

EXPLORATION FOR BIOTIC AGENTS FOR THE CONTROL OF *RUMEX CRISPUS*

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ABSTRACT

The Biological Control of Weeds Laboratory-Europe located in Rome, Italy has conducted surveys for biotic agents that might be utilized for the control of curly dock, *Rumex crispus*, in the United States. One hundred and ninety-eight species of insects have been identified from collections centred in Italy. A number of plant pathogens have also been collected and are under study in Switzerland. Preliminary host specificity tests have been conducted on several insect species.

INTRODUCTION

More than 200 species have been identified in the genus *Rumex*, and most of them are to be found in the northern temperate zones. Three distinctive features characterize the genus: an abundance of flowers arranged in whorls on simple or branched inflorescences, a jointed peduncle, and a double circlet of perianth segments surrounding the achene (Häflinger and Brun-Honl. 1976).

Rumex crispus L. is thought to be a native of Europe (Salisbury 1961), but its origin is obscured by its wide distribution. It is believed by Allard (1965) to be one of the 12 most successful non-cultivated colonizing species in the world. Hughes (1938) lists *R. crispus* as one of the five most widely distributed plants in the world's flora. A *R. crispus* plant may produce 100 to 40 000 seeds (Cavers and Harper 1964).

R. crispus, or curly dock is a perennial, reproducing by seed. The stout tap-rooted plant may reach 30 to 150 cm in height. The basal leaves are 4 to 5 times as long as wide, narrowly lanceolate, acute and usually cuneate at the base. The petiole is usually shorter than the lamina. Leaf margins undulate, a characteristic from which the name curly dock originates. Branches of inflorescence are erect or ascending, solitary; lower whorls are usually remote; pedicels 2 to 2½ times as long as the valves; $2N=60$. *R. Crispus* is an extremely variable species, with many interspecific hybrids recorded. Hybridization is exceedingly common between species of the subgenus *Rumex* (Cavers and Harper 1964).

The docks may harbour insect pests and plant diseases such as virus yellows. They compete freely with crops and will contaminate seed crops with their prolific seed production. Found throughout the United States, docks are mainly an agricultural problem in the Southeast. Problems occur in pasture and forage crops and in small grains. Research by Einhellig and Rasmussen (1973) showed that an aqueous solution of *R. crispus* was strongly inhibitory to the growth of grain sorghum and corn.

A decision was made in 1977 by Agricultural Research, Science and Education Administration, United States Department of Agriculture (AR-SEA-USDA) to begin foreign exploration for biotic enemies of this weed. Work was to be centred at the AR-SEA-USDA Biological Control of Weeds Laboratory Europe located in Rome, Italy.

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In 1969/70 Dr R.E. Inman studied the *R. crispus* pathogen, *Uromyces rumicis* (Schum.) Wint., to determine its potential as a biological control agent. The study was conducted at the Rome, Italy, laboratory under a U.S.D.A. grant to the Stanford Research Institute of Irwin, California (Frank 1971). The pathogen is widely distributed throughout Europe from the Iberian peninsula to Russia. It has also been reported in Africa, India, Japan, and Argentina. There have been three collections of *U. rumicis* made in the San Francisco, California (U.S.A.) area, the earliest dated 1903. Additional research on this pathogen is currently being conducted by Dr G. Defago at the Institute of Specialized Botany, Ecole Polytechnique Federale, 2, rue de l'Universite, Zurich, Switzerland, under a USDA-SEA-AR research grant. Dr Defago hopes to increase our knowledge of the alternate host, *Ranunculus ficaria* where pycnia and aeria may be produced. *U. rumicis* caused defoliation and reduced plant vigour in infected plants in Rome. Effects of different disease strains on plant vigour will be made in Zurich.

Masahisa and Naito (1973) conducted host specificity studies on the Coleoptera, Chrysomelidae, *Gastrophysa atrocyanea* as a possible biological agent for *R. obtusifolius* in Japan. Force (1966) studied the reaction of a second U.S. species of *Gastrophysa*, *G. cyanea* to its normal host species of the genus *Rumex* and certain non-host plants.

A third species, *Gastrophysa unicolor*, was studied in Spain by Garcia-Baudin and Santiago-Alvarez (1978) as a possible biological control agent for the docks. *G. viridula*, a more northern European species of the genus, has also been considered for use against the docks.

The host range of these *Gastrophysa* species seems wide; while they appear to be limited to the Polygonaceae they are not specific to a subgenus or genus within the family. This fact precludes the utilization of these species in the United States since they could conceivably feed upon native and economic species of Polygonaceae such as rhubarb, *Rheum rhabarbarum*, and buckwheat, *Fagopyrum esculentum*.

Cavers and Harper (1964) produced an excellent paper on *Rumex crispus* and *R. obtusifolius* as a part of the series on the biological flora of the British Isles. In the paper is a list of seven insect orders with 29 species reported to feed on the above species of *Rumex*. Also included is a list of 15 pathogens that were isolated from one of the two species. Table 1 is a list of pathogens isolated from *R. crispus* or *R. obtusifolius*. The information contained in the table was prepared from the literature by Dr Defago, Institute of Specialized Botany, Ecole Polytechnique Federale, Zurich, Switzerland.

The goals of the research program developed at the Rome Laboratory were to first determine the biotic agents associated with the plant in Italy and elsewhere in Europe, and secondly, to develop a biological baseline by a study of the biology of the host plant, *R. crispus*, under natural conditions in Italy. Specific chemicals that are present only at the species level were not thought to be present because of the quite common crossing of some species within the *Rumex* subgenus. Buckwheat, rhubarb, and species of docks considered to be food for wildlife narrowed the host range tolerance of any potential biological control agent.

MATERIALS AND METHODS

In order to adequately sample the phytophagous organisms associated with *R. crispus* and other species of the subgenus *Rumex* in Italy, five sites were

Table 1.— List of fungi on *Rumex crispus* L. and *R. obtusifolius* L.

Fungus	Substrate (plant part)	Country	Other hosts
<i>Ascomycotina</i>			
Discomycetes:			
<i>Pezizella dura</i> Vel.	Leaves	Czechoslov.	<i>Rumex</i> spp.
<i>Sclerotinia microspora</i> Vel.	Nerves	"	"
<i>Septatium rumicis</i> Vel.	Achenes	"	"
Loculascmycetes:			
<i>Glomiospis levantica</i> Rehm	Stems	—	—
<i>Mycosphaerella rumicis</i> (Desm.) W.B. Grove	—	—	—
<i>M. insulana</i> Bub. et Syd.	Dead leaves	—	Polygonaceae
<i>M. leptasca</i> Aueres	—	—	"
<i>M. polygonum</i> (Crie) Lind.	—	—	"
<i>Venturia rumicis</i> (Desm.) Wint.	Living leaves	—	—
Pyrenomycetes:			
<i>Amphorolopsis polygonaceorum</i> Petraik	Dead stems	Czechoslov.	<i>Rumex</i> spp.
<i>Diaporthe arctii</i> (Lasch) Nit.	—	—	—
<i>Erysiphe polygoni</i> de Cand. ex St. Amans f.sp.a.	Leaves	—	<i>Rumex</i> spp. not <i>R. acetosa</i> a. <i>R. acetosella</i>
<i>Leveillula</i> sp.	—	—	—
<i>Basidiomycotina</i>			
Hymenomycetes:			
<i>Armillaria mellea</i> (Vahl ex Fr.) Kummer	Spread from dead tree trunks to docks	—	—
Ustilaginales:			
<i>Ustilago kuebneana</i> Wolff	Ovaries Leaves Stems	Europe Central Asia	<i>Rumex</i> spp.
<i>U. bistortarum</i> (de Cand.) Korn.	Leaves	Europe USA	<i>Polygonum</i> spp.
<i>U. parlatoei</i> Fisch. de Waldh.	Stems Petioles	Europe, USA, Mexico	<i>Rumex</i> spp.
<i>U. lisui</i> Wang Yun-Chang	—	—	"
<i>U. warmingii</i> Rostrup	—	—	"
<i>Deuteromycotina</i>			
Coelomycetes:			
<i>Chaetopyrena rumicina</i> Ahmed	Stems	Pakistan	"
<i>Colletotrichum rumicis-crispi</i> Sawada	Leaves	Taiwan	—
<i>Coniothyrium rumicis</i> Pet.	Stems	Czechoslov.	—
<i>Diplodia volubilis</i> Sacc et Macbr. f. <i>rumicis</i>	Stems	Austria	<i>Rumex</i> spp.
<i>Hendersonia rumicis</i> Losa	—	Spain	—
<i>Macrophoma rumicis</i> Pet.	Stems	Italy	—
<i>Phoma herbarum</i> West.	Stems	World-wide Europe-USA	Diff. genera
<i>P. nebulosa</i> (Pers. ex Fr.) Berk	Stems	New Zeal.	"
<i>P. rumicis</i> G. Frag	Stems	Lusitania	—

Table 1 (cont.)

Fungus	Substrate (plant part)	Country	Other hosts
<i>Phomopsis durandiana</i> (Sacc. Roum) Died	Dead stems	Gr. Britain	<i>Rumex</i> spp.
<i>Rhabdospora cirsii</i> Karst. var. <i>rumicis</i> Grove	Dead stems	Europe	
Hyphomycetes:			
<i>Acrostalagmus cinnabarinus</i> var. <i>pentatus</i> Cif.	Leaves	Italy	<i>Vitis vinif.</i>
<i>Alternaria rumicicola</i> Mathur	Leaves	India	<i>Rumex</i> spp.
<i>Cercospora rumicis</i> Ellis et Langlois	—	USA	—
<i>Ovularia obliqua</i> Cooke) Oudem.	Leaves	World-wide	<i>Rumex</i> spp.
<i>Penicillium glauco-roseum</i> Dem.	Dead plants	Austria	"
<i>Ramularia decipiens</i> Ellis et Everh	Leaves	USA, Europe India	" <i>Ranunc. scleratus</i> L.
<i>R. rubella</i> (Bon.) Nannf.	Leaves	—	—
<i>R. rumicis-crispi</i> Saw.	—	Formosa	—

Table 1a.— List of fungi on *Rumex crispus* L. and *R. obtusifolius* L.

Rust fungus	Country of occurrence	Development type (and stages)	Host spectrum	
			Haplophase	Dikaryopha
<i>Aecidium minutulum</i> H.S. Jackson	USA	?	<i>Rumex</i>	?
<i>Puccinia orientalis</i> Syd. et Butl.	—	(O, I)	—	—
<i>P. orientalis</i> Otani et Akechi	Japan	?	—	<i>R. crispus</i>
<i>P. otanica</i> Hir. f. nom. nov. (= <i>P. orientalis</i> Ot. et Ake.)	Japan	(II, III)	—	<i>R. domesticus</i>
<i>P. phragmitis</i> (Schum) Korn	North hemi- sphere	Heteroform (O, I-IV)	<i>Rumex</i> spp.	<i>Phragmites</i> spp.
<i>P. trailii</i> Polwright	Europe	"	<i>Rumex</i> spp.	<i>P. communis</i>
<i>Schroeteria aster alpinus</i> (Schroet.) Magn.	Europe exc. north	"	<i>Ranunculus</i> spp.	<i>Rumex</i> spp.
<i>Uromyces rumicis</i> (Schum.) Wint.	Cosmopolit.	"	<i>Ranunc.</i> <i>ficaria</i> L.	<i>Rumex</i> spp.
<i>U. rumicis</i> f. sp. <i>aquatici</i> Gaum.	—	(O? I-IV)	"	<i>Rumex</i> spp. <i>R. aquaticus</i> main-host
<i>U. rumicis</i> f. sp. <i>obtusifolius</i>	—	"	"	<i>R. obtusifolius</i> a. oth.?

chosen from different climatic zones in the country (Table 2). Regularly spaced collections from each of these sites were made over a period of at least one year. These collections were supplemented by additional collections at randomly selected sites throughout Italy and in other European countries. This process of collecting is continuing into 1980. Figure 1 shows a map of Italy with the major collection sites indicated.

Table 2.— Major collection sites for insects and plant pathogens on *Rumex* species in Italy. 1977 to 1979

Collection area	Latitude North	Longitude East	Mean 1977 temperature C°	Mean 1977 precipitation mm
San Giorgio (Bari)	41°07'	16°47'	16.6	718
Emilia Romagna	44°50'	11°37'	13.3	834
Abruzzi (L'Aquila)	42°21'	13°24'	10.1	740
Rome				
Castel Porziano	41°46'	12°18'	15.4	881
Maccarese	41°49'	12°13'	14.9	790

Once a week at Castel Porziano and Maccarese (both about 35 km west of Rome), a 25 m transect line was randomly set out in a field containing *Rumex* beginning in January, 1978. The amount of *Rumex* plant material under the transect line was recorded to provide an index of plant density. The nearest plant to 10 randomly selected points along the transect were carefully removed from the soil, bagged and returned to the laboratory. All biotic agents on the 10 plants were collected when the plants were examined. These biotic agents were counted, associated with their damage, and preserved for future identification. Each plant was measured for height, root length, length and width of the largest leaf, and length of the flower stalk, if present.

At each visit to a study site, a field data card was filled out. This card (Spencer *et al.* 1981) was used to pinpoint the site location and to provide information on the physical parameters of the habitat, on the phenology of the host plant(s) and on the relationships between the biotic agents found on the host plant. Adult samples of these biotic agents were preserved for determination. Immatures were reared to an identifiable stage. Rearing was accomplished by placing the immature on *Rumex* until an adult was produced.

Plant diseases were sent to Dr G. Defago for identification. Insects were sent to the USDA-SEA-ARC-West, Insect Identification and Beneficial Insect Introduction Institute, Beltsville, MD.; to the Commonwealth Institute of Entomology, London, England; or to a European specialist if one was known for the particular group to be identified.

The data on the collection cards, which included the identified biotic agents, were entered into a computer (Spencer *et al.* 1981) for sorting, storage, and retrieval. Decisions as to which biotic agents were to be studied in depth for possible use in a biological control program were made as a result of a literature search on identified insects and plant pathogens and a review of the field data from the computer. The criteria used were based upon the following points:

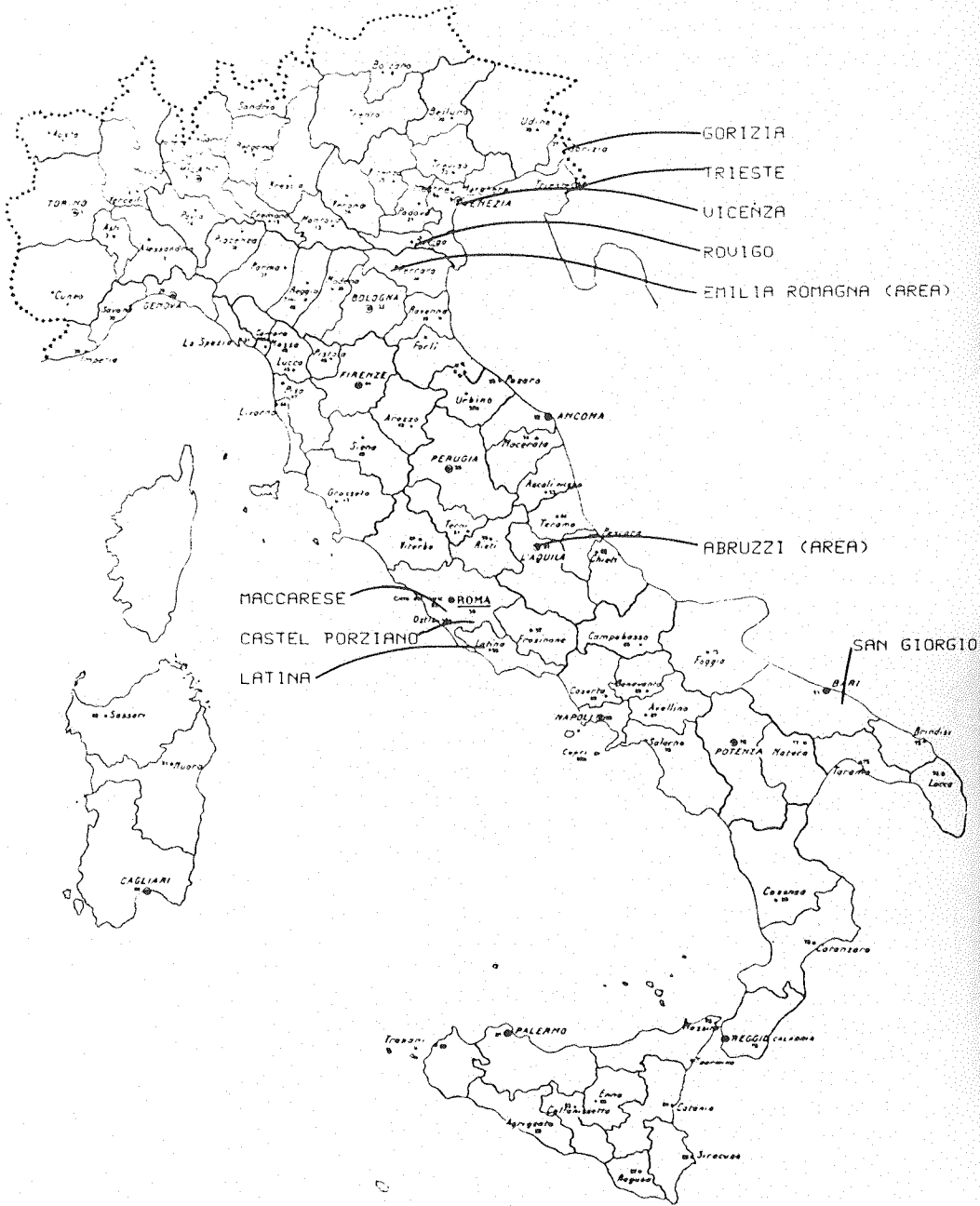


Figure 1. Map of Italy showing major collection sites for biotic agents associated with *Rumex* species.

1. host records of the insect from the literature
2. host records of related species
3. damage to *Rumex* in a field situation
4. fecundity
5. distribution
6. lack of presence in North America.

Larvae of a sesiid, *Pyropteron chrysidiforme* (Esper 1779), were found commonly in the roots of *R. crispus* and *R. obtusifolius* in numerous locations in Italy. It is recorded in the literature as occurring from England through central and southern Europe.

Roots of *R. crispus* and *R. obtusifolius* were dug from the Abruzzi area in the fall of 1978 and planted in the garden of the Rome laboratory to await the emergence of the *P. chrysidiforme* adults in the late spring.

In late 1978 and in the first few months of 1979, *Rumex crispus*, *R. obtusifolius*, *R. conglomeratus*, and possible hybrids were collected from northern Italy, from the mountainous areas around L'Aquila, and from around Rome. These plants were potted in 22 cm dia. clay pots and placed in a greenhouse under normal springtime temperature, light, and relative humidity². Adults emerging in the late spring were caged together according to their original collection sites and allowed to lay eggs on caged plants. These eggs were held for larval emergence. A preliminary larval survival test was conducted with *Rumex crispus* and *Rheum rhabarbarum*. Buckwheat, another economic Polygonaceae, is an annual with a small root so it would not serve as a host for a root-boring insect species that overwinters as a larva in a plant root. Twenty replicates of this larval survival test were set up and infested with first instar larvae from 29 June to 2 July, 1979. Some of the plants were dissected in the fall of 1979 and the remaining ones in the spring of 1980 just before adult emergence.

A 12 to 17 mm curculionid, *Lixomorbus ocularis* (Coleoptera) was found in the Rome area during the 1978 collections at Maccarese. The larvae were found commonly in the roots of *R. crispus* and were quite damaging to the roots of large *Rumex* plants. In May, 1980 mating pairs of *L. ocularis* were collected for adult food preference tests, ovipositional studies, and observations on their biology in the laboratory.

Food preference studies were conducted by placing paired adult *L. ocularis* on species of *Rumex*, *Rheum rhabarbarum*, and *Fagopyrum esculentum*. Additional pairs were held on potted *R. crispus* for biological observations. All the plants were in 22 cm dia. pots over which a rigid clear 20 cm x 55 cm high plastic tube had been placed. A cloth screen covered the top of the tube and small holes were put in the sides to allow air circulation. The experiments were conducted in the Rome Laboratory's shaded greenhouse under normal spring-time light and temperature conditions.

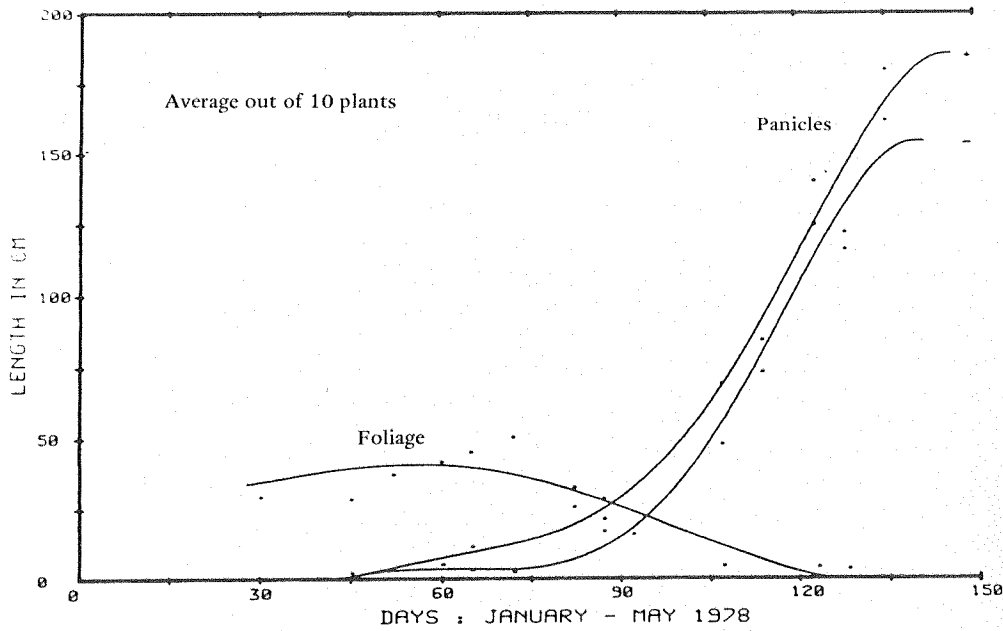
An additional preference test was conducted by caging paired adults with three different species of *Rumex* or with two species of *Rumex* and *R. rhabarbarum*. These tests were also conducted in the laboratory's greenhouse during the same time period.

RESULTS

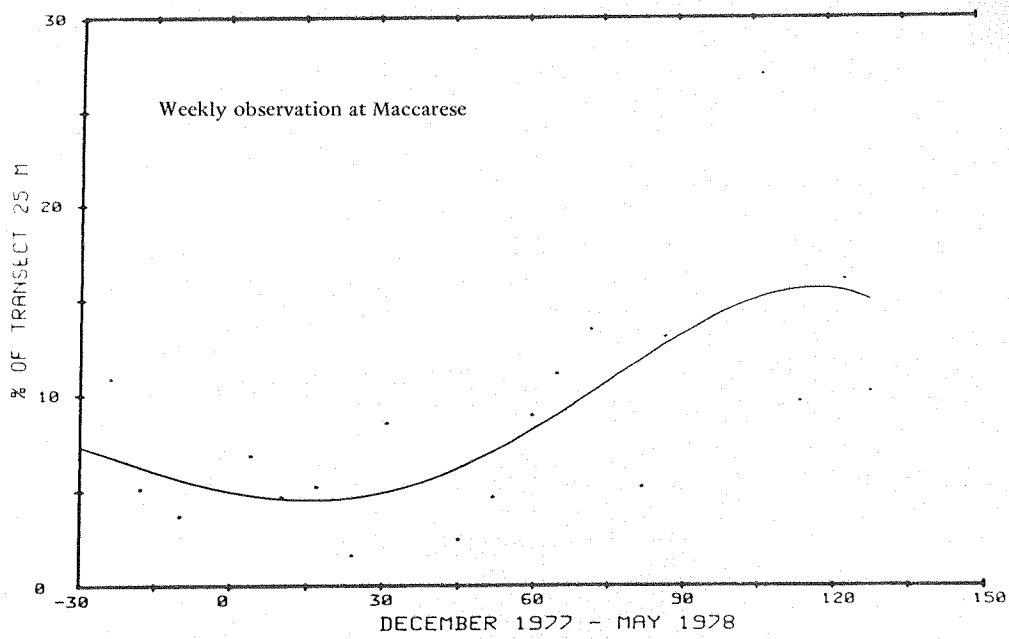
Figure 2 shows foliage and panicle growth at Maccarese from January to May 1978. Foliage began to increase at the end of January and peaked in mid-March

² Temp. mean. 16°, SD ±5.3°C; min. 5°; max. 30°C; RH mean 73.8%, SD ±17.8%; min. 40.0%, max. 100%.

RUMEX CRISPUS : FOLIAGE AND PANICLE GROWTH

Figure 2. *Rumex crispus*: Foliage and panicle growth.

RUMEX CRISPUS : PLANT DENSITY NEAR ROME

Figure 3. *Rumex crispus*: Plant density near Rome.

as the flower stalk or panicle began to arise from the rosette. Maximum panicle height was reached in early May by which time the foliage was reduced. Mature seeds were present in the field from May on into the summer.

Figure 3 shows the variation in plant density which was measured along the Maccaresse plant transect from December 1977 to May 1978. The low point present in January and February is due to the influence of freezing temperatures on the plants during this period.

Table 3 is a list taken from our computer files of the insects identified from the subgenus *Rumex*. In the field it was not always possible to correctly identify a species or a hybrid of *Rumex*. We thus restricted our collections to those plants that either appeared to be *R. crispus* or were close to *R. crispus*. The sites at which the insect species was collected, the month collected, and stage of development are also included in the table.

The sesiid, *Pyropteron chrysidiforme*, and the weevil, *Lixomorpha ocularis*, were chosen for indepth study based upon the criteria listed above.

Pyropteron chrysidiforme (Esper 1779)

Described as *Sphinx chrysidiformis* with the type locality being southern France.

Synonyms:

Sphinx haemorrhoidalis. Type locality: southern Italy.

Sphinx chalcidiformis. Type locality: Hungary.

Sesia cerceriformis. Type locality: Hungary.

Pyropteron is a small genus in the Aegeria group. Size 17 to 20 mm. Face white. Abdomen with pale yellowish rings on 4, 6 and 7; anal tuft reddish orange, sides black. Forewings orange-red, with small hyaline discal and posterior patches; costal streak and a

square spot on transverse vein touching it, indigo-black; a dark purplish fuscous terminal suffusion. Hindwings hyaline; veins, a spot on upper part of transverse vein, and termen black. Male antennae slightly hairy; female antennae slimmer and 'naked'.

Professor Clas M. Naumann of the Universitat Bielefeld, Faculty of Biology, Federal Republic of Germany is a recognized authority on the Sesiidae. In 1971, he authored the book 'Studies on the Systematics and Phylogeny of Holarctic Sesiidae (Insects, Lepidoptera)'. This book was translated from German and published by the Smithsonian Institution and the National Science Foundation, Washington, D.C. Dr Naumann feels that we may be dealing with a 'complex' within *Pyropteron*. Host records show this species to be specific to *Rumex*.

Records for the insect list it as occurring from southern Italy to northern Germany and the British Isles. *P. chrysidiforme* has been recorded from the Compositae, *Artemisia* and *Gnaphalium* (Fibiger and Kristensen 1974) and from *Artemisia campestris* and *Helichrysum* by Popescue-Gory *et al.* (1958).

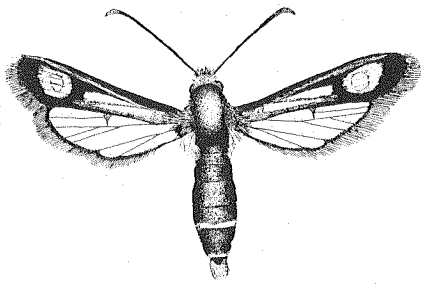


Table 3.— Insect species found on *Rumex*

Insect	Site	Month	Stage	Where found	Damage
ORTHOPTERA					
Gryllidae					
<i>Acheta domesticus</i>	Castel Porziano	Mar.	Nymph	On crown	?
	Abruzzi	Dec.	Nymph	On crown	?
<i>Gryllus campestris</i>	Abruzzi	Jan.	Nymph	On crown	?
<i>Trigonidius cicindeloides</i>	Maccarese	Dec.	Adult	On crown	?
	Maccarese	Dec.	Nymph	On crown	?
HEMIPTERA—HETEROPTERA					
Alydidae					
<i>Micrelytra fossarum</i>	Rome	July	Nymph	On crown	?
	Castel Porziano	Apr.	Adult	On leaf	?
Anthocoridae					
<i>Orius minutus</i>	Maccarese	Mar.	Adult	On crown	?
Coreidae					
<i>Bathysolen nubilus</i>	Rome, Lab.	Mar.	Adult	On leaf	?
<i>Coreus marginatus</i>	Rome	Sept.	Adult	On crown	?
	Maccarese	May	Adult	On leaf	?
	Maccarese	June	Adult	On crown	?
	Abruzzi	Sept.	Adult	On stem	?
	Abruzzi	Sept.	Adult	On leaf	?
	Abruzzi	Sept.	Nymph	On leaf	?
Cynidae					
<i>Geotomus punctulatus</i>	Maccarese	Jan.	Adult	On crown	?
	Maccarese	Apr.	Adult	On crown	?
	Abruzzi	Dec.	Adult	On crown	?
Lygaeidae					
<i>Beosus maritimus</i>	Abruzzi	Jan.	Adult	On crown	?
<i>Emblethis</i> sp.	Rome	July	Adult	On crown	?
	Abruzzi	Jan.	Adult	On crown	?
<i>Geocoris megacephalus</i>	Maccarese	Dec.	Adult	On crown	?
	Abruzzi	Jan.	Adult	On crown	?
<i>Nysius graminicola</i>	Emilia Romagna	Jan.	Adult	On crown	?
	Maccarese	Jan.	Adult	On crown	?
	Maccarese	Jan.	Adult	On crown	?
	Maccarese	Jan.	Adult	On crown	?
	Maccarese	Jan.	Adult	On crown	?
	Maccarese	Mar.	Adult	On crown	?
	Maccarese	Mar.	Adult	On crown	?
	Maccarese	Dec.	Adult	On crown	?
<i>Peritrechus</i> sp.	Emilia Romagna	Jan.	Adult	On crown	?
	Castel Porziano	Jan.	Adult	On crown	?
	Maccarese	Jan.	Adult	On crown	?
	Maccarese	Mar.	Adult	On crown	?
	Abruzzi	Jan.	Adult	On crown	?
	Abruzzi	Dec.	Adult	On crown	?
<i>Rhyparochromus</i> sp.	Abruzzi	Jan.	Adult	On crown	?
<i>Scolopestethus</i> sp.	Abruzzi	Dec.	Adult	On crown	?
<i>Stygnocoris fuliginus</i>	Maccarese	Mar.	Adult	On crown	?
	Maccarese	Dec.	Adult	On crown	?

Table 3 (cont.)

Insect	Site	Month	Stage	Where found	Damage
Pentatomidae					
<i>Eurydema oleraceum</i>	Maccarese	Mar.	Adult	On crown	?
<i>E. ventrale</i>	Castel Porziano	Jan.	Adult	On crown	?
	Maccarese	Jan.	Adult	On crown	?
	Maccarese	Jan.	Adult	On crown	?
	Maccarese	Mar.	Adult	On crown	?
	Maccarese	Mar.	Adult	On crown	?
	Maccarese	Dec.	Adult	On crown	?
	Maccarese	Dec.	Adult	On crown	?
	Maccarese	Dec.	Adult	On crown	?
Pyrrhocoridae					
<i>Pyrrhocoris apterus</i>	Maccarese	Jan.	Adult	On crown	?
	Maccarese	Jan.	Adult	On crown	?
	Maccarese	Feb.	Adult	On crown	?
	Maccarese	Mar.	Adult	On crown	?
	Maccarese	Mar.	Adult	On soil	?
	Maccarese	Dec.	Adult	On crown	?
	Abruzzi	Jan.	Adult	On crown	?
HEMIPTERA—HOMOPTERA					
Aleurodidae					
Cercopidae					
<i>Cercopis sanguinolenta</i>	Maccarese	May	Adult	On leaf	?
	Maccarese	June	Adult	On fruit	—
Cicadellidae					
<i>Cicadella viridis</i>	Vicenza, Italy	Oct.	Adult	On crown	?
<i>Aphrodes bicinctus</i>	Emilia Romagna	June	Adult	On crown	?
	Abruzzi	Nov.	Adult	On crown	?
<i>Aphrodes</i> sp.	Rome	July	Adult	On crown	?
<i>Anaceratagallia</i> sp.	Emilia Romagna	Jan.	Adult	On crown	?
LEPIDOPTERA					
Geometridae					
<i>Boarmia rhomboidaria</i>	Maccarese	Mar.	Larva	On crown	?
<i>Ematurga atomaria</i>	Trieste, Italy	June	Larva	On leaf	?
	Maccarese	June	Larva	On leaf	?
<i>Idea ochrata</i>	Lab, Rome, Italy	July	Adult	On crown	—
<i>I. seriata</i>	Lab, Rome, Italy	July	Adult	On crown	—
<i>Rhodometra sacraria</i>	Rome	Sept.	Larva	On leaf	?
	Maccarese	Sept.	Larva	On leaf	?
<i>Eupithecia centaureata</i>	Rome	July	Larva	On leaf	Light
<i>Scopula imitaria</i>	Castel Porziano	Mar.	Larva	On soil	Medium
Lasiocampidae					
<i>Lasiocampa quercus</i>	Trieste, Italy	June	Larva	On soil	—
Lymantriidae					
<i>Lymantria dispar</i>	Maccarese	June	Larva	On soil	?
Noctuidae					
<i>Hoplodrina ambigua</i>	Maccarese	Jan.	Larva	On soil	Light
	Maccarese	Feb.	Larva	On soil	Light
	Maccarese	Mar.	Larva	On soil	Light
	Maccarese	Mar.	Larva	On soil	—
	Maccarese	Apr.	Larva	On crown	Light

Table 3 (cont.)

Insect	Site	Month	Stage	Where found	Damage
<i>Mythimna albipuncta</i>	Maccaresse	Dec.	Larva	On soil	Medium
<i>M. unipuncta</i>	Maccaresse	Jan.	Larva	On crown	Light
	Maccaresse	Feb.	Larva	On soil	?
	San Giorgio	Feb.	Larva	On soil	?
	San Giorgio	Mar.	Larva	On soil	Medium
	San Giorgio	Apr.	Larva	On crown	?
<i>Noctua interjecta</i>	Castel Porziano	Mar.	Larva	On soil	Light
	San Giorgio	Apr.	Larva	On soil	Heavy
<i>N. pronuba</i>		Oct.	Larva	On crown	?
	Castel Porziano	Feb.	Larva	On soil	Medium
	Maccaresse	Jan.	Larva	On soil	Medium
	Lab, Rome, Italy	Mar.	Larva	?	?
	San Giorgio	Dec.	Larva	On soil	Heavy
<i>Peridroma saucia</i>	Maccaresse	Jan.	Larva	On leaf	Heavy
	Maccaresse	Feb.	Larva	On soil	Light
	San Giorgio	Apr.	Larva	On leaf	Light
<i>Phlogophora meticulosa</i>	Emilia Romagna	Mar.	Larva	On soil	Medium
	Castel Porziano	Feb.	Larva	On soil	Medium
	Maccaresse	Dec.	Larva	On soil	?
	Lab, Rome, Italy	May	Larva	On leaf	Light
	San Giorgio	Feb.	Larva	On soil	Heavy
	San Giorgio	Dec.	Larva	On soil	Heavy
<i>Axylia putris</i>	Rovigo, Italy	Apr.	Pupa	In soil	—
<i>Agrochola lychnidis</i>	San Giorgio	Apr.	Larva	On soil	Heavy
<i>Lacanobia oleracea</i>	Lab, Rome, Italy	July	Larva	?	?
	San Giorgio	June	Larva	On leaf	?
<i>Thalpopbila matura</i>	Abruzzi	Sept.	Adult	On soil	—
<i>Autographa gamma</i>	Lab. Rome, Italy	Nov.	Larva	On leaf	Medium
Pyrilidae					
<i>Udea ferrugalis</i>	Maccaresse	Jan.	Larva	On crown	?
	Maccaresse	Jan.	Larva	On leaf	Light
	Maccaresse	Dec.	Adult	On soil	—
	San Giorgio	June	Larva	On crown	?
Sesiidae					
<i>Pyropteron chrysidiforme</i>	Rovigo, Italy	Apr.	Larva	In root	Medium
	Vincenza, Italy	Oct.	Larva	In root	Medium
	Emilia Romagna	Jan.	Larva	In root	Medium
	Emilia Romagna	Jan.	Larva	In root	Medium
	Emilia Romagna	Oct.	Larva	In root	Heavy
	Emilia Romagna	Oct.	Larva	In root	Heavy
	Emilia Romagna	Oct.	Larva	In root	Light
	Emilia Romagna	Oct.	Larva	In root	Heavy
	Emilia Romagna	Oct.	Larva	In root	Light
	Emilia Romagna	Oct.	Larva	In root	Heavy
	Emilia Romagna	Oct.	Larva	In root	Light
	Emilia Romagna	Oct.	Larva	In root	Heavy
	Emilia Romagna	Oct.	Larva	In root	Heavy
	Emilia Romagna	Dec.	Larva	In root	Heavy
	Emilia Romagna	Dec.	Larva	In root	Heavy
	Rome	Sept.	Larva	In root	Medium
	Rome	Sept.	Larva	In root	Medium
	Castel Porziano	Mar.	Larva	In root	Heavy

Table 3 (cont.)

Insect	Site	Month	Stage	Where found	Damage
	Castel Porziano	Mar.	Larva	In root	Heavy
	Castel Porziano	Apr.	Larva	In root	Heavy
	Maccarese	Mar.	Larva	In root	Heavy
	Maccarese	Apr.	Larva	In root	Medium
	Maccarese	May	Larva	In root	Medium
	Maccarese	May	Larva	In stem	Medium
	Maccarese	June	Adult	In air	—
	Lab. Rome, Italy	Sept.	Larva	In root	Medium
	Abruzzi	Jan.	Larva	In root	Medium
	Abruzzi	Jan.	Unknown	In root	—
	Abruzzi	Jan.	Larva	In root	Medium
	Abruzzi	Jan.	Larva	In root	Medium
	Abruzzi	May	Larva	In root	Heavy
	Abruzzi	May	Larva	In root	Heavy
	Abruzzi	May	Larva	In root	Heavy
	Abruzzi	May	Larva	In root	Medium
	Abruzzi	Sept.	Larva	In root	Medium
	Abruzzi	Nov.	Larva	In root	Medium
	Abruzzi	Nov.	Larva	In root	Medium
	Abruzzi	Nov.	Larva	In root	Medium
	Abruzzi	Nov.	Larva	In root	Light
	Abruzzi	Dec.	Larva	In root	Heavy
	Abruzzi	Dec.	Larva	In root	Heavy
	Abruzzi	Dec.	Larva	In root	Heavy
	Abruzzi	Sept.	Larva	In root	Medium
	Abruzzi	Sept.	Larva	In stem	Light
	Abruzzi	Nov.	Larva	In root	Medium
	Abruzzi	Nov.	Larva	In root	Medium
	Abruzzi	Nov.	Larva	In root	Medium
	San Giorgio	Jan.	Larva	In root	Medium
	San Giorgio	Feb.	Larva	In root	Medium
	San Giorgio	Feb.	Larva	In root	Medium
	San Giorgio	Mar.	Pupa	In root	—
	San Giorgio	Apr.	Larva	In root	Heavy
	San Giorgio	May	Pupa	In root	—
Tortricidae					
<i>Olethreutes lacunana</i>	Rovigo, Italy	Apr.	Larva	On leaf	Light
Pterophoridae					
<i>Pterophorus pentadactyla</i>	Maccarese	May	Adult	On leaf	—
Gracillariidae					
<i>Calybites phasianipennella</i>	San Giorgio	June	Pupa	On leaf	—
DIPTERA					
Anthomyiidae					
<i>Pegomya bicolor</i>	Lab. Rome, Italy	May	Pupa	On crown	—
	Lab. Rome, Italy	May	Larva	In leaf	Light
	Lab. Rome, Italy	May	Larva	In leaf	Medium
	Lab. Rome, Italy	June	Larva	In leaf	Medium
	Lab. Rome, Italy	Sept.	Larva	In leaf	Medium
Chloropidae					
<i>Meromyza</i> sp.	Rome	Sept.	Adult	On crown	—
Tipulidae					
<i>Nephrotoma crocata</i>	Lab. Rome, Italy	Mar.	Pupa	In detritus	—

Table 3 (cont.)

Insect	Site	Month	Stage	Where found	Damage
	Lab. Rome, Italy	Mar.	Adult	?	—
	Lab. Rome, Italy	Mar.	Adult	?	—
	Abruzzi	Jan.	Pupa	In detritus	—
Drosophilidae					
<i>Scatophila</i> sp.	Maccarese	Dec.	Adult	On crown	—
Dolichopodidae					
<i>Sciapus pallens</i>	Lab. Rome, Italy	Mar.	Adult	?	—
	Lab. Rome, Italy	Apr.	Adult	On leaf	—
Tachinidae					
<i>Bithia modesta</i>	Rovigo, Italy	Apr.	Adult	In insect	—
	Lab. Rome, Italy	Mar.	Adult	In insect	—
	Lab. Rome, Italy	Apr.	Adult	In insect	—
	Lab. Rome, Italy	Apr.	Adult	In insect	—
	Abruzzi	May	Adult	In insect	—
	Abruzzi	Nov.	Adult	In insect	—
	Abruzzi	Nov.	Adult	In insect	—
	San Giorgio	May	Adult	In insect	—
<i>Exorista larvarum</i>	Emilia Romagna	Jan.	Adult	?	—
<i>Triarthria setipennis</i>	Maccarese	Jan.	Pupa	On soil	—
Scatophaginae					
<i>Norellia spinimana</i>	Herault, France	Mar.	Pupa	On soil	—
	Emilia Romagna	Oct.	Pupa	In petiole	—
	Emilia Romagna	Oct.	Larva	In petiole	Light
	Emilia Romagna	Oct.	Larva	In petiole	Light
	Emilia Romagna	Oct.	Larva	In petiole	Light
	Emilia Romagna	Oct.	Larva	In petiole	Light
	Emilia Romagna	Oct.	Pupa	In petiole	—
	Emilia Romagna	May	Larva	In stem	Light
	Maccarese	May	Larva	In petiole	Light
	Maccarese	Sept.	Pupa	In crown	—
	Lab. Rome, Italy	Mar.	Adult	?	—
	Lab. Rome, Italy	Apr.	Pupa	In crown	—
	Lab. Rome, Italy	May	Larva	In petiole	Medium
	Lab. Rome, Italy	May	Larva	In petiole	Medium
	Lab. Rome, Italy	May	Larva	In petiole	Medium
	France	Mar.	Larva	In petiole	Medium
Syrphidae					
Sciomyzidae					
<i>Pherbellia cinerella</i>	Abruzzi	Nov.	Pupa	In crown	—
HYMENOPTERA					
Tenthredinidae					
<i>Ametastegia equiseti</i>	Vicenza, Italy	Oct.	Larva	On leaf	Light
	Rome	June	Larva	On leaf	Light
	Maccarese	May	Larva	On leaf	Light
	Maccarese	May	Larva	On leaf	Light
	Maccarese	May	Larva	On leaf	Light
	Lab. Rome, Italy	June	Larva	On leaf	Medium
	Lab. Rome, Italy	June	Larva	On leaf	Medium
Ichneumonidae					
<i>Centeterus</i> sp.	Abruzzi	Dec.	Adult	On crown	—
<i>Diadegma</i> sp.	Maccarese	Mar.	Adult	?	—

Table 3 (cont.)

Insect	Site	Month	Stage	Where found	Damage
<i>Gambrus</i> sp.	Abruzzi	May	Pupa	On root	—
<i>Heterischnus</i> sp.	Emilia Romagna	Jan.	Adult	On crown	—
<i>Lysibia nanus</i>	Lab. Rome, Italy	Feb.	Adult	?	—
<i>Lysibia</i> sp.	Lab. Rome, Italy	Feb.	Adult	?	—
<i>Nepiera collector</i>	Maccarese	Dec.	Adult	In insect	—
Braconidae					
<i>Apanteles byphantriae</i>	Maccarese	Dec.	Adult	On crown	—
<i>Apanteles</i> sp.	Vicenza, Italy	Oct.	Pupa	On leaf	—
	Vicenza, Italy	Oct.	Adult	In insect	—
	Vicenza, Italy	Oct.	Adult	In insect	—
	Vicenza, Italy	Oct.	Pupa	On leaf	—
	Rome	Sept.	Adult	In insect	—
	Rome	Sept.	Adult	In insect	—
<i>Microgaster curvicrus</i>	Maccarese	Mar.	Pupa	In stem	—
<i>Rogas</i> sp.	Maccarese	Dec.	Adult	In insect	—
	San Giorgio	Feb.	Adult	In insect	—
Andrenidae					
<i>Andrena</i> sp.	Maccarese	Jan.	Adult	On crown	—
Eucoilidae					
<i>Trybiographa</i> sp.	Emilia Romagna	Mar.	Adult	?	—
	Emilia Romagna	Mar.	Adult	In insect	—
	Emilia Romagna	Oct.	Adult	In insect	—
	Emilia Romagna	Oct.	Adult	In insect	—
	Lab. Rome, Italy	May	Adult	In insect	—
Eulophidae					
<i>Entedon</i> sp.	Castel Porziano	Dec.	Pupa	In stem	—
	San Giorgio	June	Pupa	In stem	—
<i>Sympiesis gregori</i>	Rome	July	Adult	In insect	—
<i>Eulophidae</i> sp.	Lab. Rome, Italy	July	Adult	In insect	—
Halictidae					
<i>Halictus</i> sp.	Abruzzi	Sept.	Adult	On crown	—
COLEOPTERA					
Bruchidae					
<i>Bruchidius nudus</i>	Maccarese	Mar.	Adult	On crown	?
<i>B. quinqueguttatus</i>	Maccarese	Dec.	Adult	On crown	?
<i>Bruchus rufipes</i>	Castel Porziano	Mar.	Adult	On crown	?
<i>B. guttalis</i>	Abruzzi	Nov.	Adult	On crown	?
<i>Spermophagus sericeus</i>	Emilia Romagna	Oct.	Adult	On seed	?
	Maccarese	Jan.	Adult	On crown	?
	Maccarese	Jan.	Adult	On crown	?
	Maccarese	Feb.	Adult	On seed	?
	Maccarese	Apr.	Adult	On crown	?
	Maccarese	May	Adult	On flower	—
	Maccarese	Dec.	Adult	On crown	—
Chrysomelidae					
<i>Haltica oleracea</i>	Vicenza, Italy	Oct.	Adult	On leaf	?
	Abruzzi	Jan.	Adult	On crown	?
<i>Baetocnema tibialis</i>	Maccarese	Dec.	Adult	On crown	?
<i>Baetocnema</i> sp.	Rome	July	Adult	On crown	?
	Rome	Sept.	Adult	On crown	?
<i>Chrysolina banksi</i>	Lab. Rome, Italy	Sept.	Adult	On leaf	?

Table 3 (cont.)

Insect	Site	Month	Stage	Where found	Damage
<i>Chrysolina baemoptera</i>	Maccarese	Sept.	Adult	In soil	?
<i>C. rossia</i>	Maccarese	Jan.	Adult	On crown	?
	Maccarese	May	Adult	In soil	?
	Maccarese	May	Adult	In soil	—
	Maccarese	Sept.	Adult	On crown	?
<i>Adonia variegata</i>	Abruzzi	Dec.	Adult	On crown	—
<i>Gastrophysa polygoni</i>	Maccarese	Jan.	Adult	On crown	?
	Maccarese	Mar.	Adult	On soil	?
	Maccarese	Mar.	Adult	On leaf, soil	—
	Maccarese	Mar.	Adult	On soil	?
	Maccarese	Apr.	Adult	On crown	?
	Maccarese	Dec.	Adult	On crown	?
	Maccarese	Dec.	Adult	On crown	?
<i>Leptomona erythrocephala</i>	France	Mar.	Adult	On crown	?
<i>Smaragdina affinis</i>	Emilia Romagna	May	Adult	On leaf	?
<i>Lachnaea</i> sp.	Emilia Romagna	June	Adult	On leaf	?
<i>Trimarcha tenebricosa</i>	CH	Aug.	Adult	On leaf	Medium
	CH	Aug.	Adult	On leaf	Medium
	CH	Aug.	Adult	On leaf	Medium
<i>Phratora</i> sp.	Castel Porziano	May	Adult	On soil	—
<i>Psylliodes</i> sp.	Emilia Romagna	June	Adult	On crown	?
	Maccarese	Dec.	Adult	On crown	?
<i>Podagrica</i> sp.	Latina, Italy	Sept.	Adult	On leaf	?
	Rome	July	Adult	On crown	?
	Maccarese	Jan.	Adult	On crown	?
<i>Longitarsus tabidus</i>	Rome	Sept.	Adult	On crown	?
<i>Hypocassida subferruginea</i>	Latina, Italy	Sept.	Adult	On leaf	?
<i>Cassida</i> sp.	Maccarese	July	Adult	On leaf	?
	Abruzzi	Nov.	Adult	On leaf	?
<i>Labidostomis</i> sp.	Maccarese	June	Adult	On seed	?
<i>Gastroidea viridula</i>	Germany	July	Adult	On crown	Medium
	Gorizia, Italy	June	Egg	On leaf	—
	Gorizia, Italy	June	Egg	?	—
	Gorizia, Italy	June	Adult	On leaf	—
<i>Cryptocephalus connexus</i>	Maccarese	June	Adult	On seed	?
<i>Cryptocephalus</i> sp.	Emilia Romagna	July	Adult	On seed	?
	Rome	July	Adult	On crown	?
	Rome	Sept.	Adult	On crown	?
	Maccarese	May	Adult	On crown	?
	Maccarese	June	Adult	On crown	?
	Maccarese	June	Adult	On seed	?
Coccinellidae					
<i>Adalia bipunctata</i>	Maccarese	Feb.	Adult	On crown	—
	Maccarese	Dec.	Adult	On crown	—
	Abruzzi	Jan.	Adult	On crown	—
	Abruzzi	Jan.	Adult	On crown	—
<i>Coccinella septempunctata</i>	San Giorgio	Mar.	Adult	On crown	—
<i>C. undecimpunctata</i>	Maccarese	Mar.	Adult	On crown	—
<i>Scymnus apetzoides</i>	Abruzzi	Nov.	Adult	On crown	?

Table 3 (cont.)

Insect	Site	Month	Stage	Where found	Damage
<i>Scymnus frontalis</i>	Abruzzi	Sept.	Adult	On crown	?
	Rome	Sept.	Adult	On crown	?
	Maccarese	Dec.	Adult	On crown	?
<i>S. interruptus</i>	San Giorgio	June	Adult	On seed	?
<i>S. leavaillauti</i>	Lab. Rome, Italy	July	Adult	On leaf	?
<i>S. marginalis</i>	Emilia Romagna	May	Adult	On leaf	?
	Rome	July	Adult	On crown	?
<i>S. nigrinus</i>	Rome	July	Adult	On crown	?
<i>S. rubromaculatus</i>	Latina, Italy	Sept.	Adult	On soil	?
<i>Scymnus (Pullus) sp.</i>	Rome	Sept.	Adult	On crown	?
<i>Thea 22-punctata</i>	Rome	July	Adult	On crown	?
	Maccarese	Feb.	Adult	On crown	—
	Maccarese	Mar.	Adult	On crown	—
<i>Tytthaspis 16-punctata</i>	Castel Porziano	Jan.	Adult	On crown	—
	Maccarese	Dec.	Adult	On crown	—
<i>Rhyzobius litura</i>	Latina, Italy	Sept.	Adult	On leaf	?
	Rome	Sept.	Adult	On crown	?
	Castel Porziano	Mar.	Adult	On crown	?
	Maccarese	Jan.	Adult	On crown	?
	Maccarese	Mar.	Adult	On crown	?
	Maccarese	May	Adult	On crown	?
	Maccarese	June	Adult	On crown	—
	Abruzzi	Jan.	Adult	In detritus	?
	Abruzzi	Jan.	Adult	In detritus	?
	Abruzzi	Dec.	Adult	On crown	?
	<i>Nephus (Sidis) sp.</i>	Lab. Rome, Italy	Apr.	Adult	On seed
<i>Subcoccinella 24-punctata</i>	Abruzzi	Nov.	Adult	On crown	—
Curculionidae					?
<i>Apion (Erythrapion) miniatum</i>	Austria	Oct.	Adult	On crown	?
	Switzerland (CH)	Aug.	Adult	On leaf	Light
	Herauld (France)	Mar.	Larva	In stem	Light
	Rovigo, Veneto, Italy	Apr.	Adult	On leaf	—
	Vincenza, Veneto	Oct.	Adult	On leaf	?
	Emilia Romagna	Jan.	Adult	On crown	?
	Emilia Romagna	Mar.	Adult	On soil	—
	Emilia Romagna	June	Adult	On leaf	?
	Emilia Romagna	Oct.	Adult	On leaf	?
	Emilia Romagna	Oct.	Adult	On crown	?
	Emilia Romagna	June	Adult	In stem	—
	Emilia Romagna	June	Larva	In stem	Medium
	Emilia Romagna	June	Pupa	In root	—
	Emilia Romagna	June	Larva	In stem	Light
	Emilia Romagna	June	Pupa	In stem	—
	Rome	July	Adult	On leaf	?
	Rome	Sept.	Adult	On crown	?
Maccarese	June	Adult	On fruit	?	
Maccarese	June	Adult	On seed	?	
Lab. Rome, Italy	June	Adult	On leaf	?	
Abruzzi	Jan.	Adult	On leaf	Medium	
Abruzzi	June	Larva	In stem	Medium	

Table 3 (cont.)

Insect	Site	Month	Stage	Where found	Damage
<i>Apion (Perapion) violaceum</i>	Abruzzi	July	Larva	In root	Medium
	Abruzzi	July	Pupa	In stem	—
	Abruzzi	July	Pupa	In root	—
	Abruzzi	Nov.	Pupa	In stem	—
	Abruzzi	Nov.	Adult	On crown	?
	Abruzzi	Nov.	Adult	On crown	?
	Abruzzi	Nov.	Adult	On crown	?
	Austria	Oct.	Adult	In stem	—
	Herault, France	Mar.	Adult	On leaf	?
	Rovigo, Italy	Apr.	Adult	On leaf	—
	Rovigo, Italy	Apr.	Larva	In petiole	Light
	Emilia Romagna	Mar.	Adult	On leaf	—
	Emilia Romagna	June	Adult	On stem, leaf	Light
	Emilia Romagna	June	Adult	On crown	?
	Emilia Romagna	June	Adult	On stem, leaf	?
	Rome	May	Larva	In stem	Light
	Rome	June	Pupa	In stem	—
	Rome	June	Adult	On leaf	Light
	Castel Porziano	Mar.	Adult	On leaf	—
	Castel Porziano	Apr.	Adult	On leaf	—
	Castel Porziano	Apr.	Larva	In stem	Light
	Castel Porziano	Apr.	Larva	In stem	Light
	Castel Porziano	May	Larva	In stem, petiole	Medium
	Castel Porziano	May	Larva	In stem	Medium
	Maccarese	Jan.	Adult	On crown	?
	Maccarese	Mar.	Adult	On leaf	?
	Maccarese	Mar.	Adult	On crown	?
Maccarese	Apr.	Larva	In stem	Light	
Maccarese	May	Larva	In stem	Light	
Maccarese	May	Pupa	In stem	—	
Maccarese	May	Larva	In stem	Light	
Maccarese	May	Adult	On crown	—	
Maccarese	June	Adult	On crown	?	
Lab. Rome, Italy	Mar.	Adult	On leaf	?	
Lab. Rome, Italy	Apr.	Larva	In stem	Light	
Abruzzi	June	Pupa	In stem	—	
Abruzzi	Nov.	Adult	In stem	—	
Abruzzi	Nov.	Adult	On crown	?	
Abruzzi	Nov.	Adult	On crown	?	
San Giorgio	May	Larva	In stem	Light	
San Giorgio	June	Adult	On seed	?	
Portugal	Mar.	Adult	On leaf	—	
Portugal	Mar.	Adult	On leaf	Light	
Portugal	Mar.	Larva	In stem	Medium	
<i>Apion</i> sp.	Rome	June	Larva	In stem	Light
	Rome	Sept.	Adult	On crown	?
<i>Hypera philantha</i>	Maccarese	Apr.	Larva	In stem	Light
	Castel Porziano	Feb.	Larva	On leaf	Light
	Castel Porziano	Dec.	Larva	On leaf	Light

Table 3 (cont.)

Insect	Site	Month	Stage	Where found	Damage
	Maccarese	Jan.	Larva	On leaf	Light
	Maccarese	Jan.	Larva	On leaf	Light
	Maccarese	Jan.	Larva	On leaf	Light
	Maccarese	Mar.	Larva	On leaf	Light
	Maccarese	Mar.	Larva	On leaf	Light
	Maccarese	Mar.	Adult	On soil	?
	Maccarese	Mar.	Larva	On leaf	Light
	Maccarese	Mar.	Larva	On leaf	Light
	Maccarese	Sept.	Adult	On crown	?
	Maccarese	Dec.	Larva	On leaf	Light
	Maccarese	Dec.	Adult	On crown	Light
	Lab. Rome, Italy	Jan.	Egg	?	—
	Lab. Rome, Italy	Nov.	Larva	On leaf	Light
	San Giorgio	Jan.	Larva	On leaf	Light
	San Giorgio	Feb.	Larva	On leaf	Medium
	San Giorgio	Mar.	Larva	On leaf	Light
<i>Lixus anguinus</i>	Maccarese	Jan.	Adult	On crown	?
	Maccarese	Mar.	Adult	On crown	?
<i>L. ascanii</i>	Maccarese	Mar.	Adult	On crown	?
<i>L. vilis</i>	Abruzzi	July	Adult	In stem	—
<i>Lixus</i> sp.	Emilia Romagna	May	Adult	On leaf	?
<i>Otiorhynchus armatus-</i>	Lab. Rome, Italy	June	Adult	On stem	?
<i>romanus</i>	Lab. Rome, Italy	June	Adult	On stem	?
<i>O. dalmatinus</i>	Castel Porziano	Mar.	Adult	On crown	?
<i>O. ovatus</i>	Lab. Rome, Italy	July	Larva	In soil	?
<i>O. trophonius</i>	Maccarese	June	Adult	On crown	?
	Maccarese	Sept.	Adult	On crown	—
	Maccarese	Sept.	Adult	On crown	?
<i>Polydrusus sericeus</i>	Emilia Romagna	May	Adult	On leaf	?
<i>P. tibialis</i>	Emilia Romagna	May	Adult	On leaf	?
<i>Donus crinitus</i>	Maccarese	Mar.	Adult	In detritus	?
	Maccarese	Sept.	Adult	In root	?
	Maccarese	Sept.	Adult	In crown	?
	Maccarese	Dec.	Adult	On crown	?
<i>D. salviae</i>	Latina, Italy	Sept.	Adult	On crown	?
<i>Rhinoncus pericarpious</i>	Switzerland (CH)	Aug.	Adult	On leaf	?
	Emilia Romagna	Oct.	Adult	On crown	?
	Emilia Romagna	Dec.	Adult	On leaf	?
	Rome	June	Adult	On crown	?
	Rome	Sept.	Adult	In root	—
	Rome	Sept.	Larva	In crown	?
	Rome	Sept.	Adult	On leaf	?
	Maccarese	Sept.	Adult	In root	—
	Lab. Rome, Italy	Aug.	Adult	In root	—
	Lab. Rome, Italy	Aug.	Larva	In root	Light
	Lab. Rome, Italy	Sept.	Adult	In root	—
	Abruzzi	June	Adult	On leaf	?
	Abruzzi	July	Larva	In root	Medium
	Abruzzi	Nov.	Adult	On crown	?
	Abruzzi	Nov.	Adult	In root	—
	Abruzzi	Dec.	Adult	On leaf	?

Table 3 (cont.)

Insect	Site	Month	Stage	Where found	Damage
	Abruzzi	Dec.	Adult	?	—
	Abruzzi	Sept.	Adult	On root	Light
	Abruzzi	Nov.	Adult	On crown	?
<i>Rhytideres plicatus</i>	Maccarese	Jan.	Adult	On crown	?
	Maccarese	Sept.	Adult	On crown	?
<i>Sitona crintus</i>	Maccarese	Jan.	Adult	On crown	?
<i>S. puncticollis</i>	Maccarese	Jan.	Adult	On crown	?
	Maccarese	Dec.	Adult	On crown	?
	Abruzzi	Jan.	Adult	On crown	?
<i>Sitona</i> sp.	Maccarese	Sept.	Adult	On crown	—
	Maccarese	Sept.	Adult	In crown	—
	Maccarese	Sept.	Adult	In crown	—
	Abruzzi	Nov.	Adult	On crown	—
<i>Lixomorphus ocularis</i>	Maccarese	Jan.	Adult	In stem	—
	Maccarese	Apr.	Adult	In stem	—
	Maccarese	June	Adult	On crown	?
	Maccarese	June	Larva	In root	Light
	Maccarese	June	Adult	On crown	?
	Maccarese	June	Larva	In root	Medium
	Maccarese	Sept.	Adult	In root	—
	Maccarese	Sept.	Adult	In stem	—
	Maccarese	Sept.	Adult	In root	—
	Maccarese	Sept.	Adult	In root	—
	Maccarese	Sept.	Adult	On soil	—
	Maccarese	Sept.	Adult	In root	—
<i>Curculio (Balanobius) salicivorus</i> Paikull	Rovigo, Italy	Apr.	Adult	On crown	?
<i>Baris coetulescens</i>	Maccarese	Mar.	Adult	On leaf	?
<i>Cycloderes canescens</i>	Maccarese	Mar.	Larva	In soil	?
	Maccarese	Sept.	Adult	In crown	—
<i>Phyllobius</i> sp.	Lab. Rome, Italy	June	Adult	?	—
	Abruzzi	June	Adult	On leaf	?
<i>Tychius cuprifus</i>	Rome	Sept.	Adult	On crown	?
Scarabaeidae					
<i>Aphodius</i> sp.	Maccarese	Sept.	Adult	On crown	?
Staphylinidae					
<i>Aleocharinae</i> sp.	Abruzzi	Jan.	Adult	On crown	—
<i>Paederinae</i> sp.	Maccarese	Feb.	Adult	On crown	—
	Maccarese	Feb.	Adult	On crown	—
<i>Paederus</i> sp.	Maccarese	Jan.	Adult	In soil	—
	Maccarese	Mar.	Adult	On crown	—
<i>Quedini</i> sp.	Maccarese	Feb.	Adult	On crown	—
	Maccarese	Apr.	Adult	On crown	—
<i>Steninae</i> sp.	Abruzzi	Jan.	Adult	On crown	—
<i>Tachyporinae</i> sp.	Maccarese	Mar.	Adult	On crown	—
	Abruzzi	Jan.	Adult	On crown	—
Cantharidae					
<i>Cantharis</i> sp.	Maccarese	June	Adult	In leaf	—

Table 3 (cont.)

Insect	Site	Month	Stage	Where found	Damage
Pselaphidae					
<i>Reichenbachia</i> sp.	Abruzzi	Jan.	Adult	On crown	?
Lagriidae					
<i>Lagria birta</i>	Maccarese	Apr.	Larva	In detritus	—
	Maccarese	May	Adult	On soil	?
	San Giorgio	June	Adult	In air	—
Tenebrionidae					
<i>Gonocephalus pusillum</i>	Maccarese	Jan.	Adult	On soil	?
	Maccarese	Mar.	Adult	On crown	?
	Maccarese	Sept.	Adult	In crown	?
	Maccarese	Sept.	Adult	In root	?
	Maccarese	Sept.	Adult	In crown	?
<i>Stenosis angustata</i>	Maccarese	Sept.	Adult	On crown	—
	Maccarese	Sept.	Adult	On crown	?
<i>Pedinus femoralis</i>	Maccarese	Mar.	Adult	On crown	—
	Maccarese	June	Adult	On crown	?
	Maccarese	Sept.	Adult	In root	?
	Maccarese	Sept.	Adult	On crown	?
Silphidae					
<i>Silpha obscura</i>	Maccarese	Mar.	Adult	On soil	—
	Maccarese	Apr.	Adult	On soil	—
Elateridae					
<i>Agriotes</i> sp.	Castel Porziano	Jan.	Adult	On crown	?
	Castel Porziano	Dec.	Adult	On crown	—
	Maccarese	Jan.	Larva	In soil	?
Anthicidae					
<i>Anthicus anthorinus</i>	Maccarese	Jan.	Adult	In detritus	?
	Maccarese	Feb.	Adult	In detritus	?
	Maccarese	Dec.	Adult	In detritus	?
	Abruzzi	Jan.	Adult	In detritus	?
	Abruzzi	Dec.	Adult	In detritus	?
	Abruzzi	Dec.	Adult	On crown	?
<i>A. instabilis</i>	Latina, Italy	Sept.	Adult	On crown	?
	Castel Porziano	Jan.	Adult	On crown	—
	Castel Porziano	Feb.	Adult	In detritus	?
	Maccarese	Jan.	Adult	In detritus	?
	Maccarese	Jan.	Adult	In detritus	?
	Maccarese	Jan.	Adult	On crown	?
	Maccarese	Feb.	Adult	In detritus	?
	Maccarese	Mar.	Adult	In detritus	?
	Maccarese	Mar.	Adult	On crown	?
	Maccarese	Mar.	Adult	On crown	?
	Maccarese	Dec.	Adult	In detritus	?
	Maccarese	Dec.	Adult	In detritus	?
<i>Endomia tenuicallis</i>	Maccarese	Mar.	Adult	On crown	?
	Maccarese	Dec.	Adult	On crown	—
<i>Formicomus pedestris</i>	Emilia Romagna	Dec.	Adult	In detritus	?
Carabidae					
<i>Agonum dorsale</i>	Emilia Romagna	Mar.	Adult	On soil	—
<i>Amara</i> sp.	Rovigo, Italy	Apr.	Adult	On crown	—
<i>Bembidion</i> sp.	Maccarese	Mar.	Adult	On crown	—

Table 3 (cont.)

Insect	Site	Month	Stage	Where found	Damage	
<i>Bradycellus</i> sp.	Castel Porziano	Mar.	Adult	On crown	—	
	Maccarese	Jan.	Adult	On crown	—	
	Maccarese	Apr.	Adult	On crown	—	
	Maccarese	Apr.	Adult	On soil	—	
	Maccarese	Apr.	Adult	On soil	—	
	Maccarese	May	Adult	In detritus	—	
	Maccarese	May	Adult	On soil	—	
	Maccarese	May	Adult	On crown	—	
	Maccarese	Dec.	Adult	In detritus	—	
	Maccarese	Dec.	Adult	On crown	—	
<i>Calathus</i> sp.	Maccarese	Mar.	Adult	On crown	—	
	Maccarese	Mar.	Adult	On crown	—	
<i>Demetrias</i> sp.	Maccarese	Mar.	Adult	In detritus	—	
<i>Dichirotrichus</i> sp.	Maccarese	Mar.	Adult	On crown	—	
<i>Dromius</i> sp.	Emilia Romagna	June	Adult	In detritus	—	
	Rome	July	Adult	On crown	—	
	Castel Porziano	Jan.	Adult	On crown	—	
	Castel Porziano	Feb.	Adult	In detritus	—	
	Castel Porziano	Dec.	Adult	In detritus	—	
	Maccarese	Jan.	Adult	In detritus	—	
	Maccarese	Jan.	Adult	On crown	—	
	Maccarese	Jan.	Adult	On crown	—	
	Maccarese	Jan.	Adult	On crown	—	
	Maccarese	Jan.	Adult	On crown	—	
	Maccarese	Mar.	Adult	In detritus	—	
	Maccarese	May	Adult	In detritus	—	
	Maccarese	Dec.	Adult	On crown	—	
	<i>Microlestes</i> sp.	Emilia Romagna	Jan.	Adult	On crown	—
		Rome	July	Adult	On crown	—
Castel Porziano		Jan.	Adult	On crown	—	
Castel Porziano		Feb.	Adult	On crown	—	
Maccarese		Jan.	Adult	On crown	—	
Maccarese		Feb.	Adult	On crown	—	
Maccarese		Dec.	Adult	On crown	—	
Abruzzi		Jan.	Adult	On crown	—	
Abruzzi		Nov.	Adult	On crown	—	
Abruzzi		Dec.	Adult	On crown	—	
Castel Porziano		Mar.	Adult	On crown	—	
Maccarese		Dec.	Adult	On crown	—	
<i>Pterostichus</i> sp.	Maccarese	Apr.	Adult	On crown	—	
<i>Trechus</i> sp.	Maccarese	Apr.	Adult	On crown	—	
<i>Trichocellus</i> sp.	Maccarese	Apr.	Adult	On crown	—	
Buprestidae						
<i>Capnodis tenebricosa</i>	Emilia Romagna	Dec.	Larva	In root	Medium	
	Maccarese	Jan.	Adult	In stem	—	
	Maccarese	Jan.	Larva	In root	Heavy	
	Maccarese	Jan.	Larva	In root	Heavy	
	Maccarese	Jan.	Larva	In root	Light	
	Maccarese	Feb.	Larva	In stem	Medium	
	Maccarese	Mar.	Larva	In root	Heavy	
	Maccarese	Mar.	Larva	In root	Light	
	Maccarese	Mar.	Larva	In root	Heavy	
	Maccarese	Mar.	Larva	In root	Medium	
	Maccarese	Mar.	Larva	In root	Medium	
	Maccarese	Mar.	Larva	In root	Medium	

Table 3 cont.)

Insect	Site	Month	Stage	Where found	Damage
	Maccarese	Sept.	Larva	In root	Light
	Maccarese	Sept.	Pupa	In root	—
	Maccarese	Sept.	Larva	In root	Medium
	Maccarese	Sept.	Pupa	In root	—
	Maccarese	Sept.	Adult	In root	—
	Maccarese	Sept.	Adult	In root	—
	Maccarese	Sept.	Pupa	In root	—
	Maccarese	Sept.	Larva	In root	Death
	Maccarese	Sept.	Larva	In root	Heavy
	Maccarese	Sept.	Adult	In root	—
	Maccarese	Sept.	Pupa	In root	—
	Maccarese	Sept.	Larva	In root	Light
	Maccarese	Dec.	Adult	In stem	—
	Maccarese	Dec.	Larva	In root	Heavy
	Maccarese	Dec.	Larva	In root	Heavy
	Lab. Rome, Italy	Sept.	Larva	In root	Heavy
	Abruzzi	July	Larva	In root	Light
	Abruzzi	Nov.	Larva	In root	Light
	Abruzzi	Sept.	Larva	In root	Heavy
	Abruzzi	Sept.	Larva	In root	Heavy
	Abruzzi	Nov.	Larva	In root	Medium
	San Giorgio	May	Adult	On soil	—
Hydrophilidae					
<i>Cercyon</i> sp.	Maccarese	Dec.	Adult	In detritus	?
Mordellidae					
Nitidulidae					
<i>Brachypterus glaber</i>	Lab. Rome, Italy	June	Adult	On flower	?
<i>Meligethes</i> sp.	Maccarese	May	Nymph	On stem	—
Phalacridae					
<i>Olibrus bisignatus</i>	Maccarese	Mar.	Adult	In detritus	?
Lathridiidae					
<i>Corticaria</i> sp.	Castel Porziano	Mar.	Adult	On crown	?
<i>Enicmus transversus</i>	Maccarese	June	Adult	On seed	?
Byrrhidae					
<i>Simplocaria</i> sp.	Maccarese	June	Adult	On crown	?
NEUROPTERA					
Hemeroibiidae					
<i>Micromus angulatus</i>	Emilia Romagna	Jan.	Adult	On crown	—
	Maccarese	Feb.	Adult	On crown	—
	Maccarese	Dec.	Adult	On crown	—
Ascalaphidae					
<i>Ascalaphus libelluloides</i>	San Giorgio	June	Adult	On seed	—

Difficulties in the identification of the species may have accounted for these records. However, plant species of the other recorded hosts will be used in host range tests for *P. chrysidiforme* in 1981.

Dr Naumann doubts that there are good morphological characters to separate the species within *Pyropteron*, if in fact they do exist. *P. chrysidiforme* overwinters as a larva in the roots of *Rumex* spp. Pupation occurs in late March and April depending upon soil temperatures. In our greenhouse, adult emergence began after the first of June. Field emergence in the Rome area is probably in the latter part of June. Typically, as the adult begins to leave the chrysalid, it crawls from a hollow broken stem or other hole in the crown. Thus we were able to see where an adult had emerged from a plant by the empty chrysalid projecting from the emergence hole. Emergence took place from 12 noon to 2 p.m. when the sun was shining into the greenhouse and the air temperature had risen. As with other sesiids, the adult female appears to release a pheromone. Females were observed to rest on the cage soon after emergence and extend their abdomen with the posterior tufts splayed outwards in a fan shape. Males in the cages became active and seemed to have little difficulty in finding the females. Mating posture is tail-to-tail and was observed to last for 10 minutes. Eggs are randomly placed on *Rumex* plants in a cage situation. Four females laid an average of $457 \pm$ S.D. 191 eggs over a period of eight days in 1980. Eggs are charcoal grey to black. Upon eclosion, larvae crawl downward on the outside surface of the plant to the soil level. We theorize that the larvae enter the root at a point just below the surface of the soil.

Table 4 shows *P. chrysidiforme* larval survival on *R. crispus* and rhubarb. Thirteen larvae or pupae were found on the 20 *R. crispus* test plants.

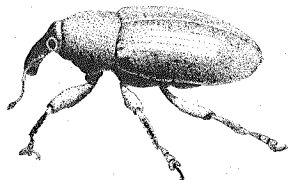
Table 4. *Pyropteron chrysidiforme* larval survival test on *Rumex crispus* and *Rheum rhabarbarum*. Five larvae per plant were placed around the potted plant's base. Plants infested from June 29 to July 2, 1979.

Dissection period	No. plants dissected	No. larvae found	No. pupae found
<i>Rumex crispus</i>			
Fall (Oct.)	5	5	0
Spring (June)	15	0	8
Total	20	5	8
<i>Rheum rhabarbarum</i>			
Fall (Oct.)	10	2 ^a	0
Spring (June)	10	0	0
Total	20	2	0

^a The two larvae found in rhubarb were undersized, compared with the larvae on *Rumex* and appeared to have stopped feeding.

Two larvae were found in two roots of the 20 rhubarb plants. The larvae had bored into the roots, eaten out a small cell, and then their development appeared to have stopped. Because of the *P. chrysidiforme* larvae found in rhubarb when we dissected 10 plants in the fall of 1979, we delayed further dissections until just before adult sesiids should be emerging in the spring of 1980. This delay was to allow complete development on rhubarb if it was possible. It can be seen in Table 4 that no further larvae (or pupae) were found in the 10 rhubarb plants dissected in June 1980 while eight pupae were found in 15 *R. crispus* plants. Further tests are under way in 1980 to ascertain the host range of *P. chrysidiforme*.

Lixomorphus ocularis Fabricius (1792)



Lixomorphus ocularis is a dark brown, oblong, flightless weevil. The entire body of the adult may be covered with a yellow pollen-like pubescence which seems to rub off with age. When the yellow colouration is present a rose coloured band can be seen along the lateral edges of the elytra running anteriorly to the mandibles on the rostrum. The eyes are encircled by a dense ring of white scales. No doubt it is this characteristic of the species that led Fabricius to use the name *ocularis*. Very little has been found in the European literature on *L. ocularis* and nowhere is it listed as a pest. Our collections of the

weevil have been limited to three sites around Rome. Our interest in *L. ocularis* resulted from the amount of damage the larva can inflict upon the root of *R. crispus* and the lack of information on any other known host. Very little is known about the biology of *L. ocularis* and the immature stages are undescribed.

In May 1979 and 1980 adults were found feeding and mating on *R. crispus* in the area of Rome. Mating pairs were collected in both years and brought into the laboratory for study. In May 1979 fertile *L. ocularis* eggs were placed singularly in the stems of *R. crispus* and *R. rhabarbarum* in a larval survival test that was replicated four times. When the plants were dissected in October 1979 one *R. crispus* root contained a teneral adult.

In 1980 ca. 30 pairs of *L. ocularis* were field collected from an area about 30 km north of Rome and brought into the laboratory. It appears that these adults emerge from pupae in the fall and overwinter in hollow stems of *Rumex* or in hollowed out roots. In late April or early May the adults are sexually active and feed on the leaves of *Rumex* and perhaps other Polygonaceae. Preliminary observations indicate that adults are flightless and that egg laying may not begin for several weeks after their spring appearance. Laboratory and field observations have shown that individual eggs are laid at the base of a *Rumex* plant. Females in the laboratory have produced few eggs and laboratory dissection of females indicated slow oogenesis and a low fecundity (<25 eggs per ♀).

Adult *L. ocularis* couples caged on buckwheat, rhubarb, *R. crispus*, *R. acetosa*, *R. scutatus*, and *R. conglomeratus* showed no significant preference

for any of the species. Very few (<10) eggs were laid by females on any of the caged plants.

CONCLUSION

Collections in Italy and elsewhere in Europe showed that the subgenus *Rumex* is a host to a large number of insects and plant pathogens. We have hopes of being able to use a plant pathogen as a bioherbicide. However to date, a pathogen with the host specificity and necessary virulence has not been found. Active research in this area is going on in the laboratories of Dr. G. Defago in Zurich, Switzerland.

Two hundred insects have been identified from *Rumex*, but only a small number of these species might be usable as agents for the biological control of *R. crispus* because of host specificity, effectiveness, fecundity, dispersal ability, and such factors as host of related species, worldwide distribution, etc.

Preliminary host specificity testing of the sesiid, *Pyropteron chrysidiforme* has been encouraging and additional indepth studies are under way both for host range and bionomics of the species.

Lixomorphus ocularis is an interesting weevil. However our preliminary tests and information gathered on its biology lead me to believe that it would not be a worthwhile biological control agent for *R. crispus*.

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REFERENCES

- Allard, R. (1965). Genetic systems associated with colonizing ability in predominantly self-pollinated species. In 'The genetics of colonizing species'. (Eds H. Baker and G. Stebbins.) (Academic Press: New York.) p.49.
- Cavers, P.B., and Harper, J.L. (1964). Biological flora of the British Isles, *Rumex obtusifolius* L. and *R. crispus* L. J. Ecol., 52:737-66.
- Einhellig, F.A., and Rasmussen, J.A. (1972). Interplant influences of *Rumex crispus*. Proc. S.D. Acad. Sci. 51:265-6.
- Fibiger, M., and Kristensen, N.P. (1964). The sesiidae (Lepidoptera) of Fennoscandia and Denmark. Fauna Ent. Scand. 2:1-91.
- Force, D.C. (1966). Reactions of the green dock beetle, *Gastrophysa cyanea* (Coleoptera:Chrysomelidae) to its host and certain non host plants. Ann. Ent. Soc. Am. 59:1119-25.
- Frank, P.A. (1971). A biological control agent for *Rumex crispus*. Proc. II Int. Symp. Biol. Contr. Weeds, Rome, Italy, pp.121-6.
- Garcia-Baudin, J.M., and Santiago-Alvarez, C. (1978). Biological control of *Rumex obtusifolius* L. I. Preliminary considerations on the species *Gastroidea*

(=*Gastrophysa*) *unicolor* Marsham (Coleoptera:Chrysomelidae). *Anales del Instituto Nacional de Investigaciones Agrarias* 6:127-39.

Haflinger, E., and Brun-Hool, J. (1976). *Rumex* L. dock. In 'Weed Tables-Wild Flora in Agricultural Crops'. (Societe Francaise du Livre: Paris.)

Hughes, W.E. (1938). Studies into the biology of some *Rumex* species. M. Sc. Thesis, University of Wales.

Inman, R.E. (1969). Control of *Rumex crispus* L. with the rust fungus, *Uromyces rumicis* (Schum.) Wint. Preliminary investigations. Proc. I Int. Symp. Biol. Contr. Weeds, Delemont, Switzerland, pp.39-40.

Masahisa, M., and Atsushi Naito (1973). Studies on the host specificity of *Gastrophysa atrocyanea* Mot. (Col.:Chrysomelidae), a potential biological control agent against *Rumex obtusifolius* L. (Polygonaceae) in Japan. Proc. III Int. Symp. Biol. Contr. Weeds, Montpellier, France, pp.97-107.

Naumann, C.M. (1977). Studies on the systematics and phylogeny of holarctic sesiidae (Insecta, Lepidoptera). Smithsonian Institution and National Science Foundation, Washington, D.C.

Popescu-Gorj, A., Niculescu, E.V., and Alexinschi, Al. (1958). 'Fauna Republicii Populare Romine, Insects 11, 1: Lepidoptera, Familia Aegeriidae.' (Bucharest.) 195 pp.

Salisbury, E.J. (1961). 'Weeds and Aliens.' (London.).

Spencer, N.R., Rosenthal, S., and Hostettler, N. (1981). A computer assisted methodology for the storage sorting and retrieval of biological field data. Proc. V Int. Symp. Biol. Cont. Weeds, Brisbane, Australia, 1980. (In Press.)