

Host-Specificity of the Palearctic Weevil *Larinus curtus* (Coleoptera: Curculionidae), a Natural Enemy of *Centaurea solstitialis* (Asteraceae: Cardueae)

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The weevil *Larinus curtus* (Coleoptera: Curculionidae) is a natural enemy of yellow starthistle, *Centaurea solstitialis* (Asteraceae: Cardueae), in Eurasia, where both the plant and the insect are native. This weevil is a candidate for the biological control of yellow starthistle in North America, where the plant is a naturalized weed. The host-specificity of adult *L. curtus* was investigated under laboratory conditions with no-choice host tests. Of 25 plant species tested, including 7 other species of *Centaurea*, oviposition was restricted to yellow starthistle and 7 other congeneric species from Europe. Based on these tests and other information, *L. curtus* appears safe to introduce into North America for biological control of yellow starthistle.

Introduction

Yellow starthistle (*Centaurea solstitialis* L.; Asteraceae: Cardueae) is an annual species, native to Eurasia, that has been accidentally introduced into North America, where it is a naturalized major weed of rangelands in the western United States. It is also a weed of alfalfa, cereal grains, orchards, vineyards, roadsides, and recreational lands (Robbins *et al.* 1970; Maddox and Mayfield 1985). Yellow starthistle infests several million ha in the western United States (Maddox 1981; Maddox *et al.* 1985) and it continues to spread (Maddox and Mayfield 1985). The spiny flowerheads render the weed unpalatable to livestock. It is toxic to horses in which it causes brain lesions leading to "chewing disease," nigropallidal encephalomalacia (Cordy 1978). At least 42 insect species attack yellow starthistle in Italy and Greece (Clement 1990). Three insect species that attack the capitula are established in the United States as of 1991 following their importation from Greece (Maddox *et al.* 1986,

Turner *et al.* in press, Turner, unpublished data). *Larinus curtus* Hochhut (Coleoptera: Curculionidae) could effectively complement these insects and contribute to the biological control of yellow starthistle.

Methods and Materials

Taxonomy, Geographic Distribution, Host Records and Life History

L. curtus belongs to the subfamily Cleoninae, tribe Lixini, subgenus *Larinomesius* Reitter (Ter-Minasyan 1967). It occurs in central and southern Italy, Sicily, Sardinia, Greece, Yugoslavia, Ukraine, the Caucasus region, Turkey, Syria, Israel, and Egypt (Sobhian and Zwölfer 1985). The genus *Larinus* is associated exclusively with host plants in the family Asteraceae (Ter-Minasyan 1967, Zwölfer *et al.* 1971) and the genus may be exclusively associated with the thistle tribe (Cardueae, *sensu lato*) (Hoffman 1954, Zwölfer *et al.* 1971) and the genus *Berkheya* in the tribe Arctoteae in

southern Africa (Clark 1990). The subgenus *Larinomesius* appears to be strongly associated with the thistle genus *Centaurea* (Zwölfer *et al.* 1971, Sobhian and Zwölfer 1985). *L. curtus* is not reported from any crop or ornamental plant (*Review of Applied Entomology Series A* 1913-91, *Zoological Record* 1864-1991, *Entomology Abstracts* 1970-86, Grandi 1951, Hoffman 1954, Balachowsky 1963, Scherf 1964, Ter-Minasyan 1978, Fremuth 1982), its only known host in the field being *C. solstitialis* (Zwölfer *et al.* 1971).

The weevil is univoltine. Adults feed on the open capitula and oviposit among the florets of flowering capitula (stages F-1 and F-2 of Maddox (1981) and Fornasari *et al.* (1991). The larvae feed inside the capitula on developing seeds (Sobhian and Zwölfer 1985, Sobhian and Fornasari 1994).

Host-Specificity Studies

Host-specificity tests were conducted during 1988-90 to assess the feeding, oviposition, and longevity of *L. curtus* on selected test plants. Adults used were collected near Thessaloniki, Greece, and shipped to the Rome, Italy, and Albany California, laboratories.

No-Choice Sleeve Cage Tests. These tests were conducted in a quarantine greenhouse in Rome at temperatures of 19-36°C, 28-96% RH, and natural lighting during June-September. The plant species used are listed in Tables 1-3. Branches of the test plants were caged in black, nylon tulle sleeve cages, each with 2 adult males and 2 females. The adults were free to move on the branch inside the cage. Branches exposed to weevils were changed as necessary, with new branches provided every 7-10 d, as a new source of food, and the number of exposed buds and flowers (or flowerheads), number of flowers (or flowerheads) fed upon, feeding damage, number of eggs laid, number and sex of dead weevils, and number of eggs in ovarioles were recorded. This procedure was repeated until all beetles died. These experiments were conducted from 25 June-3 October 1988, 5 July-12 September 1989, and 29 June-6 September 1990.

No-Choice Cage Tests. These tests were conducted in a quarantine greenhouse in Albany under natural lighting. They consisted of multiple mating pairs placed inside a 1 m²

screen cage enclosing multiple potted plants of 1 test plant species per cage (Table 4). The test plant taxa were: *C. solstitialis* from California, *C. americana* Nuttall (native species from Arizona), *C. cyanus* L. (minor ornamental and naturalized weed from commercial seed packets), *Carthamus tinctorius* L. var. S541 (safflower variety grown in the north-central states), *C. tinctorius* var. 4440 (variety grown in California), and *Cirsium douglasii* de Candolle (native species from California). For each cage test, the number of weevil pairs used in a cage was equal to the number of plants in the cage. Weevils could move freely on and between plants in a cage, and all test plants had capitula at stages potentially suitable for feeding and oviposition. Test plants were exposed to the weevils for 21 d, after which the weevils were removed from the cage. Tests were conducted from 6 July-17 August 1989, and from 20 July-24 August 1990. All capitula at a stage suitable for oviposition (F-1 and F-2; see Fornasari *et al.* [1991] for illustrations of capitulum stages) were tagged and considered as test capitula, and were later dissected and examined for eggs, larvae, or larval feeding damage. The dissections were carried out 1-7 August 1989, and 3-24 August 1990.

Results and Discussion

No-Choice Sleeve Cage Tests

Oviposition occurred almost exclusively on *C. solstitialis*, with a few eggs also laid on *C. maculosa* Lam. and *C. scabiosa* L.. Heavy feeding occurred on only *C. solstitialis* and *C. calcitrapa* L. (the leaves of the latter were heavily attacked, but no eggs were laid). There was also some feeding on *C. napifolia* L., *C. maculosa*, *C. scabiosa*, *C. cyanus* L., *C. diffusa* Lam., and *Tanacetum parthenium* Sch.-Bip. Minimal feeding was recorded on *Cirsium undulatum* (Nutt.) Spreng. and *C. tinctorius*, and no feeding was observed on *Cynara scolymus* L. and *Helianthus annuus* L.

No-Choice Cage Tests

Oviposition attempts were observed only on yellow starthistle. Some adult feeding was observed on the flowers of all test plant taxa,

Table 1. Adult feeding, oviposition, and longevity of *Larinus curtus* in no-choice host specificity sleeve cage tests, Rome, Italy, 1988. Two males and 2 females were used per test plant.

Plant Species	No. Plants	Total No. Eggs Laid	Feeding Damage Rating ¹	Total No. Exposed		Total No. Flowerheads Fed Upon	Longevity (d) $\bar{X} \pm SD (N)$	No. Eggs In Ovarioles
				Buds	Flowerheads			
<i>Centaurea solstitialis</i> L. from Greece (Control)	10	39	2	199	186	150	29.5 ± 9.6 (40)	2
<i>C. solstitialis</i> from California	10	267	2	490	486	347	42.4 ± 26.4 (40)	3
<i>C. napifolia</i> L.	10	0	1-2	254	314	149	23.5 ± 8.3 (40)	0
<i>C. calcitrapa</i> L.	9	0	2-5	255	127	87	29.2 ± 14.6 (36)	0
<i>C. maculosa</i> Lam.	10	8	1-3	267	162	123	27.1 ± 12.4 (40)	0
<i>C. scabiosa</i> L.	10	6	1-2	66	30	28	21.5 ± 7.4 (40)	0
<i>Tanacetum parthenium</i> (L.) Shultz-Bip.	10	0	1-3	107	86	36	14.5 ± 4.0 (40)	0
<i>Carthamus tinctorius</i> L.	10	0	0-1	27	39	32	22.6 ± 7.7 (40)	0
<i>Cynara scolymus</i> L.	2	0	0	2	2	0	11.1 ± 4.3 (8)	0
<i>Helianthus annuus</i> L.	9	0	0	0	13	0	15.3 ± 6.8 (36)	0

¹Based on a scale of 0 to 5; 0, no feeding; 1, very little feeding, no effect on flowerhead development; 2, considerable damage to flowerheads, but not completely eaten; 3, as point 2, with damage to stems and leaves; 4, flowerheads are destroyed; 5, as point 4, with damage to stems and leaves.

Table 2. Adult feeding, oviposition, and longevity of *Larinus curtus* in no-choice host specificity sleeve cage tests, Rome Italy, 1989. Two males and 2 females were used per test plant.

Plant Species	No. Plants	Total No. Eggs Laid	Feeding Damage Rating ¹	Total No. Exposed		Total No. Flowerheads ² Fed Upon	Longevity (d) $\bar{X} \pm SD (N)$	No. Eggs in Ovarioles
				Buds	Flower-heads			
<i>Centaurea solstitialis</i> L. from Greece (Control)	10	227	2	221	380	315	29.14 ± 11.77 (28)	3
<i>C. diffusa</i> Lam.	10	0	1-2	463	931	414	25.27 ± 11.01 (40)	0
<i>C. cyanus</i> L.	8	0	1-2	175	241	163	16.68 ± 8.34 (31)	0
<i>Tagetes erecta</i> Hort.	8	0	0-1	4	15	7 ³	7.78 ± 3.50 (28)	0
<i>Cirsium undulatum</i> (Nutt.) Spreng.	4	0	0-1	4	7	6	11.62 ± 4.64 (16)	0
<i>Gazania rigens</i> (L.) Gaertner	8	0	0-1	4	23	2	8.50 ± 2.18 (32)	0
<i>Cynara scolymus</i> (L.)	10	0	0	0	12	0	8.65 ± 3.49 (40)	0
<i>Lactuca sativa</i> L.	10	0	0	255	104	0	5.44 ± 0.50 (36)	0
<i>Carlina corymbosa</i> L.	7	0	0	103	76	0	8.00 ± 0.00 (28)	0
<i>Viola tricolor</i> L.	8	0	0	17	30	0	7.62 ± 1.61 (32)	0
<i>Medicago sativa</i> L.	8	0	0	294	573	0	7.12 ± 1.18 (32)	0
<i>Antirrhinum majus</i> L.	8	0	0	33	58	0	5.77 ± 0.84 (31)	0
<i>Silene vulgaris</i> (Moench) Garcke	8	0	0	135	100	0	6.50 ± 2.10 (24)	0

¹Based on a scale of 0 to 5: 0, no feeding; 1, very little feeding, no effect on flowerhead² development; 2, considerable damage to flowerheads³ but not completely eaten; 3, as point 2, with damage to stems and leaves; 4, flowerheads² are destroyed; 5, as point 4, with damage to stems and leaves.

²Flowerheads or flowers if not Asteraceae.

³Damage made by only one female.

Table 3. Adult feeding, oviposition, and longevity of *L. curtus* in no-choice host specificity sleeve cage tests, Rome, Italy, 1990. Two males and two females were used per test plant.

Plant Species	No. Plants	Total No. Eggs Laid	Feeding Damage Rating ¹	Total No. Exposed		Total No. Flowerheads ² Fed Upon	Longevity (d) $\bar{X} \pm SD (N)$	No. Eggs in Ovarioles
				Buds	Flowerheads ²			
<i>Centaurea solstitialis</i> L. from Greece (Control)	10	214	2	272	245	203	31.6 ± 15.6	2
<i>Carthamus tinctorius</i> L.	10	0	0-1	5	16	10	9.2 ± 1.6	0
<i>Aster novi-belgii</i> L.	10	0	0	9	13	0	5.2 ± 1.3	0
<i>Senecio vulgaris</i> L.	7	0	0	24	73	0	5.0 ± 1.0	0
<i>Papaver somniferum</i> L.	7	0	0	0	7	0	5.9 ± 2.3	0

¹Based on a scale of 0 to 5: 0, no feeding; 1, very little feeding, no effect on flowerhead² development; 2, considerable damage to flowerheads² but not completely eaten; 3, as point 2, with damage to stems and leaves; 4, flowerheads² are destroyed; 5, as point 4, with damage to stems and leaves.

²Flowerheads or flowers if not Asteraceae.

Table 4. *Larinus curtus* no-choice, host-specificity cage tests in greenhouse quarantine, Albany, California, 1989-90. One mating pair was used per test plant.

Test Plant (Year Tested)	No. of Plants Tested	No. of Capitula Tested	% Test Capitula with Eggs, Larvae or Larval Feeding Damage
<i>Centaurea solstitialis</i> L. (1989)	5	59	30.5
<i>C. solstitialis</i> (1990)	9	107	10.2
<i>C. americana</i> Nuttall (1989)	10	30	0
<i>C. cyanus</i> L. (1989)	10	254	0
<i>Carthamus tinctorius</i> L. var. s541 (1989)	10	34	0
<i>C. tinctorius</i> var. 4440 (1989)	7	151	0
<i>Cirsium douglasii</i> de Candolle (1989)	4	43	0
<i>C. douglasii</i> (1990)	7	158	0

with the greatest amount on yellow starthistle and the least on *Cirsium douglasii*. Eggs, larvae, and larval feeding damage were found only on yellow starthistle (Table 4).

Conclusions

Twenty-five plant species were tested, including 20 species of Asteraceae, 13 of which are in the thistle tribe (Cardueae). The highest amount of adult feeding was on yellow starthistle and a few other *Centaurea* spp. (Tables 1-3), even when these tests were conducted under no-choice, starvation conditions. Oviposition occurred only on yellow starthistle and, to a lesser degree, on two other species of *Centaurea* (*C. maculosa* and *C. scabiosa*) (Tables 1-4). There was no oviposition and only light adult feeding on the most closely-related economic plant species (safflower and artichoke) or native North American species (*C. americana*, *Cirsium douglasii*, *C. undulatum*) tested (Tables 1-4). These laboratory host-specificity test results are congruent with a field plot test carried out in Greece and reported by Groppe *et al.* (1990), in which the weevil oviposited and reproduced only on yellow starthistle, but not on safflower, artichoke, sunflower, *C. diffusa*, *C. maculosa*, or *Cirsium creticum*. These laboratory and field host-specificity test results, together with the fact that yellow starthistle is the only recorded field host of the weevil, strongly indicate that *L. curtus* is narrowly host-specific and would be safe to introduce into North America for the biological control of yellow starthistle.

Acknowledgments

We thank L. Andres, F. Herard, and L. Knutson for reviewing the manuscript, R. Sobhian for collecting the *L. curtus* used for these studies, and K.L. Chan, K. Melvin and K.C. Jones for assisting with the host tests in Albany.

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