Incidence of Above-Ground Arthropod Species on Musk Thistle in Tennessee[1]

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ABSTRACT During this 2-yr study, approximately 130 above-ground arthropod taxa were found on musk thistle, *Carduus nutans leiophyllus* (Pefr.) Stoj. and Stef., in Tennessee. Sixty-three families of insects, representing 13 orders, as well as seven families of arachnids and one species of chilopod, were collected from musk thistle. Arthropods were found on musk thistle throughout the growing season, with the greatest arthropod diversity found during the flowering stage. Although many established arthropod species utilized the resources of musk thistle, few of these arthropods impacted greatly upon the reproduction or survivability of the plant.

KEY WORDS Musk thistle, *Carduus*, species composition, seasonality, insect/plant interactions

Musk thistle [*Cardus nutans leiophyllus* (Pefr.) Stoj. and Stef.] is native to Europe and was introduced into North America in the late 1800s along the eastern seaboard of Canada and the United States, and also into Alabama (Batra et al. 1981). By 1976, musk thistle had been recorded from 687 counties in 40 U.S. states and was considered to be economically important in many of these areas (Dunn 1976). Musk thistle has since spread to many other counties, especially in Tennessee, where this weed infests roadsides and pastures.

This introduced plant species provides food, shelter, and habitat for many established arthropod species (Batra et al. 1981). For example, 61 species of insects were reported to be associated with musk thistle in South Dakota (Morihara & Balsbaugh 1976), and the sunflower moth, *Homoeosoma electellum* (Hulst), was found to commonly inhabit immature seed heads of musk thistle in Louisiana (Goyer 1978).

Several species of introduced herbivorous insects, *Rhinocyllus conicus* Froelich and *Trichosirocalus horridus* (Panzer), have been released and established in many musk thistle-infested areas in the United States, such as Virginia. These introduced biological control agents impact on the growth, reproduction, and survival of musk thistle. However, little information is available on the seasonal incidence and

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ecological relationships among established arthropods and introduced musk thistle, as well as on the extent of its utilization and consumption by arthropod species, particularly in the southern United States. Therefore, a 2-yr study was initiated in Tennessee to determine the above-ground arthropod fauna associated with musk thistle and to monitor the seasonality of selected arthropod species.

Materials and Methods

Several sampling and survey methods were utilized to ascertain the arthropods associated with musk thistle and their relationship to the plant. Above-ground arthropods were observed on, and collected from, musk thistle at 15 thistle-infested sites in eastern and middle Tennessee, from May to August 1989 and from April to October 1990. Specimens also were occasionally collected from several additional sites in 1990.

Species composition. Arthropod species associated with musk thistle were collected during each stage (i.e., rosette, bud, flower, and seed) of plant growth. Collections were made biweekly at each site from 22 May to 25 August 1989 and biweekly from 27 April to 5 June 1990. Additional collections were made four to five times each week from 6 June to 18 July 1990 at each site as well as at several other sites where musk thistle was abundant. Arthropods were collected biweekly from 18 July to 27 August 1990 at sites in eastern Tennessee only and from 27 August to 12 October 1990 at two additional sites in eastern Tennessee.

Methods of sampling included hand collecting, enclosing selected areas of the plant (usually the flower or areas where arthropods were observed or suspected) with kill jars, and the clipping of flowers and seed heads, which then were placed in Ziploc® freezer bags and taken to the laboratory for further examination. Collected arthropods were placed in vials containing ethyl alcohol (ca. 70%) or returned to the laboratory and pinned for later identification. In the laboratory, collected specimens were sorted and identified to order, family, genus, and species, when possible. Voucher specimens were placed in the University of Tennessee Insect Museum located on the Agriculture Campus, The University of Tennessee, Knoxville. The relative frequency of taxa in collections and observations was rated as rarely encountered [found at one or two sites on one or two sampling dates], occasionally encountered [found at $\geq$ 50% of the sites on three to six sampling dates], and commonly encountered [found at most ($\geq$ 70%) sites on more than six sampling dates].

Species seasonality and location on plant. To determine the seasonality and diversity of arthropod fauna associated with musk thistle, 30 plants were randomly selected every 2 wk at three thistle-infested sites (one site in Wilson County in middle Tennessee; one site each in Knox and Greene Counties in eastern Tennessee). At each site, one plot (3 m $\times$ 30 m) was delineated and then subdivided into 10 subplots (3 m $\times$ 3 m). During each sampling visit, three plants in each subplot were randomly selected, and each plant was examined for selected arthropod species. The numbers of these arthropods and their location on the plant (e.g., stem, leaf, bud, flower,

and seed head; top, middle, and bottom), as well as the number of branches, buds or flowers per plant, seed heads per plant, plant height, general weather conditions, and time of day, were recorded on each sampling date.

Plant-feeding insects that were believed to cause damage to musk thistle, particularly its ability to produce and release seeds, were noted, More detailed field examinations of these species and their damage were then conducted to assess their impact on the plant.

Results and Discussion

Species composition. Approximately 130 above-ground taxa were found on musk thistle in Tennessee during this 2-yr study, and their relative levels of occurrence and associated plant parts are presented in Table 1. These included 63 families of insects, representing 13 orders, as well as seven families from two orders of arachnids and one species of chilopod. Of all insects encountered, most taxa (and highest percentage of total composition of insect taxa) were in the orders Coleoptera (32.5%), Hymenoptera (17.9%), Hemiptera (15.4%), and Lepidoptera (10.3%). As may be expected with an introduced plant species, most arthropod species were only rare or occasional visitors to musk thistle (Table 1). Most of these species were incidental or visited the plant for pollen or nectar. Some species, however, were commonly encountered and utilized the nutritional resources of the plant or preyed upon other plant-inhabiting arthropods.

Seventy-seven species of insects were identified from collections from musk thistle in Tennessee. In a similar study in South Dakota, 61 arthropod species were collected from musk thistle (Morihara & Balsbaugh 1976). Of these species, only nine species with wide geographical and host ranges were common to South Dakota and Tennessee: three orthopterans [the differential grasshopper, *Melanoplus differentialis* (Thomas) (Acrididae), the redlegged grasshopper, *M. femurrubrum* (De Geer) (Acrididae), and the blackhorned tree cricket, *Oecanthus nigricornis* Walker (Gryllidae)]; three heteropterans [the tarnished plant bug, *Lygus lineolaris* (Palisot de Beauvois) (Miridae), fourlined plant bug, *Poecilocapsus lineatus* (F.) (Miridae), and *Cosmopepla bimaculata* (Thomas) (Pentatomidae)]; one homopteran [*Acanalonia bivittata* (Say) (Acanaloniidae)]; one lepidopteran [the painted lady, *Vanessa cardui* (L.) (Nymphalidae)]; and one hymenopteran [the honey bee, *Apis mellifera* L. (Apidae)]. Researchers in New South Wales identified 20 species of plant-feeding insects on musk thistle (Briese 1989); however, none of those species was found on musk thistle in Tennessee.

In Tennessee, 14 families of Coleoptera were collected, usually in association with the flower. Commonly encountered coleopterans included a soldier beetle, *Chauliognathus pennsylvanicus* (DeGeer) (Cantharidae), the spotted cucumber beetle, *Diabrotica undecimpunctata howardi* Barber (Chrysomelidae), two coccinellids [sevenspotted lady beetle, *Coccinella septempunctata* (L.), and *Coleomegilla maculata* (Mulsant)], a mordellid, *Mordella* sp., a nitidulid, *Conotelus obscurus* (Erichson), and the Japanese beetle, *Popillia japonica* (Newman). Two introduced curculionid species, *R. conicus* and *T. horridus,* also were collected from musk thistle. *R. conicus,*

Table 1. Arthropods collected from musk thistle in Tennessee, 1989-1990.

Order and Family	Species	Relative Levels of Occurrence[a]	Associated Plant Part[b]
COLEOPTERA			
Cantharidae	*Chauliognathus pennsylvanicus* (DeGeer)	C	St,L,B,F
Carabidae	– –	R	St
Cerambycidae	*Batyleoma suturale* (Say)	R	F
	Typocerus velutinus (Olivier)	R	F
	Typocerus zebra (Olivier)	R	F
	– –	R	F
Chrysomelidae	*Anomoea laticlavia* (Forst.)	O	St,B,F
	Cryptocephalus notatus quadrimaculatus (Say)	O	St,B,F
	Diabrotica undecimpunctata howardi Barber	C	St,F
	Labidoderma clivicolis (Kirby)	O	St,L
	Leptinotarsa juncta (Germar)	R	St,L
	Nodonota clypealis (Horn)	O	St,B,F
	Nodonota sp. prob. *margaretae* Schultz	O	St,B,F
	Zygogramma suturalis (F.)	R	F,Sh
Cleridae	– –	O	St,L
Coccinellidae	*Enoclerus rosmarus* (Say)	R	St
	Brachiacantha ursina (F.)	R	St,L
	Coccinella septempunctata (L.)	C	St,L,B,F
	Coleomegilla maculata (Mulsant)	C	St,L,B,F
	Hippodamia convergens (Guérin-Méneville)	O	St,L,B,F
	– –	R	St,L
	– –	R	St,L
Curculionidae	*Geraeus penicellus* (Herbst)	O	F,Sh
	Geraeus sp. nr. *picummus* (Herbst)	O	F
	Geraeus picumnus (Herbst)	O	F
	Odontopus calceatus (Say)	O	F
	Rhinocyllus conicus Froelich	O	St,L,B,F
	Trichosirocalus horridus (Panzer)	R	St,L,B
	– –	O	F
Elateridae	– –	O	St,B,F
	– –	R	St,L
Lampyridae	*Photinus* sp.	O	St,B,F
Languriidae	*Acropteroxys gracilis* (Newman)	O	F
	Languria mozardi (Latreille)	O	F
Meloidae	– –	O	St,B,F
Mordellidae	*Mordella* sp.	C	F
Nitidulidae	*Conotelus obscurus* (Erichson)	C	F
Scarabaeidae	*Euphoria sepulchralis* (F.)	O	F
	Popillia japonica (Newman)	C	St,L,B,F
	Trichiotinus piger (F.)	O	F
COLLEMBOLA			
Entomobryidae	– –	R	F
DIPTERA			
Bombyliidae	– –	R	F
Calliphoridae	*Pollenia* sp. 1	R	F
	Pollenia sp. 2	R	F
	Pollenia sp. 3	R	F
Ottidae	*Acrosticta* sp.	R	F

Table 1. Continued

Order and Family	Species	Relative Levels of Occurrence[a]	Associated Plant Part[b]
DIPTERA			
Syrphidae	*Baccha elongata* (F.)	O	F
	Microdon sp.	O	F
	Toxomerus sp.	O	F
Tipulidae	– –	O	St,L
HETEROPTERA			
Alydidae	*Alydus eurinus* (Say)	R	St,L
Anthocoridae	*Orius insidiosus* (Say)	C	F
Coreidae	*Acanthocephala terminalis* (Dallas)	R	St,L
	Euthochtha galeator (F.)	R	St,L
	Leptoglossus phyllopus (L.)	C	St,L,F
Lygaeidae	*Geocoris punctipes* (Say)	R	F
	Lygaeus kalmii (Stal)	O	St,L
Miridae	*Lopidea* sp.	C	St,L
	Lygus lineolaris (Beauvois)	C	St,L,B,F
	Poecilocapsus lineatus (F.)	C	St,L
Pentatomidae	*Cosmopepla bimaculata* (Thomas)	O	St,B,F
	Euschistus servus (Say)	C	St,B,F
	Stiretrus anchorago (F.)	R	St,B,F
	Thyanta sp.	R	St,B,F
Phymatidae	*Phymata pennsylvanica* Handlirsch	O	St,B,F
Reduviidae	*Apiomerus crassipes* (F.)	R	St,B,F
	Sinea sp.	C	St,L,B,F
Thyreocoridae	– –	O	F
HOMOPTERA			
Acanaloniidae	*Acanalonia bivittata* (Say)	R	St,B
	Acanalonia conica (Say)	R	St,B
Aphididae	– –	O	St,L
Cercopidae	*Lepyronia quadrangularis* (Say)	O	St,L,B,F
	Philaenus spumarius (L.)	C	St,L
Cicadellidae	*Oncometopia orbona* (F.)	O	St,L,B
	Paraulaeizes irrorata (F.)	O	St,L,B
Flatidae	*Anormenis chloris* (Melichar)	R	St,B
Membracidae	*Stictocephala lutea* (Walker)	C	St,B
HYMENOPTERA			
Anthophoridae	*Ceratina* sp. *calcarata* Robt. or *dupla* Say	C	F
Apidae	*Apis mellifera* L.	C	F
	Bombus sp.	C	F
Braconidae	*Cotesia* sp.	R	F
Chalcididae	*Metadonia amoena* (Say)	R	F
	– –	R	F
Eulophidae	*Paraolinx typica* Ashmead	O	Sh
Formicidae	*Crematogaster clara* Mayr	R	St
	Crematogaster pilosa (Emery)	R	St
	Formica subsericea Say	O	St,L
	Formica sp. 2	O	St,L
	Formica sp. 3	O	St,L
	Monomorium minimum (Buckley)	C	St,B,F
	– –	C	St,L,B,F,Sh

Table 1. Continued

Order and Family	Species	Relative Levels of Occurrence[a]	Associated Plant Part[b]
HYMENOPTERA			
Halictidae	*Dialictus* sp. 1	O	F
	Dialictus sp. 2	O	F
	Halictus ligatus Say	C	F
Ichneumonidae	– –	R	F
	– –	R	F
Vespidae	*Polistes* sp.	R	F
Xylocopidae	*Xylocopa* sp.	O	F
LEPIDOPTERA			
Danaidae	*Danaus plexippus* (L.)	O	F
Hesperiidae	*Atalopedes campestris* (Boisduval)	C	F
	Epargyreus clarus (Cramer)	C	F
Noctuidae	*Trichoplusia ni* (Hübner)	R	St,L[c]
Nymphalidae	*Agraulis vanillae* (L.)	O	F
	Vanessa cardui (L.)	O	St,L,F
Papilionidae	*Pterourus troilus* (L.)	O	F
Pieridae	*Colias eurytheme* Boisduval	C	F
Pyralidae	*Dicymolomia julianalis* (Walker)	C	St,Sh
Tortricidae	*Platynota* sp.	O	Sh
Yponomeutidae	*Atteva punctella* (Cramer)	O	F
Zygaenidae	*Harrisina americana* (Guerin)	R	F
MANTODAE			
Mantidae	– –	O	St,L,B,Sh
NEUROPTERA			
Chrysopidae	– –	R	F,Sh
ODONATA			
Libellulidae	*Libellula luctuosa* (Burmeister)	R	F
ORTHOPTERA			
Acrididae	*Melanoplus differentialis* (Thomas)	C	St,L,B,F,Sh
	Melanoplus femurrubrum (DeGeer)	O	St,L
Gryllidae	*Oecanthus nigricornis* Walker	O	F
Tettigoniidae	– –	O	St,L
PSOCOPTERA			
Ectopsocidae	*Ectopsocopsis cryptomeriae* (Enderlein)	O	Sh
THYSANOPTERA			
Thripidae	*Frankliniella* sp.	C	B,F
ACARI			
Ixodidae	*Amblyomma americanum* (L.)	R	L
ARANEAE			
Araneidae	*Araneus* sp.	O	F,Sh
	Argiope aurantia Lucas	C	F,Sh
	– –	O	F,Sh

Table 1. Continued

Order and Family	Species	Relative Levels of Occurrence[a]	Associated Plant Part[b]
ARANEAE			
Clubionidae	– –	O	F
Linyphiidae	– –	R	F
Oxyopidae	*Peucetia viridans* (Hentz)	C	St,F,Sh
Salticidae	– –	C	F,Sh
Thomisidae	*Misumenops celera* (Hentz)	C	St,F,Sh
	Misumenops sp. 2	C	St,F,Sh
OPILIONES	– –	O	St
(Class Chilopoda)	– –	O	St

[a] R = rarely encountered; O = occasionally encountered; C = commonly encountered.
[b] St = stem; L = Leaf; B = bud; F = flower; Sh = seed head.
[c] Only larvae were collected.

found in low numbers at most locations in eastern Tennessee, was commonly collected while *T. horridus* was rarely collected. These populations of introduced natural enemies resulted partially from established populations that moved from Virginia to Tennessee and from introductions of natural enemies made at selected locations in Tennessee (Grant et al. 1990).

Commonly encountered heteropterans included the tarnished plant bug, the fourlined plant bug, the brown stink bug, *Euschistus servus* (Say) (Pentatomidae), the leaffooted bug, *Leptoglossus phyllopus* (L.) (Coreidae), scarlet plant bugs, *Lopidea* sp. (Miridae), *Sinea* sp. (Reduviidae), and the insidious flower bug, *Orius insidiosus* (Say) (Anthocoridae). When present, the ambush bug, *Phymata* sp. (Phymatidae), was usually found on the flower, where it often searched for prey. Two homopterans, the meadow spittlebug, *Philaenus spumarius* (L.) (Cercopidae), and *Stictocephala lutea* (Walker) (Membracidae), also were commonly encountered. When present in large numbers, nymphs and adults of *P. spumarius* and the diamondbacked spittlebug, *Lepyronia quadrangularis* (Say) (Cercopidae), appeared to stunt plant growth. *Philaenus spumarius* was the most commonly encountered of these two cercopid species and accounted for approximately 90% of the two species of froghoppers. The differential grasshopper was the only orthopteran commonly encountered on musk thistle.

Spiders in the families Salticidae and Thomisidae made up more than 60% of the total spiders collected. One species of tick (the lone star tick, *Ambylomma americanum* L.) and one species of Chilopoda also were recorded.

Species seasonality and location on plant. Seasonality varied among selected taxa (Fig. 1). For example, nymphs and adults of *P. spumarius* were commonly encountered early in the growing season, but many other arthropods were observed during flowering. Flowers, first present in early

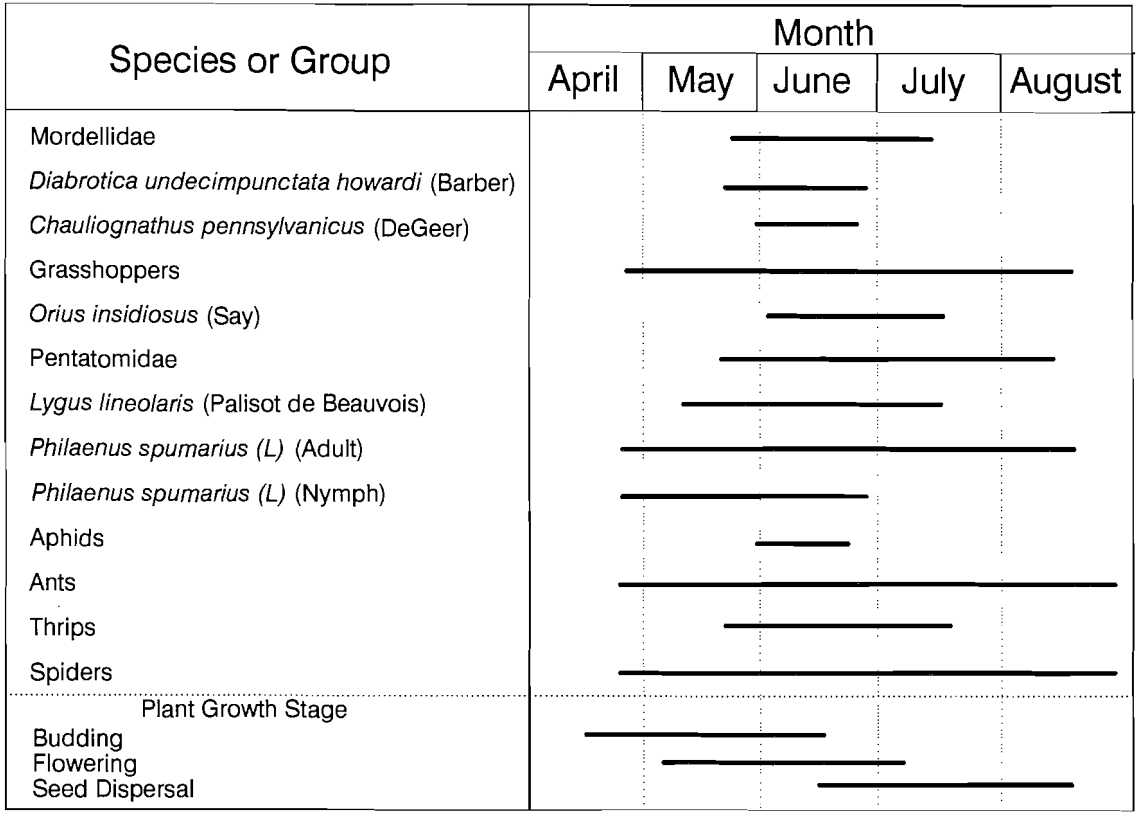

Fig. 1. Seasonality of selected arthropod taxa observed on musk thistle in eastern and middle Tennessee, 1989 and 1990.

May, were common through early July. Flowers were observed as late as 12 October on several plants outside our study area in eastern Tennessee. After seed dispersal, few arthropods (primarily spiders and ants) were found on the plants.

During the early stages (rosette to bud) of the growing season, the most commonly encountered taxa were cercopids. Adults of *P. spumarius* were usually found from mid April to mid July, and nymphs were observed from mid April to late June. Other observations suggest that nymphs are present as early as late March (J. F. G., unpublished data). In 1990, more than two froghopper nymphs per plant were found at two sites in eastern Tennessee during late April (J. F. G., unpublished data). Although the extent of damage by froghoppers was not quantified, thistle may serve as a reservoir food source for populations of froghoppers to increase and move to other areas where more preferable plants (e.g., alfalfa) may be used as a food source.

Diversity of arthropod fauna increased as musk thistle began to bud. Early in the bud stage, scarlet plant bugs occasionally fed throughout the stem and leaves; however, they did not appear to cause significant damage. The brown stink bug and the tarnished plant bug were commonly encountered from late May to mid July. The differential grasshopper also was found during this period and throughout the remainder of the growing season, particularly after the plant had attained a height of over 60 cm. The fourlined plant bug caused noticeable foliar damage when present, usually from late May to late June.

Most organisms (e.g., mordellid beetles, spotted cucumber beetle, minute pirate bug, and thrips) were associated with the flower, as it served as the primary site of food, protection, or searching for prey (Table 2). Thrips, *Frankliniella* spp. (Thysanoptera: Thripidae), were commonly encountered and often observed in large numbers within the flower. The insidious flower bug also was found in the flower, especially when large numbers of thrips were present. Many coleopterans, including cantharids, cerambycids, chrysomelids, coccinellids, curculionids, languriids, meloids, mordellids, nitidulids, and scarabs, also were found on or within the flower. Adult lepidopterans commonly encountered on flowers were the silverspotted skipper, *Epargyreus clarus* (Cramer) (Hesperiidae), *Atalopedes campestris* (Boisduval) (Hesperiidae), and the alfalfa caterpillar, *Colias eurytheme* Boisduval (Pieridae). In this study, painted lady adults and immatures were occasionally encountered, but in outbreak years, they have been reported to be common on musk thistle (J. F. G., unpublished data). Numerous hymenopterans, including *Bombus* sp. (Apidae), *Xylocopa* sp. (Xylocopidae), the honey bee, and several halictid spp., also were found on the flower. Syrphids were the most common dipterans to visit flowers.

Few organisms were associated with the seed head. The larvae of the pyralid, *Dicymolomia julianalis* (Walker), fed within the seed head, and adults emerged from fully mature seed heads (Powell et al. 1992). The psocid, *Ectopsocopsis cryptomeriae* (Enderlein) (Ectopsocidae), was found on the seed head after the seeds had been released, possibly feeding on fragments of dead insects. Spiders were most commonly encountered inside the flower, inside the seed head after flowering, or inside the seed head after seed dispersal.

Table 2. Plant structural stratification of selected arthropod taxa found on musk thistle in Tennessee, 1989 and 1990 combined.

Arthropod Taxa	n	Percent found on: Stem	Leaf	Bud	Flower	Seed head
Mordellidae	13	15.4[a]	0.0	0.0	84.6	0.0
Diabrotica undecimpunctata howardi Barber	10	20.0	0.0	0.0	80.0	0.0
Chauligonathus pennsylvanicus (DeGeer)	27	7.4	22.2	3.7	66.6	0.0
Grasshoppers	41	39.0	29.3	4.9	9.8	17.1
Orius insidiosus (Say)	36	0.0	0.0	0.0	100.0	0.0
Pentatomidae	19	21.1	0.0	10.5	21.1	47.4
Lygus lineolaris (Beauvois)	14	14.3	7.1	28.6	50.0	0.0
Philaenus spumarius (L.) (Adult)	237	44.7	42.6	9.3	2.9	0.4
Philaenus spumarius (L.) (Nymph)	206	69.9	26.2	3.4	0.5	0.0
Aphids	20	60.0	0.0	0.0	30.0	10.0
Ants	213	35.2	16.9	12.2	30.0	5.6
Thrips	1260	0.0	0.0	1.6	98.4	0.0
Spiders	49	24.5	8.2	0.0	49.0	18.4

[a] Percent of all individuals collected from musk thistle.

Within-plant stratification of arthropods varied among selected taxa (Table 3). Spatially, more organisms were found in the top one-third of the plant than in the bottom one-third. This spatial difference was primarily due to the location of flowers, which are usually found near the top of the plant. Other organisms (e.g., grasshoppers and froghoppers, especially *P. spumarius*) were located near the middle one-third of the plant and fed on stems and leaves (Tables 2 and 3).

Above-ground arthropods were found on musk thistle throughout its growing season. Stem and leaf feeders (e.g., froghoppers) were found in large numbers before plant flowering. Their density on the plant decreased as the growing season progressed. The greatest variety of arthropods was found during plant flowering, when organisms may have been foraging for pollen or nectar. Many insect species, including coleopterans, lepidopterans, and hymenopterans, fed on or within the flower. Numerous other arthropods, such as assassin bugs, minute pirate bugs, ambush bugs, and spiders, were predaceous upon organisms found on or within the flower.

As with most introduced plant species, musk thistle had few major phytophagous insects associated with it. Although many established arthropods utilized the resources of musk thistle, few of these arthropods caused sufficient injury to greatly reduce reproductive abilities or survival of the plant. Because of the low numbers of established phytophagous insects

Table 3. Within-plant stratification of selected arthropod taxa found on musk thistle in Tennessee, 1989 and 1990 combined.

Arthropod Taxa	n	Percent found on: Top of plant	Middle of plant	Bottom of plant
Mordellidae	13	100.0[a]	0.0	0.0
Diabrotica undecimpunctata howardi Barber	10	90.0	0.0	10.0
Chauligonathus pennsylvanicus (DeGeer)	27	74.1	22.2	3.7
Grasshoppers	41	34.1	48.8	17.1
Orius insidiosus (Say)	36	77.8	22.2	0.0
Pentatomidae	19	89.5	10.5	0.0
Lygus lineolaris (Beauvois)	14	92.9	7.1	0.0
Philaenus spumarius (L.) (Adult)	237	52.3	40.5	7.2
Philaenus spumarius (L.) (Nymph)	206	30.1	51.9	18.0
Aphids	20	85.0	15.0	0.0
Ants	213	60.1	23.5	16.4
Thrips	1260	98.7	1.3	0.0
Spiders	49	77.6	20.4	2.0

[a] Percent of all individuals collected from musk thistle.

that impact musk thistle, the introduction of selective, thistle-feeding biological control agents (such as *R. conicus* and *T. horridus*) becomes important.Once they become widely established in Tennessee, these two herbivorous insects may help to reduce the densities of musk thistle below pest status. Efforts are underway to distribute these biological control agents into thistle-infested areas throughout Tennessee.

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References Cited

Batra, S. W. T., J. R. Coulson, P. H. Dunn & P. E. Boldt. 1981. Insects and fungi associated with *Carduus* thistles (Compositae). United States Department of Agriculture Technical Bulletin 1616, Washington, D.C., 100 pp.

Briese, D. T. 1989. Natural enemies of Carduine thistles in New South Wales. J. Aust. Entomol. Soc. 28: 125-134.

Dunn, P. H. 1976. Distribution of *Carduus nutans, C. acanthoides, C. pycnocephalus,* and *C. crispus* in the United States. Weed Sci. 24: 518-524.

Goyer, R. A. 1978. Occurrence of the sunflower moth *Homoeosoma electellum* (Lepidoptera: Pyralidae) on musk thistle in Louisiana. Proc. Louisiana Acad. Sci. 41: 16-17.

Grant, J. F., P. L. Lambdin, S. D. Powell & R. Chagnon. 1990. Establishment of plant-feeding weevils for suppression of musk thistle in Tennessee. Univ. Tenn. Agric. Expt. Stat. Res. Rpt. 90-19, 18 pp.

Morihara, D. K. & E. V. Balsbaugh, Jr. 1976. Phytophagous insects collected on musk thistle, *Carduus nutans*, in southeastern South Dakota. Environ. Entomol. 5: 692-696.

Powell, S. D., J. F. Grant & P. L. Lambdin. 1992. Incidence of *Dicymolomia julianalis* (Lepidoptera: Pyralidae) on musk thistle in Tennessee. J. Entomol. Sci. 27: 209-216.