1974). During 1975, 14 newly hatched larvae fed 180.2 percent as much on *I. batatas* as the controls on *C. arvensis.*

The blotch leaf mines of *Bedellia somnulentella* and the serpentine leaf mines of *Stigmella* sp. were seen almost everywhere. As *B. somnulentella* already occurs in the USA and is a known pest of sweet potato (Parella and Kok, 1977) it was not tested.

The *Stigmella* sp. may be *S. freyella* Heyden which is known from species of *Convolvulus* and *Calystegia* (Hering, 1957, Spuler, 1908). In the field, *Stigmella* sp. was obtained from the leaves of *C. arvensis, C. althaeoides* and *Calystegia sepium.* Because of the difficulty of rearing it in the laboratory it was not tested. Besides these two Lepidoptera, the buprestid *Trachys punticollis* var. *obscurella* was very common in Italy. Its larvae and pupae are found in blotch mines that characteristically begin at a corner of the leaf edge where the egg is deposited. Adults feed externally on the leaves. It is known from *Convolvulus* spp. (Hering, 1957). In the field, mines were found in the leaves of *C. arvensis, C. althaeoides* and *Calystegia sepium.* When given a choice, in the laboratory during 1973, 24 adults (in two cages) fed 85 percent as much on *I. batatas* leaves as on *C. arvensis* leaves over a 16-day period. No eggs were deposited in the laboratory, so larvae were not tested. The braconid parasite *Bracon* sp. emerged from *T. puncticollis* var. *obscurella* larvae and the Eulophidae *Pnigalio* sp., *Ratzeburgiola* sp. and *Trichomalus* sp.? emerged from its mines.

Plant pathogens. None of the fungus pathogens seemed to be damaging to field bindweed except the powdery mildew, *Erysiphe convolvuli,* but this latter could have appeared at the same time as the summer die-back of *C. arvensis* only because of both being related to the onset of hot, dry weather. Powdery mildew was also seen on *C. althaeoides* and *Calystegia sepium,* but these mildews were not identified. *Erysiophe convolvuli* is known from *C. sepium* as well as *Convolvulus arvensis* (Pantidou, 1973). *Puccinia convolvuli* was found only on *Calystegia sepium,* but is known to attack *Convolvulus arvensis* and other members of that genus (Arthur, 1962). Hasan (1973) suggested that *P. convolvuli* be studied as a potential biological control agent for *C. arvensis.* This rust, known from a wide variety of hosts, already occurs in North America (Arthur, 1962). *Alternaria tenuissima* is a cosmopolitan species that is usually a secondary invader rather than a primary pathogen (Ellis, 1971).

Three insects, not listed in the table because they were not seen damaging *C. arvensis,* may be found to influence its natural control when their biologies are better known. *Acmaeodera convolvuli* Waltl (= *A. cylindrica* (F.)) (Buprestidae) adults were found on *C. althaeoides* flowers in Portugal. Adults of this species are always associated with *Convolvulus* flowers, but the larval food habits are unknown (Thery, 1942). The coccinellid *Thea 22-punctata* L. is not phytophagus, but is a fungus feeder (Imms, 1957). Fungus diseases are common on *C. arvensis,* and there is the possibility that *T. 22-punctata* could spread the spores on its body and thus spread the diseases. A *Eurytoma* sp. emerged from seeds collected for the emergence of Bruchidae. This could be a parasite of the beetles or a seed feeder itself.

CONCLUSIONS

Results of these surveys and host specificity testing indicate that European organisms are promising for use as biocontrol agents against *C. arvensis* in the USA. The arthropods *Galeruca rufa, Spermophagus sericeus,* and *Eriophyes* sp. probably have the most potential. *Tyta luctuosa* is the only one of the larger lepidopterous defoliators that does not complete development on sweet potato, and it may be of some value. *Hypocassida subferruginea* and *Pterophorus pentadactyla* are both damaging to *C. arvensis* in Europe and appear to be sufficiently host specific, but other Cassidinae and Pterophoridae are already important *C. arvensis* defoliators in North America. *Longitarsus pellucidus,*

Stigmella sp. and *Erysiphe convolvuli* may be found useful after further research on their host specificity and effects on this weed.

However, no organisms seem to be strictly monophagous on *C. arvensis.* Except for *Melanagromyza albocilia* and *Eriophyes* sp. which are known only from two species of *Convolvulus,* all the most nearly host specific feeders feed on species of both *Convolvulus* and *Calystegia.* Other members of the tribe Convolvuleae have not been used in host specificity tests. As *Calystegia sepium* is an important pest, and insects are being studied for its biological control, there is some advantage in having this degree of oligophagy in these biocontrol agents. Another advantage is that theoretically they may be more damaging to their host than strictly monophagous organisms (Harris, 1973). Thus, oligophagous organisms should be good for the biological control of *Convolvulus arvensis* within the limits of safety. As there are no commercially valuable plants in the genera *Convolvulus* and *Calystegia,* these oligophagous organisms are not likely to become economic pests. There are related species in both genera that are native to North America, and recently there has been concern that an agent released for biocontrol of *C. arvensis* might damage the native California flora. However, because of the seriousness of *C. arvensis* as a weed (Jansen et al., 1972; Holm et al., 1977), the difficulty and expense of its control by cultivation, competitive crops and herbicides (Wiese and Rea, 1959; Schweitzer et al., 1978); and the presence of herbicide-resistant populations (Whitworth and Muzick, 1967) biological control should be attempted against this pest as soon as possible.

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APPENDIX

PHYTOPHAGOUS ARTHROPODS ASSOCIATED WITH *CONVOLVULUS ARVENSIS* AND CLOSELY RELATED PLANTS IN WESTERN MEDITERRANEAN EUROPE.

Insects	Relative frequency[1]	Collected in: Country[2]	Months[3,4]	Plant association[5]	Host specificity[6]	Source of record[7]
ACARI						
Eriophyidae						
Eriophyes sp. (Not *E. convolvuli* Nalepa)	LC	I,S	4-10(N,A)	EXT-L	C	Pers.
Tetranychidae						
Tetranychus cinnabarinus Boisduval	C	I	7-9	EXT-L(A)	Poly Pest	Jeppson, et al 1975
T. urticae Koch	C	I	7-10	EXT-L(A)	Poly, Pest	Jeppson, et al 1975
COLLEMBOLA						
Sminthuridae						
Sminthurus viridis L.	LC	I	10	EXT-L(N,A)	Poly, Pest	Edwards & Heath, 1964
THYSANOPTERA						
Thripidae						
Scolothrips sp.	R	I	7	EXT-L(A)	C	Pers.
Thrips tabaci Lindeman	R	I	7,10	EXT-L(A)	Poly, Pest	Metcalf & Flint, 1962
HEMIPTERA						
Pentatomidae						
Aelia acuminata (L.)	LC	S	7(A)	EXT-SC	Poly.	Stichel, 1955-62
Carpocoris mediterraneus Tamanini	LC	S	5,7(A)	EXT-SC	Poly.	Stichel, 1955-62
Dryoderes umbraculatus (F.)	LC	S	5(A)	EXT-SC	Poly.	Stichel, 1955-62
Eurydema oleraceum (L.)	LC	S	7(A)	EXT-SC	Poly.	Stichel, 1955-62
Holeostethus strictus (F.)	LC	S	5(A)	EXT-SC	Poly.	Stichel, 1955-62
Nezara viridula (L.)	C	I,S	7-9(A,N)	EXT-L,SC	Poly, Pest	Metcalf & Flint, 1962
HOMOPTERA						
Cercopidae						
Cercopis sanguinolenta (Scopoli)	C	Y	6(A)	EXT-L,F	Poly, Pest	Grandi, 1951
Philaenus spumarius (L.)	C	F,I,Y,	2-6(N) 6(A)	EXT-St	Poly, Pest	Bonnemaison 1962
Cicadellidae						
Cicadella viridis (L.)	C	I	9,10(N,A)	EXT-St	Poly, Pest	Grandi, 1951
Platymetopius sp.	R	S	5(A)	EXT-St	C	Pers.
Selenocephalus pallens Lindberg	C	I,Y	6(A)	EXT-St	Poly.	Kaltenbach, 1874 & Melichar, 1895 & Pers.
Delphacidae						
Asiraca clavicornis (F.)	LC	A,Y	6(A)	EXT-L, St	Poly.	Edwards, 1896
Psyllidae						
Trioza sp.	R	I	8	EXT-L(N)	C	Pers.
Aphididae						
Aulacorthum solani (Kalenbach)	R	Y	6(A,N)	EXT-L	Poly, Pest	Edwards, 1896
A. speyeri Börner	R	I	10(A,N)	EXT-L	*Convallaria;* C	Borner, 1952; Pers.
Macrosiphum euphorbiae (Thomas)	R	S	10(A,N)	EXT-L	Poly, Pest	Metcalf & Flint, 1962
Myzus persicae Sulzer	C	P,Y	5,6(A,N)	EXT-L	Poly, Pest	Metcalf & Flint, 1962
Ortheziidae						
Orthezia sp.	R	I	7,8	EXT-L(N)	C	Pers.
Pseudococcidae						
Planococcus sp, prob. *citri* (Risso)	LC	I,S	5,8 (N,A)	EXT-R	Poly, Pest	Borror et al., 1976
Phenococcus sp.	R	I	8(N,A)	EXT-R	C	Pers.
Pseudococcus longispinus (Targioni-Tozzetti)	LC	S	5(N,A)	EXT-R	Poly, Pest	Borror et al, 1976

table continued

APPENDIX *cont.*

Insects	Relative frequency[1]	Collected in: Country[2]	Months[3,4]	Plant association[5]	Host specificity[6]	Source of record[7]
COLEOPTERA						
Buprestidae						
Trachys puncticollis Abeille var. *obscurella* Obenberger	A	F,I	5-9(L)	EXT-L(A)	CC	Hering, 1957
Elateridae						
Adrastus limbatus (F.)	R	Y	6(A)	EXT-L	willow; C	Reitter, 1911; Pers.
Nitidulidae						
Meligethes solidus Kugelann	R	S	7(A)	EXT-F	Poly	Porta, 1923-32
Meligethes spp. (4 species)	C	A,Y	6(A)	EXT-F	C	Pers.
Coccinellidae						
Subcoccinella 24-punctata (L.)	R	I	10(A)	EXT-L	Poly, Pest	Balachowsky, 1963
Tenebrionidae						
Gonocephalum pusillum (F.)	R	I	5(A)	EXT-L	Poly, Pest	Balachowsky, 1963
Stenosis augustata Herbst	R	I	5(A)	EXT-L	C	Pers.
Lagriidae						
Lagria hirta F.	R	I	10(A)	EXT-L	C	Pers.
Bruchidae						
Spermophagus sericeus (Geoffroy)	A	I,P,S	5-11(A)	EXT-F(A) INT-S(L)	CC	Southgate, 1979
S. variolosopunctatus Gyllenhal	C	P.S.	5(A)	EXT-F	C	Grandi, 1951
Spermophagus sp.	C	I	5(A)	EXT-F	C	Pers.
S. nr. but not *sericeus*	C	Y	6(A)	EXT-F(A)	C	Pers.
		S	9(L)	INT-S(L)		
Chrysomelidae						
Altica oleraeca (L.) or nr.	C	I,S	7,9,10(A)	EXT-L	Poly, Pest	Balachowsky, 1963
Cassida atrata F.	LC	I	5,9,10 (A,L)	EXT-L	*Salvia;* C	Freude, et al, 1966; Pers.
C. rubiginosa Müller or nr.	C	I,S,Y	5,6(A)	EXT-L	Poly	Balachowsky, 1963.
C. vittata Villers or nr.	R	Y	6(A)	EXT-L	Poly, Pest	Balachowsky, 1963
Cassida weimanni Chap.	R	I	8(E,L) 10(A)	EXT-L	C	Pers.
Cassida sp.	R	P,S	5(A)	EXT-L	C	Pers.
Chrysolina banksi (F.) or nr.	R	Y	6(A)	EXT-L	Poly, Pest	Balachowsky, 1963
Coptocephala chalybea Germar or nr.	R	P	5(A)	EXT-L	C	Pers.
Cryptocephalus sp.	R	I	10(A)	EXT-L	C	Pers.
Exosoma lusitanica (L.)	C	I,S	5(A)	EXT-F	Poly	Jolivet, 1967
Galeruca rufa Germar	A	F,I	3-11(A) 5-10(L)	EXT-L	CC	Rosenthal & Carter, 1977
Gastrophysa polygoni (L.)	LC----------I R---------- S		8,10(E,L,A)	EXT-L	Poly, Pest	Balachowsky, 1963
Hypocassida meridionalis (Suffrian) or near	C	I	7,8	EXT-L	CC	Jolivet, 1967
H. subferruginea Schrank	A	I,P,S,Y	6-8(E,L) 5-7,9(A)	EXT-L(A,L)	CC	Jolivet, 1967
Longitarsus longipennis Kutsch or nr.	R	Y	6(A)	EXT-L	Poly, Pest	Balachowsky, 1963
L. nasturtii (F.) or nr.	C	P,S	5(A)	EXT-L	Poly, Pest	Balachowsky, 1963
L. pellucidus Foudras or very nr.	A	F,I,S, Y	4-6(A) 9-10(A)	EXT-L(A) INT-R(L)	Poly	Jolivet, 1967
Oulema melanopus (L.)	R	I	5(A)	EXT-L	Poly, Pest	Balachowsky, 1963

table continued

APPENDIX *cont.*

Insects	Relative frequency[1]	Collected in: Country[2]	Months[3,4]	Plant association[5]	Host specificity[6]	Source of record[7]
Phyllotreta consobrina Curtis or nr.	R	I	4(A)	EXT-L	Poly, Pest	Balachowsky, 1963
Podagrica malvae Illiger or nr.	C	I	10(A)	EXT-L	Poly, Pest	Balachowsky, 1963
Psyllioides glabra (Duftschm.) or nr.	R	I	10(A)	EXT-L	C	Pers.
Psyllioides sp.	R	I	5(A)	EXT-L	C	Pers.
Smaragdina sp.	R	P	5(A)	EXT-L	C	Pers.
Sphaeroderma testaceum Weise or nr.	R	S	5(A)	EXT-L	Poly, Pest	Balachowsky, 1963
Curculionidae						
Apion alliareae (Herbst)	R	Y	6(A)	EXT-L	Poly	Balachowsky & Mesnil, 1935-36
A. pisi F.	C	I	9,10(A)	EXT-L	Poly, Pest	Balachowsky, 1963
Apion sp.	R	I	10(A)	EXT-L	C	Pers.
Ceutorhynchidius baldensis Schultze	R	I	9(A)	EXT-L	Poly	Hoffman, 1958
C. macculaalba (Herbst)	R	I	4(A)	EXT-L	Poly	Balachowsky, 1963
Hypera postica (Gyllenhal)	R	I	5,10(A)	EXT-L	Poly, Pest	Balachowsky, 1963
Limnobaris pilistriata (Stephens)	R	I	4(A)	EXT-L	Poly	Hoffman, 1958
Lixus iridis Olivier	R	I	5(A)	EXT-L	Poly, Pest	Balachowsky, 1963
Otiorhynchus sp.	R	I	5(A)	EXT-L	C	Pers.
Pachytychius squamosus (Gyllenhal)	R	I	5(A)	EXT-L	Poly, Pest	Balachowsky, 1963
Sitona limosus Rossi	R	I	4(A)	EXT-L	Poly, Pest	Balachowsky, 1963
S. lineatus (L.)	R	P	5(P)	EXT-L	Poly, Pest	Balachowsky, 1963
Strophomorphus sp. nr. *porcellus* (Schönherr)	R	I	10(A)	EXT-L	C	Pers.
Tanymecus palliatus (F.)	R	I	7(A)	EXT-L	Poly, Pest	Balachowsky, 1963
Phalacridae						
Olibrus (2 species)	R	I		EXT-F	CC	Pers.
Stilbus sp.	C	I	5,9,10(A)	EXT-F	CC	Pers.
Scarabaeidae						
Chasmatopterus sp.	C	P	5(A)	EXT-F	C	Pers.
Oxythyrea funesta Poda	C	S	5(A)	EXT-F	Poly, Pest	Balachowsky, 1963
Tropinote hirta Poda	C	S	5(A)	EXT-F	Poly, Pest	Balachowsky, 1963
LEPIDOPTERA						
Pyralidae						
Chrysocrambus linetellus (F.)	C	A,I	6(L)	EXT-L	Conv.	Pers.
Hydrisis ornatalis (Duponchel)	A	A,I,P,S,Y	5-11(L,P,A)	EXT-L	Conv.	Lhomme, 1923-49
Noctuelia floralis (Hübner)	LC	I	8(A)	EXT-L, St	*Tribulus*, Conv.	Baloch, 1977
Pyrausta cespitalis (Denis & Schiffermüller)	C	I----------7(L) S----------9(A)		EXT-L	*Plantago*; Poly.	Meyrick, 1927; Hrubý, 1969
Sitochra (Loxostege) verticalis (L.)	C	I,Y----------6(L) S----------7(L)		EXT-L	Poly	Meyrick, 1927
Titanio normalis Hübner, prob.	R	S,I	5(L)	INT-L	CC	Hering, 1957
Pyraustinae, unidentified sp.	LC	I	10(L)	EXT-L	C	Pers.

table continued

APPENDIX *cont.*

Insects	Relative frequency[1]	Collected in: Country[2]	Months[3,4]	Plant association[5]	Host specificity[6]	Source of record[7]
Pterophoridae						
Oidaematophorus monodactylus (L.)	C	I,S	4-10(ELPA)	EXT-L	Poly	Mohyuddin, 1969b
Pterophorus pentadactyla (L.)	C	S---------- A,I,Y---------	5(A) 6-9(L) 7-9(A)	EXT-L	C; Poly	Meyrick, 1927 Hrubý, 1964
Stenoptilia pterodactyla (L.), prob.	LC	Y---------- S----------	6(L) 10(L)	EXT-L	Poly	Lhomme, 1923-49
Olethreutidae						
Argyroploce sp. nr. *arbutella* L.	C	A	6(L)	EXT-L	Conv.	Pers.
Tortricidae						
Argyrotaenia pulchellana (Haworth)	LC	I	6(A), 10(L)	EXT-L	Poly, Pest	Balachowsky, 1966
unidentified sp.	R	I		EXT-L	C	Pers.
Archips crataeganus (Hübner)	R	A	6(L)	EXT-L	Poly	Bradley et al, 1973
Cacoecimorpha pronuba (Hübner)	LC	I,S	6(P) 9(L)	EXT-L	Poly	Bradley et al, 1973
Paracelypha rivulana Scopoli	C	I	9(P), 5(A)	EXT-L	Poly	Spuler, 1908
Spanganothis pilleriana (Denis & Schiffermüller)	R	A	6(L)	EXT-L	Poly, Pest	Bradley et al, 1973
Gelechiidae						
Brachmia triannulella (Herrich-Schäffer)	C	A,I,Y	6-8,10(L)	EXT-L	Conv.	Spuler, 1908
Brachmia sp.	R	I	7(L)	EXT-L	C	Pers.
Onebala lamprostoma (Zeller)	LC	S	9,10(L)	INT-L	C	Baloch, 1974
Oecophoridae						
Pleurota sp.	R	I	5(L)	EXT-L	C	Pers.
Scythridae						
Scythris sp.	R	I	8(L)	EXT-L	C	Pers.
Lyonetiidae						
Bedellia somnulentella (Zeller)	A	I,P,S	7-11(L,P)	INT-L	Conv, Pest	Parella & Kok, 1977
Psychidae						
Dissoctena granigerella Staudinger, prob.	LC	P,S	5(L)	EXT-F	Poly; C	Staudinger, 1859; Lhomme, 1923-49
Nepticulidae						
Stigmella sp.	A	A,F,I,P,S	5-11(L)	INT-L	CC	Pers.
Geometridae						
Boarmia selenaria (Schiffermüller)	R	I	7(L)	EXT-L	Poly, Pest	Grandi, 1951
Chiasmia clathrata (L.)	R	I	5,8(L)	EXT-L	Leguminosae; C.a.	Allan, 1949; Pers.
Ematunga atomania orientaria Staudinger	LC	I	8,10(L)	EXT-L	Poly, Pest	Grandi, 1951
Larentia clavaria (Haworth)	R	I	5(L)	EXT-L	Malvaceae; CC	Allan, 1949; Pers.
Nyssia florentina Stephan	LC	I	5,6(L)	EXT-L	Poly, Pest	Grandi, 1951
Sterrha sp.	R	I	7(L)	EXT-L	C	Pers.
Timandra amataria (L.)	R	I	7(L)	EXT-L	Poly	Allan, 1949
Noctuidae						
Aedia leucomelas (L.)	C	I,S	6-7, 9-10(L)	EXT-L	Conv.	Spuler, 1908
Agrotis seteum (Denis & Schiffermüller)	R	I	7	EXT-L	Poly, Pest	Edwards & Heath, 1964
Anepischetos lividalis (Hübner)	R	S	9(L)		*Parietaria;* C	Seitz, 1914; Pers.
Autographa gamma (L.)	C	I,S,Y	5-7, 10(L)	EXT-L	Poly, Pest	Meyrick, 1927
Axylia putris (L.)	R	I	10(L)	EXT-L	Poly	Allan, 1949
Chrysodeixis chalcytes (Esper)	R	I	9(L)	EXT-L	Poly, Pest	Forster & Wohlfahrt, 1971

table continued

APPENDIX *cont.*

Insects	Relative frequency[1]	Collected in: Country[2]	Months[3,4]	Plant association[5]	Host specificity[6]	Source of record[7]
Eilema sp	R	I	9(L)	EXT-L	C.s.	Pers.
Emmelia trabealis (Scopoli)	A	A,F,I, S,Y	5-9(A) 6-10(L)	EXT-L	C.a.; Conv.	Meyrick 1927; Pers.
Leucania sp.	R	S	9(L)	EXT-L	C	Pers.
Mamestra brassicae (L.)	R	I	12(L)	EXT-L	Poly, Pest	Meyrick, 1927
Peridroma saucia Hübner	R	I	6,10(L)	EXT-L	Poly, Pest	Metcalf & Flint, 1962
Pharetra rumicis (L.)	R	I	8(L)	EXT-L	Poly	Meyrick, 1927
Polia oleracea (L.)	LC	I	8,10(L)	EXT-L	Poly	Meyrick, 1927
Rivula sericealis (Scopoli)	R	F	6(L)	EXT-L	Poly	Allan, 1949
Scotogramma sp. *trifolii?* (Hufnagel)	LC	I	10(L)	EXT-L	Poly	Grandi, 1951
Spodoptera exigua (Hübner)	R	Y	6(L)	EXT-L	Poly, Pest	Metcalf & Flint, 1962
S. littoralis (Boisduval)	LC	S	9-10(L)	EXT-L	Poly, Pest	Jolivet, 1977
Synthymia fixa F.	R	S	5(L)	EXT—L	*Psoralea;* C	Seitz, 1914; Pers.
Tyta luctuosa (Denis & Schiffermüller)	A	A,F,I, P,S,Y	4-10(A) 5-10(L)	EXT-L	CC	Rosenthal, 1978
Xylena vetusta Hübner	R	A	6(L)	EXT-L	Poly	Meyrick, 1927
Sphingidae						
Agrius convolvuli L.	C	F,I,S,	8(E)8-10(L)	EXT-L	Poly, Pest	Allan, 1949
Hesperiidae						
unidentified sp.	R	I	10(L)	EXT-L	C	Pers.
DIPTERA						
Agromyzidae						
Melanagromyza albocilia Hendel	C	I	1,6,7,9-11 (L,P)	INT-St,C	C	Spencer, 1973

1 A = abundant, C = common, LC = locally common and R = rare.

2 A = Austria, F = France, I = Italy, P = Portugal, S = Spain, and Y = Yugoslavia.

3 Months are numbered 1 to 12.

4 Stages of insect development are given in parenthesis. A = adult, E = egg, L = larva, P = pupa, and N = nymph.

5 C = crown, F = flower, L = leaf, R = root, S = seed, SC = seed capsule, and St = stem. INT indicates internal feeding and EXT indicates external feeding.

6 Host plants are: C.a. = *Convolvulus arvensis* only, C.s. = *Calystegia septium* only, C = Convolvulus spp., CC = species of *Convolvulus* and *Calystegia,* Conv = members of the Convolvulaceae, and Poly = plants within the Convolvulaceae and other plant families.

7 Pers. = personal record. Used only where no published information about the arthropod's hosts was found or where our findings differ from published reports. All of the organisms listed will feed on *Convolvulus arvensis.*