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
Montana State University

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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Date August 6, 1982

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A thesis submitted in partial fulfillment
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of

MASTER OF SCIENCE

in

Biological Sciences

Approved:

Chairperson, Graduate Committee

Head, Major Department

Graduate Dean

MONTANA STATE UNIVERSITY
Bozeman, Montana

August, 1982

ACKNOWLEDGMENTS

I wish to acknowledge and express my appreciation for the contributions of the following people:

Dr. W. L. Morrill, my major professor, for his professional assistance throughout this research project;

The members of my thesis committee, Dr. P. K. Fay, Dr. S. R. Eversman, and Mr. J. M. Story, for their time and invaluable advice;

Mrs. S. D. Rose, Curator of the M.S.U. Entomological Collection, for her taxonomic advice and help;

All the systematicists who identified the insects mentioned in this report: the taxonomists of the Systematic Entomology Laboratory, USDA, Beltsville, MD; and the National Museum of Natural History, Smithsonian Institution, Washington, DC; J. Lattin, P. Oman, K. A. Phillips, and G. M. Stonedahl, Oregon State University, Corvallis; L. A. Kelton, Biosystematics Research Institute, Ottawa; M. W. Nielson, Forage Insects Research Laboratory, Tucson, AZ; G. J. Michels, Jr., Texas A&M University, Amarillo; R. J. Beshear, The University of Georgia, Experiment; J. A. Onsager and E. A. Oma, U.S.D.A. Rangeland Insect Laboratory, Bozeman; R. M. Bohart, University of California, Davis; D. K. Young, Michigan State University, East Lansing;

The Western Agricultural Research Center and the Montana weed districts for the funding of this research project.

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ABSTRACT

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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.

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[1] Jackson, 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 (Morihara 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 florescentiae 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
Altica carduorum Guerin	1964	200	Ravalli	USDA	No recovery
	1966	200	Gallatin	USDA	No recovery
Ceutorhynchus litura (F.)	1973	200	Gallatin	USDA	Inc. slowly
Urophora cardui (L.)	1978	92	Ravalli	USDA	No recovery

[a]Data 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 applciation 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

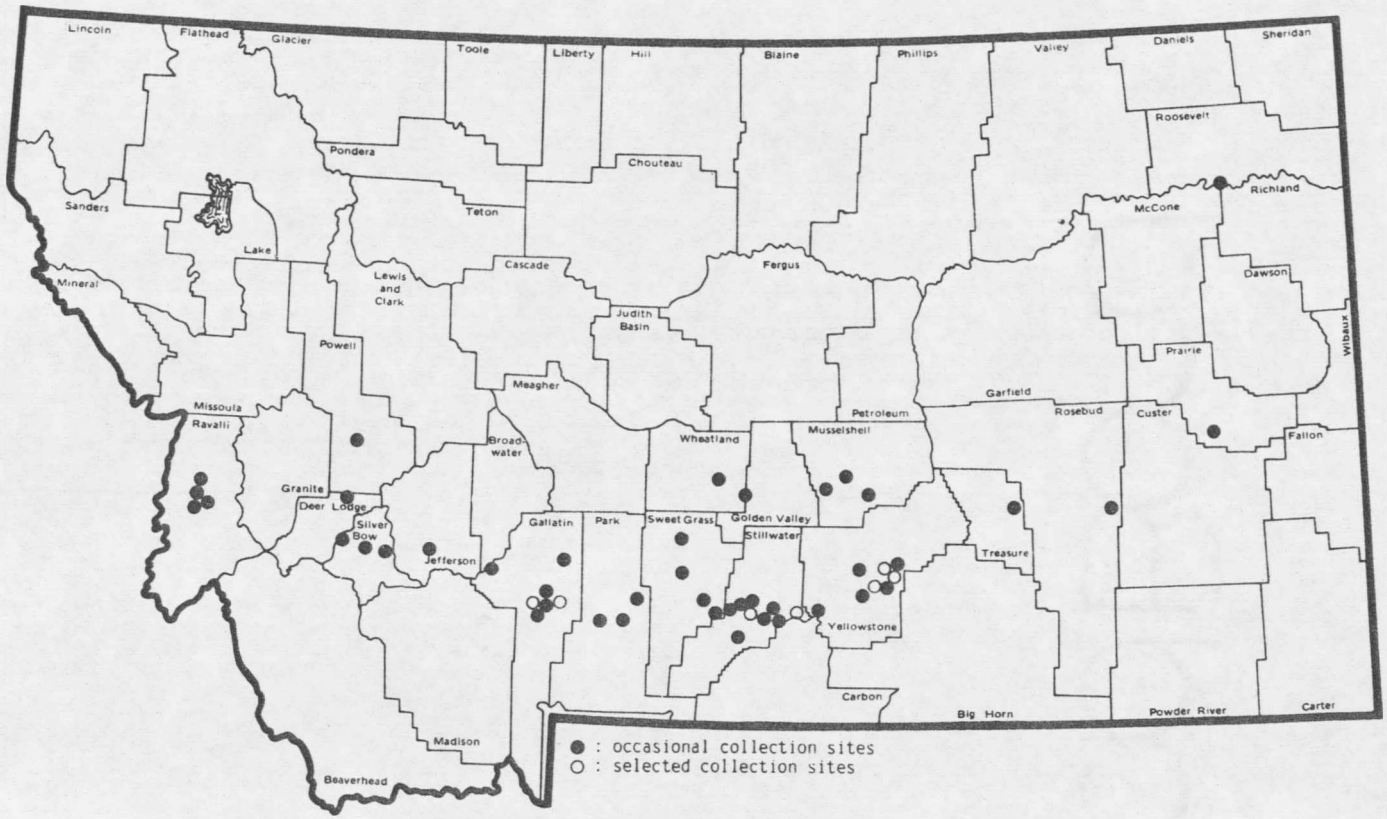

Figure 1. Collection sites of the insect survey on Canada thistle, 1981.

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 (P. obtegens) 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 Gilbert[1] 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.

[1]Whitehead, 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.