



The insect fauna of Canada thistle, *Cirsium arvense* (L.) Scop. in southern Montana
by Hilde De Smet-Moens

A thesis submitted in partial fulfillment of the requirements for the degree of MASTER OF SCIENCE
in Biological Sciences

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Abstract:

Insects associated with *Cirsium arvense* (L.) Scop, in southern Montana are reported. Fifty-six
phytophagous species and 47 visiting insects were collected, identified and tabulated.

Four insect species, *Corythucha distincta* Osborn and Drake (Hemiptera: Tingidae), *Bans* sp., poss.
cirsii Gilbert (Coleoptera: Curculionidae), *Vanessa cardui* L. (Lepidoptera: Nymphalidae), and *Orellia*
ruficauda (Fabricius) (Diptera: Tephritidae), were considered conspicuous, because of their damage
inflicted to the thistle plant.

More insects were found associated with the developing seed heads than with foliage, stems or roots.

The information gathered on this local survey can be valuable for future introductions of insect
biological control agents. It forms the foundation for follow-up studies with indigenous insect species.

Augmentation and redistribution of established monophagous insects, such as *Ceuthorynchus litura* and
Baris sp. should be considered. Transmission experiments are necessary to evaluate the potential of
these monophagous insects as thistle pathogen vectors. The combination of two stress-factors will
increase the impact on the thistle plant in the field.

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August 6, 1982

THE INSECT FAUNA OF CANADA THISTLE, CIRSIUM ARVENSE (L.) SCOP

IN SOUTHERN MONTANA

by

HILDE DE SMET-MOENS

A thesis submitted in partial fulfillment
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of

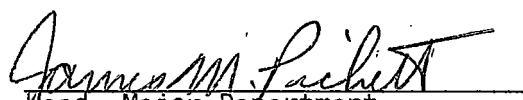
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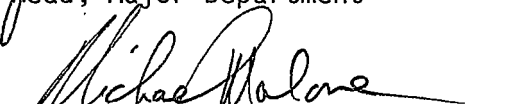
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ABSTRACT

Insects associated with Cirsium arvense (L.) Scop. in southern Montana are reported. Fifty-six phytophagous species and 47 visiting insects were collected, identified and tabulated.

Four insect species, Corythucha distincta Osborn and Drake (Hemiptera: Tingidae), Baris sp., poss. cirsii Gilbert (Coleoptera: Curculionidae), Vanessa cardui L. (Lepidoptera: Nymphalidae), and Orellia ruficauda (Fabricius) (Diptera: Tephritidae), were considered conspicuous, because of their damage inflicted to the thistle plant.

More insects were found associated with the developing seed heads than with foliage, stems or roots.

The information gathered on this local survey can be valuable for future introductions of insect biological control agents. It forms the foundation for follow-up studies with indigenous insect species.

Augmentation and redistribution of established monophagous insects, such as Ceuthorynchus litura and Baris sp. should be considered. Transmission experiments are necessary to evaluate the potential of these monophagous insects as thistle pathogen vectors. The combination of two stress-factors will increase the impact on the thistle plant in the field.

INTRODUCTION

Cultural and chemical control practices have historically been the main approaches to weed control. Both methods are aimed at removing unwanted plants as quickly as possible, a short term approach requiring considerable annual expenditures of resources and energy (Andres and Goeden, 1971). Biological control of weeds has become a popular alternative because it is a means of controlling weeds without the high energy costs of cultural practices and without the residue and pollution problems of herbicides.

Biological control of weeds is the deliberate use of insects or other plant parasites to reduce the density of a weed to an acceptable level (Harris, 1971b). Biocontrol, when effective, is relatively inexpensive, long-lasting and the benefits are cumulative. This approach has strengths and weaknesses different from other methods and hence is advantageous under certain conditions (Harris, 1971b; Maw, 1982). Most crops of arable land have many species of weeds as competitors. Thus, controlling one species through biological control would require spraying or cultivation for control of the other species. On the other hand, dominance of one weed species is typical on range land. Such a dominant weed is a very suitable subject for biological control. Even a slight increase in pressure can have a significant effect (Harris, 1971b).

One of the initial steps in developing a biological weed control program is to determine the natural enemies attacking the weed species,

in both its native and its present geographic ranges (Maw, 1980; Harris, 1971a). Initial surveys expand insight and understanding of the weed ecology, host ranges, ethology and insect-host interrelationships. The information gathered in the local surveys indicates the niches occupied by indigenous species, so that chances of introducing a biocontrol agent that may duplicate or compete with an already present species are minimized (Maw, 1976).

The objectives of this study were: 1) to determine the endemic insect fauna associated with the different growth stages of Canada thistle, Cirsium arvense (L.) Scop., in Southern Montana, and 2) to evaluate the damage inflicted by the most conspicuous species.

LITERATURE REVIEW

The Host Plant

Cirsium arvense (L.) Scop. is a troublesome perennial weed in Montana. Indigenous to Europe, Western Asia and Northern Africa, it was probably introduced to North America in the 17th Century (Detmers, 1927; Peschken, 1971). Infestations of Canada thistle now occur throughout the agricultural areas of Canada and the northern half of the United States (Peschken, 1971; Hitchcock, et al., 1973). A recent survey indicated that this troublesome weed infests 1.5 million acres in Montana.¹

Canada thistle damages a wide variety of crops by competitive use of light, moisture and nutrients (Hodgson, 1977). Heavy infestations in pastures and ranges reduce forage yields considerably. The weed also harbors insects that attack economic crops and is an alternate host for some pathogenic organisms (Moore, 1975).

Cirsium arvense (L.) Scop. is a polymorphic species. Stem, leaf and flower characteristics vary considerably. Botanists usually recognize three or four morphological variants, all interbreeding freely (Moore and Frankton, 1974; Hodgson, 1964; Detmers, 1927). Canada thistle is dioecious and reproduction occurs from seed and rhizome pieces. Detmers (1927) stated that honey bees were the chief pollination agents.

¹Jackson, M. J., 1982. Personal communication.

In Montana, the thistle plants emerge in early May, when the mean weekly air temperature reaches 5°C (Moore, 1975). Rosettes are formed followed by stem elongation approximately three weeks after emergence (Moore, 1975). Flowering begins in mid-June and continues into September. Growth begins decreasing in July, and ceases by early August.

The obnoxious character of this weed is due mainly to the rapid vegetative propagation of its creeping horizontal rhizomes, giving rise to numerous aerial shoots (Moore, 1975). This extensive branched rhizome system makes Canada thistle difficult to control. Cultural, mechanical and chemical control methods can be effective in cultivated fields if used persistently in a long range control program (Hodgson, 1977). Where Canada thistle is a prevalent weed in range land, fallow fields, waste lands, roadsides or railways, biological control by insects can be a reasonable adjunct. These host specific insects are harmless to non-target plants and may be able to multiply and disperse to adjacent infestations.

Biological Control of Canada Thistle

The principles and procedures of biological weed control have been well defined and illustrated with some spectacular successes (De Bach, 1964; Van den Bosch, et al., 1982). Biological control strives to reduce the abundance of a weed species by introducing or augmenting the weed's natural enemies. Huffaker (1959) lists examples in which

naturally occurring insects have played an important role in affecting the abundance of a particular plant species. The introduction of host specific phytophagous organisms has received the most emphasis to date (Andres, et al., 1976). The steps involved in such a technique are described by Harris (1971b).

Cirsium arvense (L.) Scop. is a prime candidate for biological control (Hume, 1982; Harris, 1971b, Andres, et al., 1976) because:

1. The plant has little or no value to people or wildlife.
2. It tends to grow in dense populations, representing a dominant weed in pasture and waste areas.
3. It is an introduced weed, and has very few parasites and predators.
4. It is not closely related to major economic crop plants; however artichoke (Cynara scolymus L.) and safflower (Carthamus tinctorius L.) belong to the same Cynareae tribe.
5. Many of the thistle infestations occur in inaccessible areas and thus lend themselves to biocontrol efforts (Story, 1980).
6. The widespread distribution of the weed will result in low cost per acre of control. This cost per acre will be lower than that of other control methods (Harris, 1979).

Biological control will increase the environmental pressure on Canada thistle. At best, the natural enemies may eliminate the need for other control methods over much of the plant's range and form a sound basis for future weed management schemes. At least, they would augment existing control practices (Batra, et al., 1981).

The Commonwealth Institute of Biological Control began work on the control of Canada thistle in 1961, with a study of its parasites in Europe (Peschken, 1971). Eighty insect species were found to feed on the weed, Altica carduorum Guer. (Coleoptera: Chrysomelidae), Ceutorhynchus litura (Fab.) (Coleoptera: Curculionidae) and Urophora cardui (L.) (Diptera: Tephritidae) were selected for further study because of their apparent host specificity (Peschken, 1971; Zwolfer, 1964). All three insects have been released in Canada and the United States.

Altica carduorum Guerin failed to establish in all release sites due to climatic stress and attack by insect predators (Peschken, et al., 1970).

Ceutorhynchus litura (F.) is established in a wide range of climates in Canada (Peschken, et al., 1980), Montana and Idaho; however, the range of infestation is increasing very slowly. While this weevil exerts stress on its host in the laboratory (Peschken and Beecher, 1973), there is no evidence that C. litura controls Canada thistle in the field (Peschken, et al., 1981).

Urophora cardui (L.) has become established and is spreading in eastern Canada (Peschken, et al., 1980). A microsporidian disease of U. cardui (Nosema sp.) is one of the causes leading to failure of establishment in the Western states. Other reasons, such as infertility of the flies, or spring frost killing of the larvae may have been additional causes of mortality (Peschken, et al., 1982).

Apparently the two established introduced insects will not control Canada thistle. Further stress factors from other insects, pathogens or plant competition are needed to control this weed.

Few potentially effective and host specific insects from Zwolfer's list (1964) are still available. Tingis ampliata H.-S. (Heteroptera: Tingidae) was recently tested for host specificity in the laboratory. It was considered unsafe for introduction in Canada, because its hosts include safflower and globe artichoke. The approval for release of Lema cyanella (L.) (Coleoptera: Curculionidae) has been withheld because it attacks several Cirsium spp. indigenous to North America (Peschken, et al., 1980).

The present concern for native Cirsium species has become a critical issue. Had such stringent host specificity requirements been applied in the past, a number of insects would never have been released. This fear for native flora could lengthen the screening process considerably and many promising agents could be rejected. Biological control could then become impractical and very expensive. Peschken (1982)

reviewed successful biological weed control projects and concluded that no target weed has ever become rare. He stated that it is very unlikely that native plants, which are in equilibrium with their own insect fauna, would support additional insect species.

Populations of Canada thistle are also attacked by numerous indigenous insects and pathogens. Natural enemies, associated with Canada thistle in North America have been reported by Moore (1975), Maw (1976), Watson, et al. (1980), Detmers (1927), and Andres (1980). Among the most important species were:

- a. The painted lady butterfly, Vanessa cardui L. (= Pyrameis cardui L., = Cynthia cardui (L.)) (Lepidoptera: Nymphalidae). The larvae occasionally cause spectacular defoliation of thistles in local areas. It is a migratory butterfly, and its numbers fluctuate annually, making it unreliable as a natural control agent. It can be a pest of sunflower and soybean (Moriwaka and Balsbaugh, 1976) and many other plants.
- b. The Canada thistle midge Dasyneura gibsoni Felt (Diptera: Cecidomyiidae), which attacks the developing seed heads.
- c. Orellia ruficauda (F.) (= Trypeta fluorescentiae L.) (Diptera: Tephritidae) which attacks up to 70% of the thistle heads. This seed head fly was probably accidentally introduced from Europe (Harris, 1971a).

- d. Cassida rubiginosa Muell. (Coleoptera: Chrysomelidae). This beetle was accidentally introduced into the United States (Ward, 1976), and defoliates Canada thistle at high populations. This flea beetle has become widely established in the Eastern United States (Ward, 1976).
- e. The systemic autoecious rust Puccinia obtegens (Link) Tul. is an endemic pathogen, host specific to Canada thistle. Natural infection is not high enough for economic control. Since host resistance is an important factor limiting rust infection, an aggressive strain may be more effective as a biocontrol agent of Canada thistle (Turner, 1981).

None of the listed species suppress Canada thistle populations below the economic level. However, investigations of the biology of the most destructive organisms could result in the development of approaches whereby populations of these natural enemies are augmented to increase their damage to Canada thistle (Watson, et al., 1980; Ward, 1976; Turner, 1981).

Biological Control of Canada Thistle in Montana

The biological control program of Canada thistle in Montana began with the liberation of Altica carduorum Guerin in 1964. Subsequently, the stem weevil Ceutorhynchus litura (F.) was released in 1973 and Urophora cardui (L.) in 1978 (Story, 1979) (Table 1). Of the three,

Table 1. Information on the insects released in Montana for the biological control of Canada thistle.^a

Insect	Date Insects Released	No. Insects Released	County where Released	Source of Insect	Status of Insect
<u>Altica</u>					
<u>carduorum</u> Guerin	1964	200	Ravalli	USDA	No recovery
	1966	200	Gallatin	USDA	No recovery
<u>Ceutorhynchus</u>					
<u>litura</u> (F.)	1973	200	Gallatin	USDA	Inc. slowly
<u>Urophora</u>					
<u>cardui</u> (L.)	1978	92	Ravalli	USDA	No recovery

^aData from Story, J. M., 1979.

only Ceutorhynchus litura (F.) has survived and become established. Attempts to redistribute the weevil were made in 1977 at the Bozeman site, when 95% of the shoots were found to be mined (Story, 1980). Plants infested with C. litura larvae were collected in June from the release site and transplanted in other areas of Montana.

The reasons for failure of Altica carduorum Guerin and Urophora cardui (L.) to establish in Montana are not known. Additional attempts to establish U. cardui will be made as more insects become available (Story, 1980).

The biological weed control program in Montana is increasing in momentum. Interest and awareness by the public and academic communities are growing. Endemic plant pathogens, particularly Puccinia obtegens (Turner, 1981) and Sclerotinia sclerotiorum (Simmonds, 1982) are being investigated as potential biocontrol agents against Canada thistle in Montana. The use of plant pathogens may extend the application of biological weed control to include cultivated areas.

MATERIALS AND METHODS

Study Sites

A total of 50 sites were surveyed throughout the 1981 growing season, starting April 15 and ending September 30 (Figure 1). This period covers rosette, vegetative, flowering and fruiting stages of the thistle plant. Most of the locations represent occasional collection sites. Seven were selected for more intensive weekly or bi-monthly sampling (Table 2). Selection of these sites was based on extent of thistle infestation, habitat-type, accessibility and absence of herbicide and pesticide use.

Collecting Methods

The samples were collected by the following methods:

1. Stands of Canada thistle plants were examined carefully for insect infestations and external symptoms of endophagy. Feeding or oviposition damage was recorded in the field and whenever possible correlated with the insect species present.
2. Most of the insects were collected by handpicking, the only method allowing correct localization of the sampled specimens. Sweeping disturbed the insects and did not always dislodge individuals on upper and lower parts of the plant.
3. Occasionally, a simple polyethylene-bag sampling technique was used (Trumble, et al., 1975). A large polyethylene bag

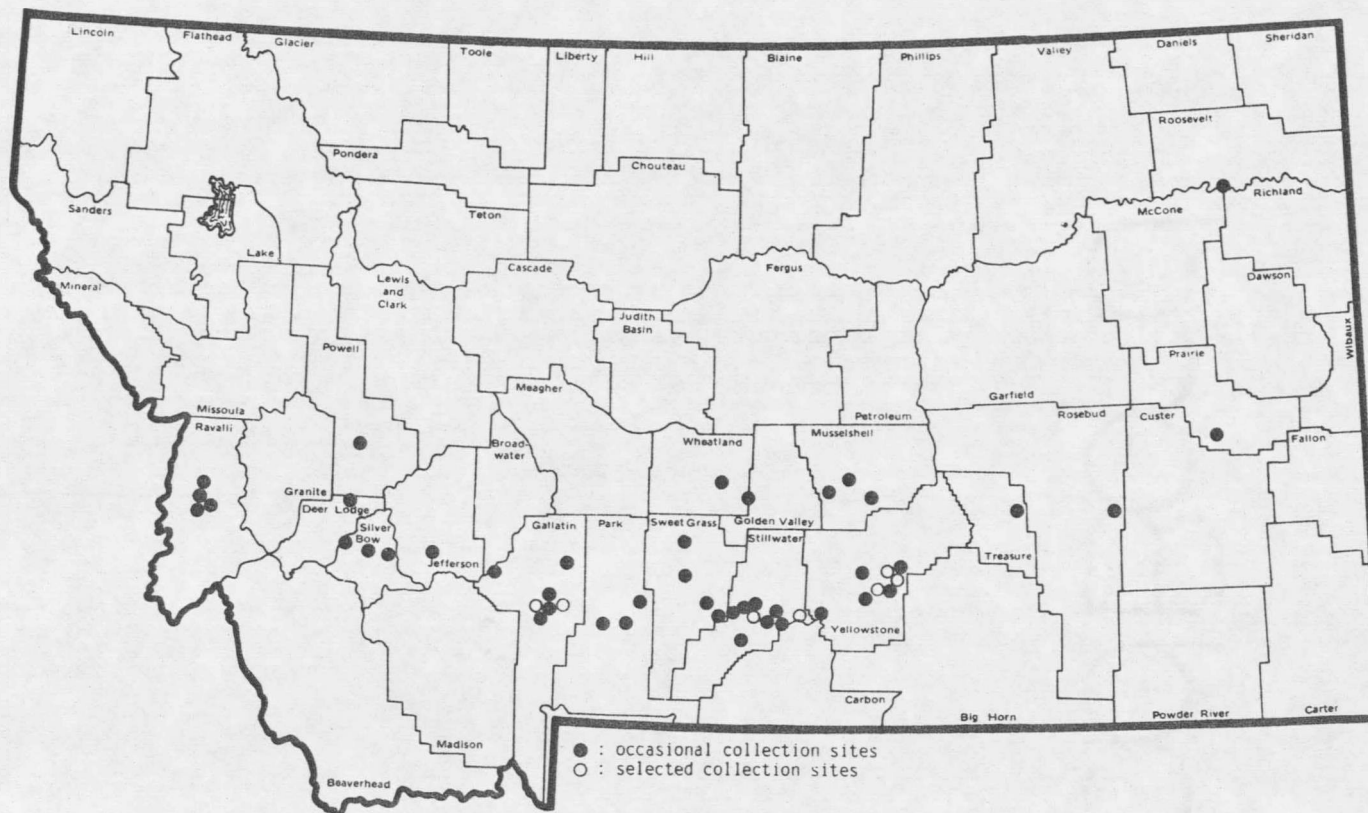


Figure 1. Collection sites of the insect survey on Canada thistle, 1981.

Table 2. Selected collection sites of the 1981 insect survey on Canada thistle.

Site	Location	Habitat
1	Agronomy Farm, Bozeman (Gallatin County)	Mowed grassland with natural rust infestation (<i>P. obtegens</i>) of 52%. (Turner, 1981).
2	Fort Ellis (Gallatin County)	Fallow field planted with wheat and barley in 1980
3	Southern Research Center Huntley (Yellowstone County)	Fallow field, bordering barley field.
4	Southern Research Center Huntley (Yellowstone County)	Waste area, shaded by high trees
5	Billings (Yellowstone County)	Hillside, natural habitat
6	Columbus (Stillwater County)	Disturbed area, roadside
7	Park City (Stillwater County)	Roadside, bordering pastureland

was inverted over the target plants and fastened at the open end. Plants were then uprooted, labeled and transported to the laboratory for examination.

4. Two to five thistle plants were selected at random and uprooted at each site. Roots, crowns and stems were dissected and examined for endophagous insects.
5. Flower heads and buds were dissected in the field. By the end of the growing season, collections of seed heads were made at different sites. Approximately 50% of the seed heads were examined in the laboratory and the rest were stored in polyethylene bags to recover emerging adults of endophagous species.

Experimental Rearings

Immature insects were reared to the adult stage on potted plants or fresh cut Canada thistle foliage in the insectary.

Conspicuous insects such as Baris sp., poss. cirsii Gilbert¹ and Corythucha distincta Osborn and Drake were collected in containers and confined to potted plants in the insectary. Their impact on potted Canada thistle plants was observed daily. Cages used to confine insects were cylindrical in shape (22 x 38 cm), and had wooden frames covered by a fine mesh cloth.

¹Whitehead, D. R. (Systematic Entomological Laboratory, USDA) could not supply a positive identification. We will refer to it as Baris sp.

Field Studies

Sites 5 and 6 (Table 2) were selected for observations of Baris sp. (Coleoptera: Curculionidae) on Canada thistle. Both sites were heavily infested with the weevil and its host.

1. Heights of eight damaged thistle plants were recorded in mid-June at each site and compared with heights of eight uninfested plants at the same site. Differences were tested for significance with the t - test ($P < 0.01$).
2. At the end of the growing season, 17 damaged thistle plants were uprooted, dissected, and pupal counts were made. A regression analysis was performed of the plant height over the larval frequency ($P < 0.01$).
3. Emergence traps, each covering approximately two plants, were placed in site 5, in early September, 1981. These cages, made of fine wire-netting, were conical in shape with a diameter of 80 cm. A small trap was attached on the top (Figure 2). These traps made it possible to control seasonal activity of Baris adults and to collect other insect species emerging from the same thistle plants.

Insect Identification

Insect specimens were sorted and sent to taxonomic authorities for identification.



Figure 2. Emergence trap in site 5.

RESULTS AND DISCUSSION

The insects collected on Canada thistle were grouped as 1) phytophagous insects (Table 3); 2) insects collecting pollen or nectar, insects which are incidental visitors, predators and parasitoids of other insects.

Insects collected are listed by order according to Borror, De Long and Triplehorn (1976).

Phytophagous Insects

Table 3 lists 58 species, representing six orders, 22 families and 51 genera. All of these species have adopted Canada thistle as a food plant. Twenty-six species also use this alien weed as a reproductive host. However, none of these insects are restricted solely to Cirsium arvense, with the exception of Ceutorhynchus litura (Fabricius), which has been purposely introduced for the control of Canada thistle. On the contrary, one third of the insects found feeding on Canada thistle in southern Montana are either minor or major pests of economic crops.

Four species, Corythucha distincta Osborn and Drake (Hemiptera: Tingidae), Baris sp. poss. cirsii Gilbert (Coleoptera: Curculionidae), Vanessa cardui L. (Lepidoptera: Nymphalidae), and Orellia ruficauda (Fabricius) (Diptera: Tephritidae), were considered conspicuous, because of the damage they inflicted to the thistle plant. They can be very

Table 3. Phytophagous insects collected from Canada thistle, Cirsium arvense (L.) Scop., in southern Montana, 1981.

Insects	Relative Frequency in Collection ^a	Stages ^b	Feeding ^c	Plant Association		Recorded Hosts ^f	Literature Source
				Plant Part(s) ^d	Plant Growth Stage(s) ^e		
Orthoptera							
Acrididae							
<u>Chortophaga viridifasciata</u> (DeGeer)	LC	A	ECT	L	R	P	(15,38)
<u>Eritettix simplex</u> (Thomas)	0	A	ECT	L	R	p	(15)
<u>Melanoplus bivittatus</u> (Say)	LC	N,A	ECT	L	F	p	(15,38)
<u>M. femur-rubrum</u> (DeGeer)	C	N,A	ECT	L	F	p	(15,38)
<u>M. packardii</u> Scudder	C	A	ECT	L	F	p	(15)
<u>M. sanguinipes</u> (Fabricius)	C	A	ECT	L	F	-	
Gryllidae							
<u>Allonemobius allardi</u> (Alexander and Thomas)	R	A	ECT	L	F	-	
Hemiptera							
Miridae							
<u>Chlamydatus associatus</u> (Uhler)	R	A	ECT	-	F	c	(29)
<u>Lygus lineolaris</u> (Palisot de Beauvois)	R	A	ECT	F	F	p	(29)
<u>L. robustus</u> Uhler	LC	N,A	ECT	F	V,F	c	(29)
<u>L. schulli</u> Knight	R	A	ECT	F	F	p	(29)
Tingidae							
<u>Corythucha distincta</u> Osborn and Drake	C	E,N,A	ECT	L	R,V,F	p	(13,15)
Pentatomidae							
<u>Euschistus euschistoides</u> (Vollenmolen)	0	A	ECT	L	R	p	(8,15)
<u>Euschistus</u> sp.	0	N	ECT	L	F	-	
<u>Rhytidolomia</u> sp.	0	A	ECT	L	F	-	
1 unidentified sp.	0	E	-	L	F	-	
Homoptera							
Membracidae							
<u>Ceresini</u> sp.	0	N	ECT	S	F	-	
<u>Publilia modesta</u> (Uhler)	C	A	ECT	S	R,V	p	(15)
<u>Tortistilus wickhami</u> (Van Duzee)	R	A	ECT	L	F	-	
Cercopidae							
<u>Aphrophora permutata</u> Uhler	0	A	ECT	S	V	p	(15)
<u>Philaenus spumarius</u> (L.)	C	N,A	ECT	L,S	R,V,F	p	(18)
Cicadellidae							
<u>Aceratagallia</u> sp.	R	A	ECT	L	F		
<u>Agallia</u> sp.	0	A	ECT	L	V		
<u>Cuerna</u> prob. <u>striata</u> (Walker)	0	N,A	ECT	L	R,V	p	(43)
<u>Empoasca</u> sp.	R	A	ECT	L	R		
<u>Euscelidius variegatus</u> (Kirschbaum)	R	A	ECT	L	F	p	(6,44)
<u>Macrostes fascifrons</u> (Stal)	LC	A	ECT	L	F	p	(6,44)
<u>Xerophloea viridis</u> (Fabricius)	R	N	ECT	L	F	p	(6,15)
1 unidentified sp.	R	E		S	F		

Table 3. (continued)

Insects	Relative Frequency in Collection ^a	Stages ^b	Feeding ^c	Plant Association		Recorded Hosts ^f	Literature Source
				Plant Part(s) ^d	Plant Growth Stage(s) ^e		
Aphididae							
<u>Aphis fabae</u> Scopoli	0	N,A	ECT	S	F	p	(45)
<u>Aphis</u> sp.	0	N,A	ECT	S	F	-	
<u>Brachycaudus cardui</u> (L.)	0	N,A	ECT	S	F	t	(45)
<u>Capitophorus carduinus</u> (Walker)	R	N,A	ECT	S	F	t	(45)
<u>Dactynotus</u> sp.	R	N,A	ECT	S	F	-	
Pseudococcidae							
<u>Chnaurococcus trifolii</u> (Forbes)	R	N,A	ECT	R	F	p	(16)
<u>Phenacoccus solani</u> Ferris	R	N,A	ECT	S	V	p	(15,16)
Coleoptera							
Mordellidae							
<u>Mordellistena</u> sp.	C	L	END	S	F	p	(53)
<u>Mordellistena</u> sp. "A"	0	A	ECT	L	V	-	
<u>Mordellistena</u> sp. "B"	0	A	ECT	L	V	-	
Chrysomelidae							
<u>Crioceris duodecimpunctatus</u> (L.)	R	A	ECT	L	V	p	(23)
<u>Deloyala guttata</u> (Olivier)	R	A	ECT	L	R	p	(23)
<u>Diachus auratus</u> (Fabricius)	0	A	ECT	L	R	p	(23)
<u>Pachybrachys melanostictus</u> Suffrian	0	A	ECT	L	R,V	p	(23)
<u>Systema blanda</u> Melsheimer	R	A	ECT	L	F	p	(15)
<u>Trirhabda</u> prob. <u>convergens</u> LeConte	R	A	ECT	L	F	c	(23)
Curculionidae							
<u>Baris</u> sp., poss. <u>cirsii</u> Gilbert	C	L,A	END,ECT	R,S	R,V,F	t	(17)
<u>Geutorhynchus litura</u> (Fabricius)	LC	L,A	END,ECT	S,L	R,V	t	(48)
<u>Dysticheus</u> sp.	R	A	ECT	L	F	-	
<u>Macrorhoptus</u> sp.	R	A	ECT	L	F	-	
<u>Notaris bimaculatus</u> (Fabricius)	R	A	ECT	L	R	-	
<u>Otiorhynchus ovatus</u> (L.)	0	A	ECT	L	V,F	p	(15,23)
<u>Tychius picirostris</u> (Fabricius)	R	A	ECT	L	R	c	(23)
<u>Rhinocyllus conicus</u> Froelich	C	L,A	END,ECT	F,L	R,V,F	t	(5)
Lepidoptera							
Pterophoridae							
<u>Platyptilia carduidactyla</u> (Riley)	0	L	END	S	V	c	(15)

Table 3. (continued)

Insects	Relative Frequency in Collection ^a	Stages ^b	Feeding ^c	Plant Association		Recorded Hosts ^f	Literature Source
				Plant Part(s) ^d	Plant Growth Stage(s) ^e		
Tortricidae							
1 unidentified sp.	R	L	ECT	L	V	-	
1 unidentified sp.	R	L	ECT	L	V	-	
Arctiidae							
<u>Apantesis williamsii</u> (Dodge)	R	L	ECT	L	V	c	(60)
Noctuidae							
1 unidentified sp.	O	L	END	R	F	-	
Nymphalidae							
<u>Vanessa (Cynthia) cardui</u> L.	O	L	ECT	L	V	p	(15, 60)
Diptera							
Sciaridae							
1 unidentified sp.	O	L	END	R	V, F	-	
Cecidomyiidae							
1 unidentified sp.	O	L	END	F	F	-	
Tephritidae							
<u>Orellia ruficauda</u> (Fabricius)	C	L, A	END, ECT	F	F	c	(39)
Lauxaniidae							
<u>Camptoproscopella</u> sp.	LC	A	ECT	L, F	V, F	-	

^aNumber of sites in which the species appears/50 sites; R = Rare (species found in 1 collection site), O = Occasional (species found in 2-5 collection sites), LC = Locally common (species found in 2-5 collection sites, and present in high density), C = Common (species found in more than 5 collection sites).

^bE = eggs, L = larvae, N = nymphs, A = adults.

^cECT = ectophagous, END = endophagous.

^dR = roots, S = stems, L = leaves, F = flower heads or buds.

^eR = rosette stage, V = vertical growth stage, F = flowering and fruiting stages.

^ft = thistles (host plants apparently restricted to closely related genera as *Carduus*, *Cirsium*, and *Silybum*)
c = Compositae (host plants apparently restricted to the Compositae), p = polyphagous (attacking plants belonging to different families), - = no information.

effective in local areas, although densities were too low to affect the weed populations.

Grasshoppers were collected in most of the samples, with the heaviest infestation during flowering and fruiting stages of the plant. These insects are general feeders and thus have little influence in the natural control of thistles. In addition, they are considered economic pests. Thistle rosettes were examined for feeding damage in site 1 (Table 2). The grasshoppers preferred rust infested over healthy thistle plants. Lewis (1979) suggests that such preferences are due to favorable alterations in the nutritional and/or defensive chemistry of the plant.

The most common Hemiptera collected from Canada thistle plants were Corythucha distincta Osborn and Drake and several Lygus species. The latter are common sapfeeders on grasses, weeds and a wide variety of economic plants (Kelton, 1975). C. distincta appeared in local populations, particularly in moist habitats. This lace bug was found feeding on the thistle leaves from early May throughout the growing season of the plant (Figure 3). Adults and nymphs were highly aggregated on the thistle leaves and caused brown or black feeding scars (Figure 4). When large numbers occurred per plant, the leaves became necrotic. Adults were collected in early May from sites 4, 5 and 7 (Table 2) and confined to potted thistle plants in the insectary. After two weeks, most of the plants showed aggregation of nymphs, clustered near the spot

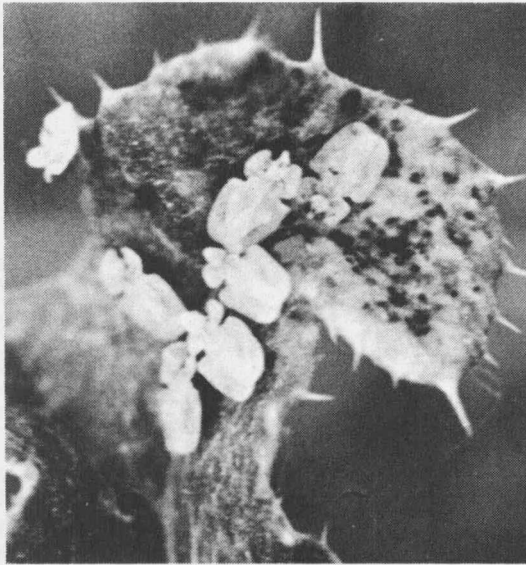


Figure 3. Corythucha distincta
adults feeding on
Canada thistle leaves.



Figure 4. Feeding damage of
Corythucha distincta
on Canada thistle.

where the eggs were laid, on the under-side of the leaf (Figure 5). After a period of six weeks, the lace bugs were present in such density that all the leaves were curled and necrotic. These plants failed to produce flower buds. C. distincta is multivoltine and has two or more generations per year, depending on the climatic conditions (Drake and Ruhoff, 1960). However, natural Corythucha populations were too small to cause substantial defoliation of the thistle plants. Lamp and McCarthy (1982) reported that nymphal populations of C. distincta on Cirsium canescens Nutt. caused necrosis of the leaves, but did not reduce the seed production of the plants. Hosto plants of C. distincta are recorded as being Carduus lanceolatus, Cnicus sp., Cirsium pulcherrimum, C. canescens, Lathyrus nuttallii, and Althaea sp.. In addition, Essig (1958) reported its occurrence on balsam root, beans, corn, lettuce, lupine, parsnip, squash, and turnip.

The spittlebug, Philaenus spumarius (L.) was found to be very abundant in a wide variety of habitats. The nymphs were observed on the thistle rosettes in early May, surrounded by a mass of spittle-like froth. The adults fed on the upper part of the thistle stem throughout the rest of the summer. P. spumarius is considered an important economic pest of forage crops in eastern United States (Halkka, et al., 1967). However, they appeared to have little effect on the thistle plants. A coincidence of high rust (P. obtegens) infestation (52%) and a high density of spittlebug nymphs was observed in site 1. In June,

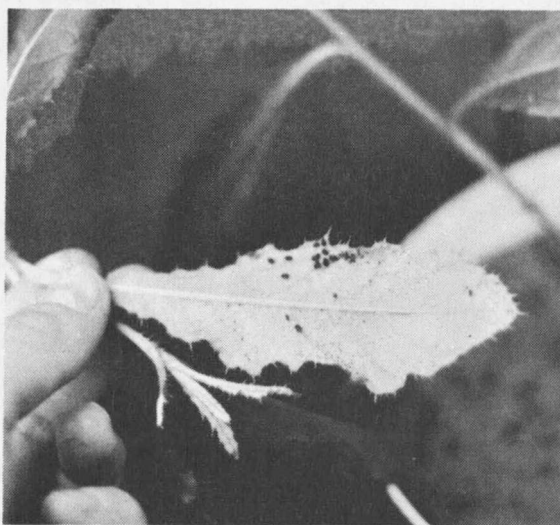


Figure 5. Aggregation of Corythucha
distincta nymphs on the
under-side of Canada thistle
leaves.

1981, a total of 425 thistle plants were examined in site 1 for spittlebug attack. An average of 29% plants were found to be infested with spittlebugs.

Publilia modesta (Uhler) was collected only as an adult on Cirsium arvense. Like the spittlebugs, they fed on the upper part of the stem from June to September and were attended by several ant species. The aphid colonies on Canada thistle were common in late July and August. Individual colonies did not reach damaging densities.

The most numerous phytophagous group in the Montana survey was represented by the order of the Coleoptera. As in the European survey (Zwolfer, 1964), the largest beetle family collected in south Montana was the Curculionidae. Four of the 15 beetle species feeding on Canada thistle are endophagous in their larval stages. Of these, Mordellistena sp. (Mordellidae), Baris sp., poss. cirsii Gilbert and Rhynocyllus conicus Froelich (Curculionidae) occurred in at least eight different collection sites, with a relative high frequency at each site.

The first Mordellistena sp. larvae mining in the thistle stems were observed by mid-July. These larvae overwinter in old thistle stalks, and pupate the following spring. The adults, probably emerging in late May, were found feeding on Canada thistle in June. The larval feeding throughout the summer apparently did not affect the normal growth and reproduction of the thistle plant.

A root-boring weevil, Baris sp. poss. cirsii Gilbert, native to North America, attacked Canada thistle in southeastern Montana. This weevil, also recorded on other Cirsium spp. (Gilbert, 1964), is probably the only indigenous insect approaching the monophagous habit. Gilbert (1964) classifies B. futilis, B. cirsii, B. brunneipes and B. monticola as four species of the same subgroup, comprising a complex of closely related species which are all restricted to hosts in the genus Cirsium. Baris cirsii has been recorded on six different Cirsium hosts in California: C. quercetorum, C. occidentale, C. coulteri, C. californica, C. cymosum and C. foliosum. In our survey, Baris sp. poss. cirsii was only observed on Cirsium arvense and was found especially in disturbed areas, roadsides and grasslands. Both adult and larval feeding were observed in sites 5 and 6 and in the insectary.

Baris adults overwinter as unemerged adults in the roots of their hosts and emerged in early spring by making their way through old larval galleries to the base of the stem. There was no indication of activity in the cells of overwintering adults. At the time of emergence, the thistles were about five to 20 cm tall. The weevils started feeding between the newly formed distal leaflets of the young thistles (Figure 6); later in middle and lower leaf axils of taller plants. Generally, two specimens per plant were observed, up to four on taller plants. The feeding on the young plants usually damaged the primary vertical shoot. Damaged plants produced new side shoots, resulting in



Figure 6. Baris sp. adult feeding on
thistle rosette.

a general bushy appearance, which were distinctive in the field. Heights of eight damaged thistle plants were recorded at sites 5 and 6 and compared with height of eight uninfested plants at the same site. Adult feeding reduced the vertical growth of the thistle plant significantly (Table 4). In early May, Baris adults were transferred from site 5 to the insectary and confined to potted thistle plants, where their impact on the plants was observed. Most of these plants, already under heavy stress due to low light intensity, did not survive the attack of the weevil (Figure 7) and the plants died within two weeks. Field observations in Montana indicated that emerged adults lived from two to four months, were highly localized in distribution and dispersed by ambulation or occasionally by flight. Gilbert (1964) reports that there is a period of about three weeks between emergence and oviposition. Oviposition sites, always in the lower half of the plant, vary during the season, becoming progressively lower on the main stem. The first Baris larvae were detected in site 5 by mid July.

The larvae were feeding actively in the thistle roots, about 15 cm below ground level. The central vascular cylinder, as well as the cortical tissue of the roots, were either consumed or used for the construction of the pupal chamber (Figure 8). By the end of July, the small bushy plants wilted and failed to produce flower buds (Figure 9). A total of 17 wilted plants were uprooted by the end of the growing season and unemerged adults were counted. I found an average of

Table 4. Average plant heights (cm) of eight *Baris* infested and eight uninfested thistle plants in sites 5 and 6, June 19, 1981.

Site	Plant Height, cm [*]	
	Weevil Present	Weevil Absent
5	26.00	58.10
6	32.25	71.00

*Plant heights were significantly different, t-test ($P < 0.01$).

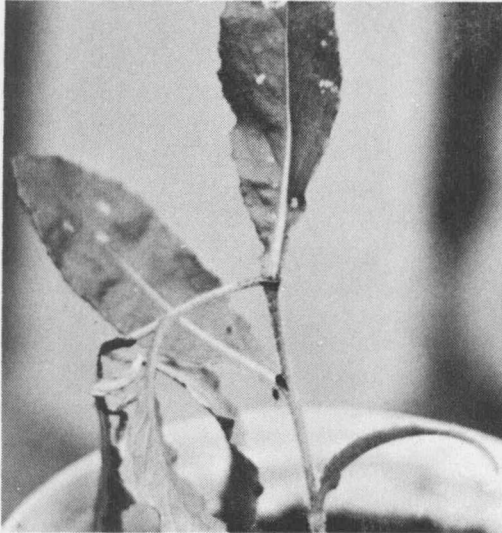


Figure 7. Feeding damage of Baris sp. adults on potted thistle plants in the insectary.

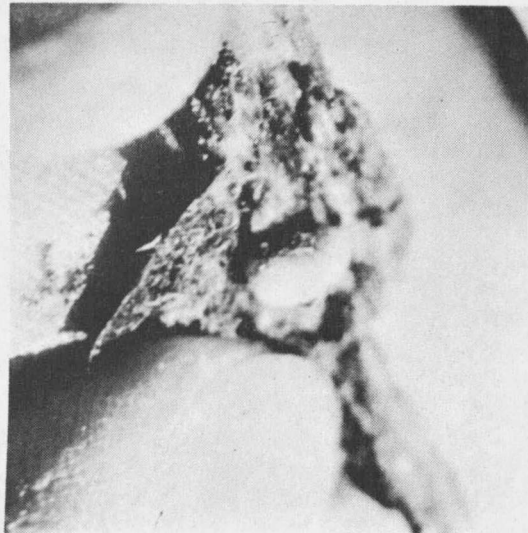


Figure 8. Baris sp. larva in Canada thistle root.



Figure 9. Wilted thistle plant in site 5, infested with Baris sp. larvae.

1.6 unemerged adults per Canada thistle plant and discovered a significant correlation between plant height and larval frequency ($r = 0.766$, $P < 0.01$) (Figure 10). This could be due to a higher larval survival rate in taller plants or to a higher imaginal frequency on the larger plants early in the season.

The damage inflicted by the weevil is both direct and indirect, covering the entire growing season of the plant. Adults stress the plant in early spring by destroying the meristematic tip and affecting the vertical growth of the plant. Larvae burrow into the vascular tissue of the root and block transport, stunting the overall growth of the plant and preventing seed production. Both adult and larval feeding render the plant susceptible to invasion by other organisms. Diseases associated with weevil damage have not been identified. Field observations showed that other insects invade damaged roots. Two scale insects, Chnaurococcus trifolii (Forbes) and Phenococcus solani Ferris (Homoptera: Pseudococcidae), and unidentified Sciaridae (Diptera) larvae were collected from thistle roots damaged by Baris larval feeding.

Unidentified factors apparently prevent the buildup of high densities of Baris populations. Very little is known about predators and parasites of the genus Baris. None have been observed in the survey, with the exception of one Cantharis sp. larva found associated with a Baris larva in the thistle root. The role of inquiline insects is not yet known, but it is apparent that these insects could be competitors or

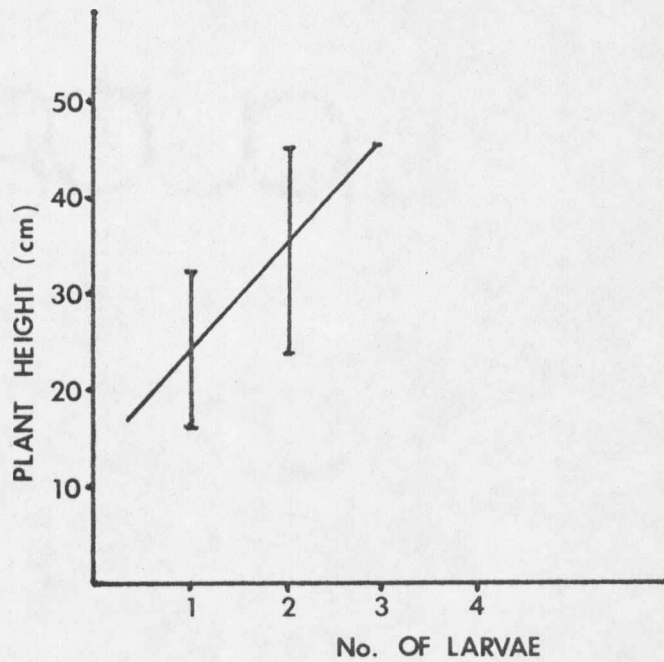


Figure 10. Linear regression of plant height (cm) versus larval frequency, August 1981. The b value ($b=11.183$, $S.E.=2.43$) is significantly different from zero ($P < 0.01$).

may interrupt or impede oviposition. In all collection sites infested with Baris, Mordellistena larvae were found feeding in the stem pith of the same plant. In site 6, Rhinocyllus conicus and Baris were present on the same plant. Gilbert (1964) reported that when larvae of Orellia are abundant in Cirsium, larvae of Baris are scarce or wanting. This was supported by my observations.

Rhinocyllus conicus Froelich is a thistle seed head-feeding weevil, introduced from France for the control of Carduus nutans L. (musk thistle). This weevil also attacks Canada thistle. Larvae of R. conicus in Canada thistle seed heads frequently eat through the wall of the bud, and thereby become vulnerable to predacious insects and spiders (Rees, 1982). A maximum of three larvae per flower bud were observed in our survey. Growth cracks in infested Canada thistle seed-heads and stems were very common.

Two species of Lepidoptera were found to defoliate thistle plants. The most common, Vanessa cardui L., the painted lady, started feeding on the thistle leaves in late May, causing considerable defoliation in local areas. Because it is a migratory butterfly, its numbers fluctuate widely from year to year and make it unreliable as a natural control agent. It can also be a pest of sunflower and soybean (Moriyama and Balsbaugh, 1976). The artichoke plume moth, Platyptilia carduidactyla Riley, was reared on field collected thistle stems. It is considered a troublesome pest of globe artichoke in California (Essig, 1958).

Most adult Diptera collected in the Montana survey were considered occasional visitors, with the exception of the seed-head fly, Orellia ruficauda (Fabricius), representing one of the most common insects in our survey. Adults appeared on the flower buds from early summer throughout July. The larvae feed on the thistle seeds (Figure 11) and weave a cocoon of pappus hairs, in which they overwinter. By the end of the summer a total of 350 seed-heads were collected at four different sites. Of these, 170 were dissected in the laboratory and O. ruficauda pupae were counted. The remaining seed-heads were stored to recover emerging O. ruficauda adults and possible parasites. Our study showed an upper limit of 38% heads attacked by O. ruficauda with an average of 1.5 larvae per head (Table 5). This is 32% less than Virly and Watson (1977) reported from studies at Macdonald College (Quebec). A high occurrence of R. conicus in sites A and B, and Baris sp. in sites C and D, are probably reducing or inhibiting the O. ruficauda infestation.

An unidentified Cecidomyiidae larva frequently occurred in my collections throughout the summer. The larvae were found feeding in the young flower buds. All attempts to rear this insect failed. This could possibly be Dasyneura gibsoni Felt, as reported by Detmers (1927) infesting both staminate and carpellate thistle heads.

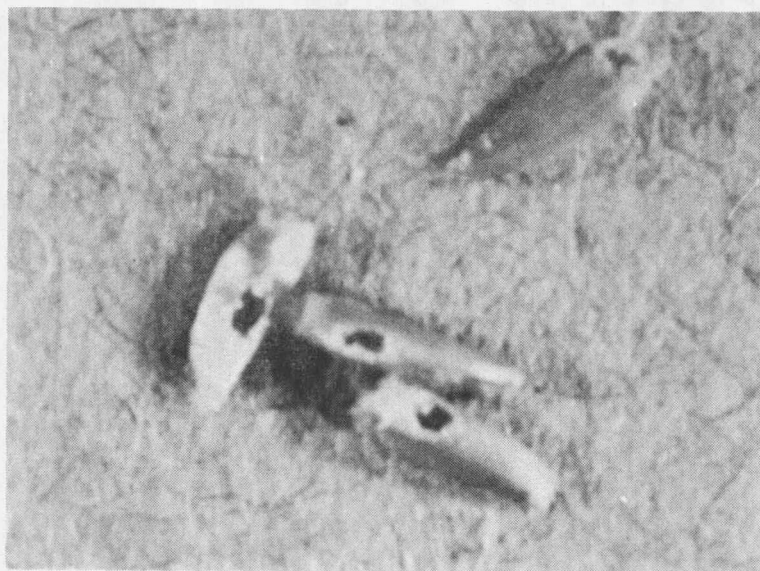


Figure 11. Feeding damage of Orellia ruficauda larvae on Canada thistle seeds.

Table 5. Infestation of Canada thistle heads by Orellia ruficauda (Fabricius), September 3, 1981.

	% Heads Attacked	Mean Number of Pupae/Head
Site A (n=60)	38.30	2.04
Site B (n=37)	33.30	2.16
Site C (n=52)	7.70	1.00
Site D (n=21)	9.50	1.00

n = total number of seed heads examined for each collection site.

Visitors, Predators and Parasitoids

The visitors included in Table 6 are pollen collectors, nectar feeders, or insects tending on aphids and membracids.

Most of the predaceous insects collected in the Montana survey are common predators preying on immature or small insects, such as aphids or thrips. Larvae of Phyllobaenus sp. were observed feeding on O. ruficauda larvae in Canada thistle seed-heads. Formica podzolica Francoeur was found tending aphids on Canada thistle. This species is known to harvest R. conicus larvae on Canada thistle (Rees, 1982).

Of the parasitic Hymenoptera, listed in Table 6, two species, Pteromalus sp. and Eurytoma sp. were collected from pupal chambers of R. conicus in thistle seed heads. In early August, a total of 615 seed heads were collected in site 2 and examined in the laboratory. R. conicus infestation was based on pupal chamber counts. One hundred twenty-two (20%) seed-heads were found to be infested with R. conicus. Of these, 20% contained adult Pteromalids, identified as Pteromalus sp. None of these were reared from R. conicus larvae and have not been recorded as parasitoids of R. conicus in the United States (Dowd and Kok, 1982; Rees, 1982). Surles (1974) reported Eurytoma sp. (Eurytomidae) as a larval parasitoid of R. conicus in Europe.

The parasitoids reared from Orellia ruficauda pupae and larvae in the insectary were identified as Eulophidae (Hymenoptera). At the end of the summer, Canada thistle, seed-heads, collected at four different

Table 6. Visitors, predators, and parasitoids collected from Canada thistle, Cirsium arvense (L.) Scop. in southern Montana, 1981.

Insects	Relative Frequency in Collection ^a	Stages Collected ^b	Plant Part(s) ^c	Plant Growth Stage(s) ^d	Habits	Source
Hemiptera						
Anthracoridae						
<u>Orius tristicolor</u> (White)	0	N.A	F	F	predaceous on mites, aphids, thrips, other small insects and eggs	(1,30)
Nabidae						
<u>Nabis alternatus</u> Parshley	LC	N.A	L	R,V,F	predaceous on aphids, thrips and other small insects	(30)
Reduviidae						
<u>Sinea diadema</u> (Fabricius)	R	A	L	F	predaceous on soft bodied insects	(8,30)
Lygaeidae						
<u>Geocoris</u> sp.	R	N.A	L	V,F	-	
Neuroptera						
Hemerobiidae						
<u>Micromus variolosus</u> Hagen	0	A	L	F	-	
Chrysopidae						
<u>Chrysopa carnea</u> Stephens	0	A	L	F	pollen and nectar feeder	(7)
Coleoptera						
Elateridae						
<u>Ctenicera glauca</u> (Germar)	R	A	L	R	flower visitor	(15)
Cantharidae						
<u>Cantharis</u> sp.	0	A	L	R	predaceous on <u>Aphis</u>	(15,23)
prob. <u>Cantharis</u> sp.	R	L	R	F	-	
Anobiidae						
<u>Tricorynus productus</u> White	R	A	L	R	-	
Dermestidae						
<u>Attagenus canadensis</u> Casey	R	A	L	R	flower visitor	(23)
Cleridae						
<u>Phyllobaenus</u> or <u>Isohydnocera</u> sp.	0	L	F	F	Feeding on <u>O. ruficauda</u> leaves predaceous on wood-boring insects	Pers. observ. (23)
<u>Phyllobaenus</u> sp.	R	A	L	V		
<u>Trichodes ornatus</u> Say	R	A	F	F	flower visitors larvae predaceous on bees and wasps	(15,23)

Table 6. (continued)

Insects	Relative Frequency in Collection ^d	Stages Collected ^b	Plant Part(s) ^c	Plant Growth Stage(s) ^d	Habits	Source
Melyridae						
<u>Collops bipunctatus</u> Say	0	A	L	V,F	flower visitors	(15,23)
<u>Collops tricolor</u> (Say)	R	A	L	V,F	-	
<u>Malachius aeneus</u> L.	R	A	L	V	-	
Coccinellidae						
<u>Brachyacantha ursina</u> (Fabricius)	R	A	L	V	-	
<u>Coccinella transversoguttata</u> <u>transversoguttata</u> Falderman	0	A	L	F	-	
<u>Hippodamia convergens</u> Guerin	LC	E,L,A	L	F	predaceous on <u>Aphis</u> sp., eggs and larvae	(15)
<u>H. parenthesis</u> (Say)	R	A	L	F	predaceous on <u>Aphis</u> sp.	(15)
<u>H. quinquesignata</u> <u>quinquesignata</u> (Kirby)	LC	E,L,A	L	R,V,F	predaceous on <u>Aphis</u> sp.	(15)
<u>Hyperaspis undulata</u> (Say)	R	A	L	F	predaceous on various unarmored scales	(15)
<u>Scymnus (Pullus) postpinctus</u> Casey	R	A	L	R	-	
Lepidoptera						
Pyrallidae						
1 unidentified sp.	LC	A	L	V	-	
Blastobasidae						
1 unidentified sp.	R	A	L	V	-	
Diptera						
Chironomidae						
<u>Cricotopus</u> sp.	R	A	L	R	-	
Sciaridae						
<u>Bradysia</u> sp.	R	A	F	F	-	
Bombyliidae						
<u>Systoechus vulgaris</u> Loew	LC	A	F	F	predaceous on grass- hopper egg pods	(9)
Syrphidae						
<u>Sphaerophoria philanthus</u> (Meigen)	LC	A	F	F	-	
<u>Syrirta pipiens</u> (L.)	0	A	F	F	-	
Anthomyiidae						
<u>Delia platura</u> (Meigen)	0	A	F	F	larva is a pest of vegetables	(9)

Table 6. (continued)

Insects	Relative Frequency in Collection ^a	Stages Collected ^b	Plant Part(s) ^c	Plant Growth Stage(s) ^d	Habits	Source
Scathophagidae						
<u>Scathophaga stercoraria</u> (L.)	O	A	L	V	predaceous on blow-fly and house fly	(15)
Tachinidae						
<u>Hyalomya aldrichii</u> Townsend	R	A	F	F	parasite of Hemiptera	(9)
<u>Peleteria</u> sp.	R	A	F	F	-	
Hymenoptera						
Xyelidae						
<u>Xyela obscura</u> (Strobl)	R	A	F	F	-	
Braconidae						
<u>Bracon</u> sp.	R*	A	F	F	-	
Ichneumonidae						
<u>Thyrateles</u> sp., poss. <u>lugubator</u> (Gravenhorst)	R	A	L	V	parasite of several Nymphalidae	(31)
1 unidentified sp.	R	A	L	V	-	
1 unidentified sp.	R	A	F	F	-	
Eulophidae						
1 unidentified sp.	O	L	F	F	parasite of <u>O. ruficauda</u> larvae	(pers. observ)
1 unidentified sp.	C	L	F	F	parasite of <u>O. ruficauda</u> larvae	(pers. observ)
Pteromalidae						
<u>Pteromalus</u> sp.	LC	L,A	F	F	-	
Eurytomidae						
<u>Eurytoma</u> sp.	O	A	F	F	-	
Chrysididae						
<u>Hedychrum spiloventer</u> French	R	A	F	F	parasite of Cecerine wasp	(Bohart, R.M. pers. comm.)
Formicidae						
<u>Formica neoclara</u> Emery	O	A	S,L	R,V,F	Tending aphids	(66)
<u>F. obscuriventris clivia</u> Creighton	LC	A	S,L	R,V	Tending aphids	(66)
<u>F. podzolica</u> Francoeur	R	A	S,L	V,F	Tending aphids	(pers. observ)
<u>Formica</u> sp.	R	A	S,L	F	Tending Membracids	(pers. observ)
<u>Myrmica incompleta</u> Provancher	O	A	S,L	V	-	
Pompilidae						
<u>Pompilus</u> sp.	R	A	F	F	predaceous on spiders	(31)
Apidae						
<u>Apis mellifera</u> L.	LC	A	F	F	feeding on nectar and pollen	(31)
<u>Bombus</u> sp.	O	A	F	F	feeding on nectar and pollen	(31)

^aNumber of sites in which the species appears/50 sites; R = Rare (species found in 1 collection site), O = Occasional (species found in 2-5 collection sites), LC = Locally common (species found in 2-5 collection sites, and present in high density), C = Common (species found in more than 5 collection sites).

^bE = eggs, L = larvae, N = nymphs, A = adults.

^cR = roots, S = stems, L = leaves, F = flower heads or flower buds.

^dR = rosette stage, V = vertical growth stage, F = flowering and fruiting stages.

sites were examined for O. ruficauda infestation (Table 5). At the same time parasitized O. ruficauda pupae were counted (Table 7, Figure 12). An average incidence of 49% parasitism was observed.

Summary

Whenever Canada thistle is found, it has a large number of insects associated with it. Although many of those insects are strays from other plants, many of them can be considered as incidental visitors and about one third of the listed phytophagous species also attack economic plants. Only a few insects were considered conspicuous because of their damage inflicted to the thistle plant and because of their commonness to the collections.

The insect survey in southern Montana indicates that Cirsium arvense has been exploited by three seed head-feeding insects, three stem-boring insects, one root-boring insect, and two defoliating agents. Considering their incidence of attack, more insects were associated with the developing seed heads than with foliage, stems or roots.

Although some insects caused considerable plant stress, further stress factors from other insects and pathogens are needed to control this weed. Few potentially effective and host specific insects from Zwolfer's list are still available for future introductions. Thus, the information gathered in this survey could form the foundation for follow-up studies on endemic species. Stenophagous insects, as

Table 7. Parasitism of Orellia ruficauda (Fabricius) pupae in Canada thistle seed heads, September 3, 1981.

	Total # Heads Attacked	Total # Pupae	Total # Parasitized Pupae
Site A (n=60)	23	47	21
Site B (n=37)	12	26	7
Site C (n=52)	4	4	3
Site D (n=21)	2	2	1

n = Total number of seed heads examined for each collection site.



Figure 12. Parasitized Orellia ruficauda pupa.

Ceuthorynchus litura and Baris sp., which are established, but are spreading slowly, could be augmented and redistributed over the state.

The potential of the combination of two stress-factors, to increase the impact on the thistle plants in the field, should be investigated. Insect damage and a pathogen form a perfect combination. In their study of insect involvement in pathogen transmission, Harris and Maramorosch (1980) stated: "We often overlook the fact that insect invaders of plants are always, without any exception, accompanied or followed by fungi and bacteria." Endemic pathogens of Canada thistle are present; two fungal diseases, Puccinia obtegens and Sclerotinia sclerotiorum and an aster yellow caused by a mycoplasma-like organism. The weevils Ceuthorynchus litura, Rhinocyllus conicus and Baris sp. are potential vectors of both, viral and fungal diseases. Transmission experiments are necessary to evaluate their potential as thistle pathogen vectors.

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