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The Phytophagous Insect Fauna of Scotch Thistle, *Onopordum acanthium* L., in Southeastern Washington and Northwestern Idaho

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Abstract

Scotch thistle, *Onopordum acanthium* L. (Asteraceae: Cardueae), a plant of Eurasian origin, has become an increasingly serious pasture, rangeland, wasteland, and roadside weed in the western United States. Prior to the implementation of a biological control agent acquisition and release program, a domestic survey was carried out at 16 sites in five southeastern Washington and northwestern Idaho counties between 1995-96 to ascertain the plant's existing entomofauna. Thirty phytophagous insect species in six orders and 17 families were found to be associated with the thistle. Hemiptera, Homoptera, and Coleoptera were the dominant ectophagous taxa, encompassing 50, 20, and 17% of all species found, respectively. The family Miridae contained 60% of the hemipteran fauna. *Onopordum* herbivores were polyphagous ectophages, and none of them reduced populations of or caused appreciable damage to the plant. The only insect that consistently fed and reproduced on *O. acanthium* was the aphid *Brachycaudus cardui* (L.). A notable gap in resource use was the absence of endophages, particularly those attacking the capitula, stems, and roots. Consequently, the importation of a complex of nonindigenous, niche-specific natural enemies may prove to be a highly rewarding undertaking.

Key Words: *Onopordum*, Scotch thistle, weed, biological control, entomofauna

Scotch thistle, *Onopordum acanthium* L. (Asteraceae: Cardueae), a plant native to Mediterranean Europe and central western Asia (Briese 1989a), was introduced into the eastern United States during the late nineteenth century (Young and Evans 1969). The thistle has since become naturalized in the western United States. In California, Idaho, Oregon, Washington, and other states, habitats aggressively invaded by this noxious weed tend to be ecologically disturbed, heavily grazed, of reduced economic value, and receive low amounts of annual precipitation. Dense infestations of the plant reduce pasture and rangeland forage productivity and impede livestock and wildlife movement, as well as negatively impact transportation and utility line corridors and wasteland areas. The weed presently occurs on an estimated 3,600 ha in 23 of the 39 counties in Washington. The hectarage infested in Idaho is not known.

Scotch thistle reproduction is entirely by seed and the plant is typically a biennial, although it may also act as a summer or winter annual or even short-lived perennial. Most plants range between 0.9 and 1.2 m in height (Parsons 1981) but some are 2.4 m tall and 1.8 m in diameter (Piper 1984). Several spinose stems may develop from the root crown,

FOOTNOTE

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and multiple branches may radiate from the stems. The leaves of *O. acanthium* are lobed and have spines along the margins, the margins continuing as spiny wings down the stems. The stems and leaves are densely covered with cottony hairs, giving the plant a gray-green appearance. The spiny capitula, with their reddish-violet florets, may be solitary or clustered towards the ends of branches. A single plant may develop up to 310 flower heads (Young and Evans 1969). Achenes are brown to mottled black, conspicuously wrinkled, and have a pappus of finely toothed hairs and bristles. Between 20,000 and 40,000 achenes are produced per plant (Roberts and Chancellor 1979).

Current methods of Scotch thistle population reduction involve the utilization of mechanical and chemical controls, both of which are labor intensive, impractical or inadvisable in some situations, and often cost-prohibitive. Classical biological control has been implemented in Australia (Briese *et al.* 1996) and could prove to be a highly important form of plant management in the United States.

The objective of this investigation was to assess the indigenous insect fauna associated with *O. acanthium* in southeastern Washington and northwestern Idaho and determine existing insect associations and levels of feeding damage. This work constituted a prelude to Scotch thistle exotic natural enemy acquisition and release in Washington and elsewhere in the western United States.

Materials and Methods

Immature and mature phytophagous insects were collected from *O. acanthium* at four locations in southeastern Washington (Asotin, Columbia, Garfield, and Whitman Counties) and one location in northwestern Idaho (Nez Perce County) on 28 occasions during 1995-96. Two sampling sites were selected within each county annually. Plants at all localities were examined for insect injury during their early and late vegetative, flowering, fruiting, and senescent stages once a week from mid-May to mid-August. The leaves, stems, and capitula of three or four plants per site were examined *in situ* and ectophagous insects were collected by hand or aspiration. A series of 10-20 sweeps of bolted plants was also taken on each sampling date. The leaves and stems of two plants per site were dissected in the field for endophagous insects. Six capitula from each of four plants per site were field-dissected during the pre-flowering, flowering, post-flowering, and fruiting stages to ascertain endophagous insect occurrence. Additionally, two entire plants were uprooted at each site and returned to the laboratory where the roots, leaves, stems, and capitula were dissected and closely examined for endophage presence. Plant damage was noted and attributed to a particular insect species whenever possible. An average of two man-h were spent collecting at each site on every visit. Field-collected immature and adult insects were preserved in 70% ethyl alcohol for subsequent identification. Insects identified in this study have been deposited in the Maurice T. James Entomological Museum at Washington State University.

Following Briese *et al.* (1994), insect observations included all phytophagous insects encountered on the plant, exclusive of pollen and nectar feeders. Relative frequency of insect occurrence was recorded as: rare (found at less than 15% of the sample sites); occasional (found at 15-50% of the sites); and common (found at more than 50% of the sites).

Similarity coefficients were calculated to compare faunal collections among sampling regions, with the comparisons being based on the county sampled. The similarity coefficient used was that reported by Faith (1983):

$$C = \frac{a + d/2}{a + b + c + d},$$

where a = number of species in both samples A and B (joint occurrences), b = number of species in sample B but not A, c = number of species in sample A but not B (exclusive occurrences), and d = number of species in neither sample A or B (joint absences). This coefficient has the property of giving joint absences a neutral effect on the coefficient, an advantage considering that their biological meaning is unclear (Faith 1983). Relative values of the similarity coefficient indicate a degree of similarity and, although not statistically applied, this measure was used to demonstrate relatedness among the *O. acanthium* insect populations examined within the region.

Results and Discussion

Phytophagous insects associated with *O. acanthium* in southeastern Washington and northwestern Idaho are listed in Table 1. Inclusion in Table 1 was based either on direct observation of feeding damage, or an insect's consistent occurrence on the plant in numbers and/or throughout the collection period. Six orders, 17 families, and 30 species were represented. The Hemiptera, Homoptera, and Coleoptera were well represented, encompassing 50, 20, and 17% of all insects collected, respectively. These same orders were also the most species rich ones associated with *O. acanthium* in Europe (Briese *et al.* 1994). The Hemiptera and Coleoptera each had representatives from five families, and the Homoptera was represented by three families. The family Miridae accounted for 60% of the hemipterans associated with Scotch thistle, making it the dominant family in terms of species richness. Lepidopterans made up 7% of the entomofauna, and the orders Orthoptera and Thysanoptera each accounted for 3%. Undoubtedly, this list of Scotch thistle-attacking insects could be expanded by further collection and extension of the survey into other geographic areas in the western United States.

Similarity coefficients among the counties sampled are given in Table 2. These values indicate ranked similarity and show relatively low species similarity among the counties. The coefficients are highly similar, ranging from 0.25 to 0.36 for seven of 10 area combinations. These values suggest that low species similarity existed throughout the area sampled, substantiating the low overall species number as well as the general absence of specialist herbivores on *O. acanthium*. The insect herbivores on Scotch thistle can be viewed as generalist species, i.e., polyphagous ectophages not intimately attuned ontogenetically to the morphology or phenology of the plant. Fifty percent of the arthropods that Briese (1989b) found associated with carduine thistles in New South Wales, Australia, fit this classification as well.

Only four (13%) of the 30 insect species were observed consistently feeding upon *O. acanthium* as immatures or adults in the survey area. Interestingly, all were ectophages and ineffective in diminishing plant population abundance. These insects included *Brachycaudus cardui* (L.) (Homoptera: Aphididae), *Philaenus spumarius* (L.) (Homoptera: Cercopidae), *Melanoplus bivitattus* (Say) (Orthoptera: Acrididae), and *Vanessa cardui* (L.) (Lepidoptera: Nymphalidae). Of these, *B. cardui* was the most commonly collected species. The aphid typically fed and reproduced on the stems beneath developing capitula, inflicting only moderate injury. Only slight injury to *O. acanthium* could be attributed to *P. spumarius* nymphal feeding. *Melanoplus bivittatus* was essentially an opportunistic and incidental herbivore whose late summer foliage consumption did not adversely impact the thistle's growth and reproduction. The larvae of *V. cardui* are known to feed on many plant species, including other thistle genera (Piper 1988). Considerable defoliation of *O. acanthium* resulted from such attack but the butterfly's

Table 1.
Phytophagous insects associated with Scotch thistle, *O. acanthium*, in southeastern Washington and northwestern Idaho

Taxon	Relative[a] frequency	Associated plant part[b,c] Lf	St	Rt	Cp	Sweep[c]	Stage[d]	Feeding[b,d]	Location[e]
Orthoptera									
Acrididae									
Melanoplus bivittatus (Say)	O	E	E		E	E	N, A	N-Lf, A-Lf	G, W, NP
Thysanoptera									
Thripidae									
Unidentified sp.	O				E		L, A		C, W
Hemiptera									
Berytidae									
Neides muticus (Say)	R					E	A		As
Miridae									
Chlamydatus sp.	R					E	A		As
Deraecoris sp.	R					E	A		As, C
Irbisia pacifica (Uhler)	O	E	E			E	N, A		As, G, NP
Leptopterna dolibrata (L.)	R	E				E	N, A		G, NP
L. ferrugata (Fallea)	R					E	N, A		G
Lygus sp.	O	E	E			E	N, A		As, C, G, NP, W
Orthops scutellatus (Uhler)	R					E	A		As, G
Playiognathus sp.	O					E	A		C, G, NP, W
Unidentified sp.	R	E					A		NP
Pentatomidae									
Pitedia ligata (Say)	R	E				E	A		As, W
Rhopalidae									
Arhyssus scutata (Stal)	R					E	A		NP
Boisea trivittatus (Say)	R	E	E			E	A		C, G
Stictopleurus punctiventris (Dallas)	R					E	A		NP
Scutelleridae									
Eurygaster shoshone Kirkaldy	R		E			E	A		G, W

Taxon	Relative[a] frequency	Associated plant part[b,c] Lf	St	Rt	Cp	Sweep[c]	Stage[d]	Feeding[b,d]	Location[e]
Homoptera									
Aphididae									
Brachycaudus cardui (L.)	C	E	E		E	E	N, A	N-Lf, St	As, C, G, NP, W
Cercopidae									
Aphrophora sp.	R	E					A		As
Philaenus spumarius (L.)	O	E	E			E	N, A	N-Lf, St	C, G, NP, W
Cicadellidae									
Deltacephalis sp.	O	E				E	A		G, NP
Dikraneura sp.	O	E				E	N, A		As, G, NP, W
Unidentified sp.	O					E	A		As, C, NP, W
Lepidoptera									
Pieridae									
Unidentified sp.	R	E					L		G, NP
Nymphalidae									
Vanessa cardui (L.)	O	E			E	E	L, A	L-Lf, A-Cp	As, G
Coleoptera									
Apionidae									
Apion sp.	R					E	A		NP
Chrysomelidae									
Phyllotreta sp.	R					E	A		As
Curculionidae									
Larinus sp.	O	E	E		E		A		As, NP, W
Mordellidae									
Mordella sp.	R					E	A		W
Nitidulidae									
Thalycra sp.	R					E	A		C

[a] C, common; O, occasional; R, rare.

[b] Cp, capitulum; Lf, leaf; Rt, root; St, stem.

[c] E, ectophagous.

[d] A, adult stage observed; L, larval stage observed; N, nymphal stage observed.

[e] As, Asotin Co.; C, Columbia Co.; G, Garfield Co.; NP, Nez Perce Co.; W, Whitman Co.

Table 2.
Similarity coefficients of each pair of counties sampled in the survey

County pairs	Whitman	Columbia	Garfield	Nez Perce	Asotin
Whitman	—-				
Columbia	0.36	—-			
Garfield	0.27	0.26	—-		
Nez Perce	0.28	0.25	0.31	—-	
Asotin	0.26	0.20	0.20	0.20	—-

overall impact on the plant was deemed negligible.

Since no specialist insects were encountered on the plant during this survey, ectophagous fruit-, stem-, and leaf-feeding niches are open. Specialist *Onopordum* leaf- and stem-attacking ectophages of European origin would almost certainly more effectively exploit these resources as opposed to the generalist herbivores currently associated with the weed. A guild of specialized rosette defoliators and crown feeders could adversely affect seed production potential by inhibiting bolt formation and inflorescence development.

No endophagous insects whatsoever were discovered during the survey. Briese (1989b) reported that only 5% of the phytophagous insects encountered on *Onopordum* in Australia were endophages compared to 38% in Europe. Of the European endophagous fauna, 21% were fruit feeders, 9% stem and root feeders, and 8% stem and leaf feeders (Briese 1989b). As suggested by Goeden and Ricker (1986), the absence of *Onopordum* endophages may be attributable to the lack of congeneric thistle species within the region that would afford preadapted, specialist feeders the opportunity to cross over to the weed. This absence of an endophagous feeding guild in the Scotch thistle-infested areas of Idaho and Washington is highly significant. All endophagous feeding niches are open for exploitation by nonindigenous specialist insects. A guild of capitulum feeders could be of great importance in the regulation of *O. acanthium* as the effective occupation of this niche could significantly impact plant reproduction and survival (Briese *et al.* 1994).

Host-specificity testing of several candidate European natural enemies of *O. acanthium* has begun at the Exotic and Invasive Weed Research Unit, USDA-ARS, Albany, CA (J. Balciunas, personal communication). Two curculionids examined to date (*Lixus cardui* Olivier and *Lixus* sp.) have demonstrated the ability to feed and complete development on several indigenous thistles (*Cirsium* spp.), making these insects unsuitable for release in the United States. A third rosette root-infesting weevil, *Trichosirocalus* sp., is still undergoing evaluation. It is hoped that the beetle or other yet to be tested insects will be host-specific enough to be approved for release against Scotch thistle in the western United States.

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