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The Interrelation between Natural Enemies of the Invasive Plant *Lepidium draba* L., Established in a Natural Pasture in Eastern Romania

Nela TALMACIU[1)], Ramona HUMA[2)], Mihai TALMACIU[1)]

[1)] *University of Agricultural Sciences and Veterinary Medicine, 3 M. Sadoveanu Alley, 700490, Iasi, Romania; ntalmaciu@yahoo.com*

[2)] *Fruit-Growing Research-Development Centre, 175 Rue Voinesti, 707305, Iasi, Romania; k_ramona2006@yahoo.com*

Abstract

Lepidium draba L. (family *Brasicaceae*), originally from Europe, is a problematic plant in many agricultural ecosystems in Romania. A literature survey revealed that 196 phytophagous organisms are associated with *L. draba,* and 80 of them were found during field surveys. In Romania *Ceutorhynchus cardariae*, *Psylliodes wrasei*, and *Aceria drabae* are the most promising biological agents available for controlling *L. draba.* Observations were made in natural pastures by the Department of Iassy in eastern Romania in 2008. The most common invasive species were *Xanthium italicum, Xanthium spinosum, Elaeagnus angustifolia, L. draba, Euphorbia cyparissias,* and *Verbascum phlomoides*, which dramatically decrease ecosystem productivity. Here we present results obtained based on field test-plant relationship phytophagy between *L. draba* L. and *P. wrasei* Leonardi and Arnold. We studied plants of the *Brasicaceae* family: *L. draba, L. crenatum, Armoracia rusticana,* and *Barbarea orthoceras*. Test plots comprised four *L. draba* planted 5 cm apart, with two test plants (*L. draba, L. crenatum, B. orthoceras,* or *A. rusticana*) planted at one of three planting distances (30 cm, 15 cm, and 5 cm) on each side of the central plants. Each planting distance variant was repeated four times, and for each variant all observations were made on 16 central *L. draba* plants and 8 of each test plant: *L. draba, L. crenatum, B. orthoceras* and *A. rusticana*. A total of 144 plants was studied: 48 central *L. draba* plants and 96 of each test species. These results do not contradict previous evidence that oligophagous species *P. wrasei* controls the *L. draba*. *P. wrasei* is also a potential biologic control agent for *B. orthoceras* (American yellowrocket), which is native to North America, including much of Canada and the western United States, as well as parts of Asia.

Keywords: *Lepidium draba*, atropodes phytophags, *Psylliodes wrasei*

Introduction

The flora composition is transforming in the majority pasture ecosystems used for grazing, frequently through adaptation of the surface with undesirable species (weeds) with low economic value. The mechanisms through which some plants manifest an invasive characteristic in natural and anthropic ecosystems, both in Europe and throughout the world, are very advanced (Fenner and Lee, 2001; Keane and Crawley, 2002; Wolfe, 2002; Jakobs *et al.*, 2004).

One of the most common explanations for the increased vigor of invasive plants is the removal of natural enemies. Thus, numerous and complex studies have been directed at the introduction of pests and phytopathogenic agents found at the sites of origin of these invasive species (Wilson *et al.*, 1990; Frenzel, and Brandl, 1998, 2003; Hinz *et al.*, 2000, 2003, 2004; Southwood, 2000; Keane *et al.*, 2002; Gerber *et al.m* 2004; Cripps *et al.*, 2009). These studies have identified some biological agents for the control of these pests, as well as for industrial production.

Our preliminary research was performed in pastures from the central region of Moldavia that were exploited in a non-rational and inadequate manner and contained invasive weeds (*L. draba*, *Euphorbia cyparissias, Artemisia* sp., *Achillea* sp., *Linaria vulgaris*), with small fodder qualities or that have the capacity to synthesize substances that are toxic to animals, which dramatically decrease the productivity of the ecosystems.

Hoary cress (*L. draba*; *Cardaria draba*; *Brassicaceae*) is a perennial mustard, indigenous to southwestern (Caucasus region) and central Asia. It spread to the rest of Europe approximately 300 years ago; is now naturalized throughout continental Europe, as suggested by Hegi (1986); and is regarded as a serious weed in Eastern Europe and the former Soviet Union (Holm *et al.,* 1991). Hoary cress is an aggressive invader capable of thriving in nearly all types of soil and habitats, but grows particularly well in disturbed and irrigated areas (Lyons, 1998). It is usually avoided by cattle, but if grazed it can be toxic to livestock. *L. draba* displaces valuable pasture forage species and reduces native biodiversity (Sheley and Stivers, 1999; Cripps *et al.*, 2006).

Hoary cress is a perennial herb that reproduces by seeds and by horizontal creeping roots. The stem is stoutish, erect or spreading; the plant grows up to 10-80 cm tall, and quickly becomes pubescent. The root system is well-developed, comprising a main tap root that reaches a depth of 1.2 to 2 m. The leaves are alternating, simple, and

mostly toothed. The basal leaves are to 4 to 10 cm long, have a slight stem, and are long and flat (Manoliu *et al.*, 1996). The flowers are small, white, with petals up to 3 to 5 cm long. The fruit is heart-shaped and contains two seeds. This plant flowers in April-May, bears fruits in June-July (Parvu, 2005).

A literature survey revealed that 196 phytophagous organisms are associated with *L. draba,* and of these, 80 were found during field surveys. Six phytophagous insect species were selected as potential biological control agents based on records of their restricted host range (Hinz *et al.*, 2004): the gall-forming weevil *Ceutorhynchus cardariae* Korotyaev (*Coleoptera, Curculionidae*), the stem-miner *Ceutorhynchus merkli* Korotyaev, the seed-feeder *Ceutorhynchus turbatus* Schultze, the flea beetle *Psylliodes wrasei* Leonardi and Arnold (*Coleoptera, Chrysomelidae*), the gall mite, *Aceria draba* Nal. (*Acari, Eriophyidae*), and the root-gall forming weevil *Ceutorhynchus assimilis* Paykull (Lipa, 1978; Hinz *et al.*, 2008).

In Romania, the most promising biological control agents are *Ceutorhynchus cardariae*, *P. wrasei*, and *Aceria drabae* (Chatened du Gaetan, 1990; Panin, 1951; Fumanal *et al.*, 2004; Hinz *et al.*, 2008). One of the specialist herbivores on *L. draba*, the flea beetles, *P. wrasei* Leonardi and Arnold, have been documented to follow their host plant to Europe and Romania.

The flea beetle, *P. wrasei* Leonardi and Arnold (*Coleoptera, Chrysomelidae*) was recently described as a new species in Europe (Leonardi and Arnold, 1995 cit. Cripps *et al.*, 2006). Field observations in Romania indicate that *P. wrasei* is often locally abundant and impacts the plant by killing developing shoots in the spring.

This species is currently being investigated as a potential biological control agent for *L. draba*. Females lay eggs by late summer and autumn in the soil. Larvae hatch in early spring and develop on the shoots of *L. draba*. The larvae transform into pupae in the soil and the new generation of adults emerge in June. The flea beetles feed for 2 to 3 weeks on foliage, then estivate, and recommence feeding on rosettes in late August. Preliminary host specificity tests indicate that *P. wrasei* has a restricted host range (Cripps *et al.*, 2006; Hinz *et al.,* 2008).

Materials and methods

To determine the host range of a potential agent, host specificity tests are conducted in either the area of origin of the target weed or under quarantine conditions in the invaded range (Frenzel *et al.*, 1998; Colautti *et al.*, 2004; Hinz and Schwarzlaender, 2004).

A first useful indication of the suitability of a phytophagous organism as a potential biological control agent that can save a lot of resources is its field host range in its area of origin, especially in cases where the target plant contains many closely related species growing in the same habitat or area. If the organism is only found (as adult or larvae) on the target weed, but not on closely related congeners, it shows that the organism has evolved a close relationship with its main host and that it will be less likely to influence non-target species.

Some of the plants that are native to the invaded range of the target weed may have never been exposed to the potential biological control agent. For example, within the family *Brassicaceae*, there are 49 genera native to North America. Host-specificity tests therefore must be conducted to assure that the potential agent will not attack non-target species (Cripps *et al.*, 2005; Kuhlmann *et al.*, 2006; Buschmann *et al.,* 2005; Puliafico *et al.*, 2008).

Host-specificity tests are usually first conducted under no-choice conditions to determine the so called physiological or fundamental host range of a potential biological control agent, defined as those plant species on which the agent is able to develop. Plants accepted under no-choice conditions are subsequently exposed in an environment where the agent has to choose between the target plant and one non-target plant (single choice test) and then in an environment where the potential agent has a choice between the target plant and several non-target plants (multiple choice test). The multiple choice tests are often conducted in field cages. The determination of the realized or ecological host range of a potential biological control agent is therefore generally conducted under open-field conditions.

This testing sequence, which progressively reduces the degree of restriction, deleting unattached plants at each stage, until only a few remain to be tested under conditions as near natural as possible, is a reliable way to determine the safety of potential biological control agents, and to avoid the rejection of safe agents.

Some studies have demonstrated how the flea beetle reduces the species diversity of weeds and increase the rate of secondary plant succession by selecting more palatable species, commonly annual and perennial species (Cripps *et al.,* 2006; Hinz *et al.,* 2008).

The core species groups in the European ranges largely comprise oligophagous species, which is consistent with other work documenting that oligophages are predominant on *Brassicaceae* plants in Europe (Frenzel and Brandl, 1998). *P. wrasei* is a oligophagous species that is restricted to the *Brassicaceae* family.

The present study examined the following plants of the *Brasicaceae* family: *L. draba, L. crenatum, Armoracia rusticana*, and *Barbarea orthoceras*.

On June 12, 2008, seeds from each population were sown into trays. After the development of the first true leaves, individual seedlings were transferred to pots Aug. 5th. A total of 144 plants: 72 *L. draba* plants and 72 plants (24 plants each *L. crenatum, A. rusticana,* and *B. orthoceras*) were used in the study.

The experiment was arranged as follows (Fig. 1): four potted plants of *L. draba* (green: *L. draba* plants, LD-C) were placed centrally 5 cm apart, and two potted plants

(white, test plants: *L. draba* [LD], *L. crenatum* [LC], *A. rusticana* [AR], and *B. orthoceras* [BO]) were placed laterally (30 [3:1], 15 [3:2], or 5 [3:3] cm from the central plants) on either side of the central plants.

Each planting distance variant was repeated four times, all observations were made on the 16 central *L. draba* plants and 32 laterally placed test plants.

In the spring, April 22-23, all plants were analyzed and the presence of weevil, flea beetle, *P. wrasei*, the number of adults, and the attack made on the plants (from rosset, from overground root, from underground root, atacked shoots) on all plants in the experiment were recorded (Fig. 2).

In the first variant (V1) with the test plants planted 30 cm from the central plants, 8 of the 16 central *L. draba*

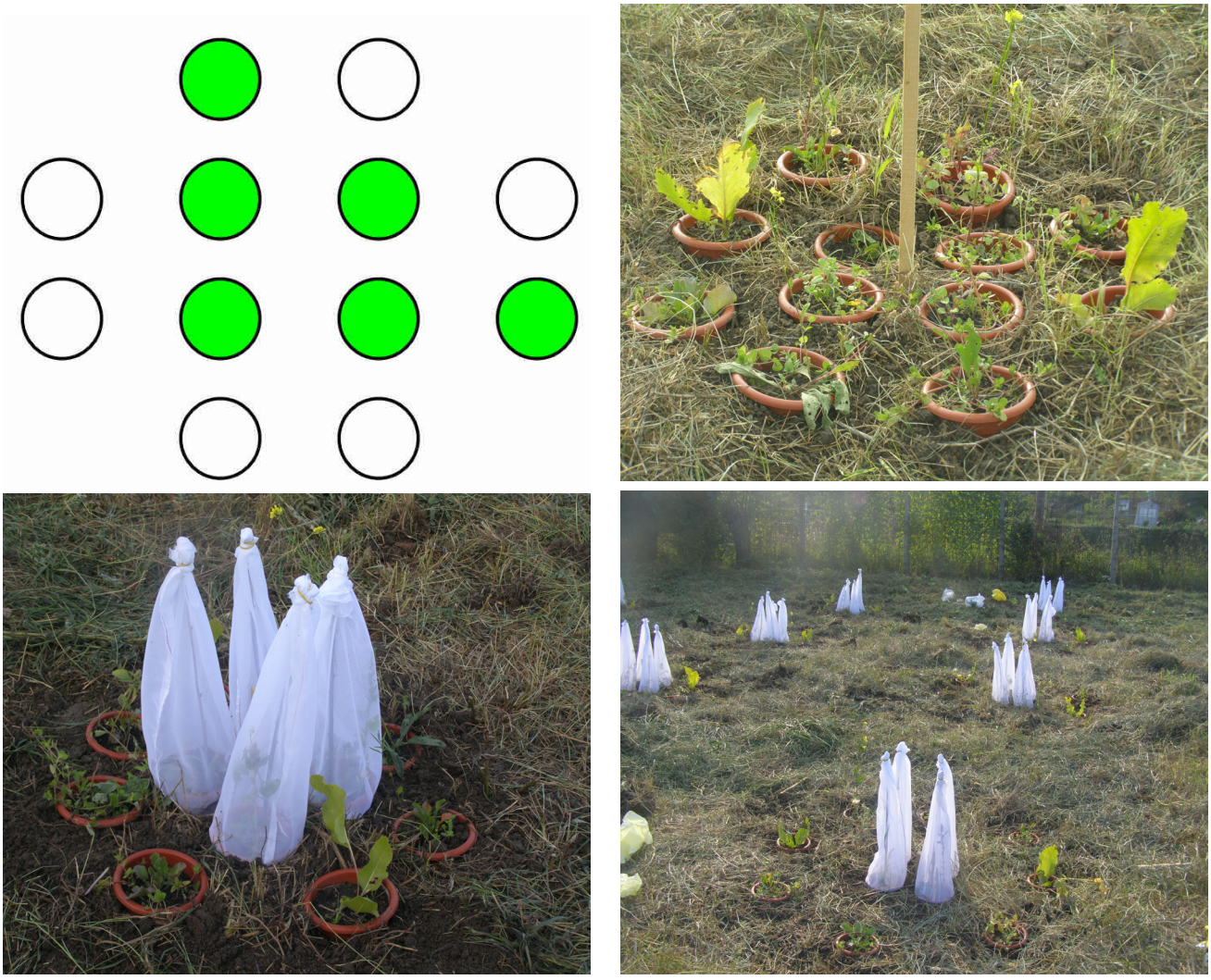

Fig. 1. Experimental design

Results and discussion

After installation of the plants, adult *P. wrasei* Leonardi and Arnold were collected in the field from Sept 16-30, 2008. A total of 288 adults were collected. On Oct. 1, six adult *P. wrasei* were placed on each of the central *L. draba* plants and isolated using cloth bags.

On Oct. 10, the central plants were uncovered, the *P. wrasei* adults were released, and all plants were slightly watered. On Oct. 7, we verified the presence of adults and that *P. wrasei* attacked only the *L. draba* plants (at the base or on the undersides of the leaves).

plants were attacked and the 32 test plants were attacked as follows: 3 *L. draba* plants and 8 *B. orthoceras* plants, of which *P. wrasei* attacked 4 plants and other weevils attacked 4 plants (Tab. 1).

In the second variant (V2), with the test plants planted 15 cm from the central plants, 9 of the 16 central *L. draba* plants were attacked and the 32 test plants were attacked as follows: 2 *L. draba* plants and 8 *B. orthoceras* plants, of which *P. wrasei* attacked 2 plants and other weevils attacked 6 plants(Tab. 2).

In the third variant (V3), with test plants planted 5 cm from the central plants, 7 of the 16 central *L. draba* plants

Tab. 1. Distance of planting in the first variant and the attack of the *P. wrasei* on plant

Plot	Plant sp.	Plant code	Distance	Atacked from rossete	Overground root	Underground root	Shoots	Remarks	keep plants for adult	*P. wrasei* adult
1	*Lepidium draba*	1-1-LD-c	3	0	0	1	0	dried rossete	no	0
1	*Lepidium draba*	1-2-LD-c	3	0	0	5	3	dried rossete	yes	1 P.w.
1	*Lepidium draba*	1-3-LD-c	3	7	0	0	5		yes	1 P.w.;
1	*Lepidium draba*	1-4-LD-c	3	0	1	3	1	dried rossete	yes	0
1	*Lepidium draba*	1-1-LD	1	4	0	8	5		yes	1 P.w.;
1	*Lepidium draba*	1-2-LD	1	6	0	5	1		yes	1 P.w.;
1	*Barbarea orthoceras*	1-1-BO	1	1	0	0	0	attack by weevil and	yes	0
1	*Barbarea orthoceras*	1-2-BO	1	1	0	0	1	flea beetle	yes	6 P.w.;
1	*Lepidium crenatum*	1-1-LC	1	1	0	0	0		no	0
1	*Lepidium crenatum*	1-2-LC	1	1	0	0	0		no	0
1	*Armoracia rusticana*	1-1-AR	1	6	0	0	0		no	0
1	*Armoracia rusticana*	1-2-AR	1	3	0	0	0		no	0
2	*Lepidium draba*	2-1-LD-c	3	9	1	0	3		yes	2 P.w. ;
2	*Lepidium draba*	2-2-LD-c	3	0	1	3	1	dried rossete	yes	0
2	*Lepidium draba*	2-3-LD-c	3	5	0	2	1		yes	1 P.w.
2	*Lepidium draba*	2-4-LD-c	3	2	0	0	0		no	0
2	*Lepidium draba*	2-1-LD	1		0	0	0	dried rossete	no	0
2	*Lepidium draba*	2-2-LD	1	3	0	4	0		no	0
2	*Barbarea orthoceras*	2-1-BO	1	1	0	0	0	attack by weevil and	yes	0
2	*Barbarea orthoceras*	2-2-BO	1	1	0	0	0	flea beetle	yes	0
2	*Lepidium crenatum*	2-1-LC	1	2	0	0	0		no	0
2	*Lepidium crenatum*	2-2-LC	1	1	0	0	0		no	0
2	*Armoracia rusticana*	2-1-AR	1	7	0	0	0		no	0
2	*Armoracia rusticana*	2-2-AR	1	5	0	0	0		no	0
3	*Lepidium draba*	3-1-LD-c	3	0	3	1	1	dried rossete	yes	1 P.w.;
3	*Lepidium draba*	3-2-LD-c	3	1	0	5	0		no	0
3	*Lepidium draba*	3-3-LD-c	3	5	0	8	1		yes	1 P.w. ;
3	*Lepidium draba*	3-4-LD-c	3	1	0	0	0		no	0
3	*Lepidium draba*	3-1-LD	1	0	0	1	0	dried rossete	no	0
3	*Lepidium draba*	3-2-LD	1	5	0	0	3		yes	1 P.w.
3	*Barbarea orthoceras*	3-1-BO	1	1	0	0	0	attack by weevil	yes	0
3	*Barbarea orthoceras*	3-2-BO	1	1	0	0	1	and flea beetle	yes	2 P.w. ;
3	*Lepidium crenatum*	3-1-LC	1	2	0	0	0		no	0
3	*Lepidium crenatum*	3-2-LC	1	8	0	0	0		no	0
3	*Armoracia rusticana*	3-1-AR	1	5	0	0	0		no	0
3	*Armoracia rusticana*	3-2-AR	1	8	0	0	0	1 weevil larva	yes	0
4	*Lepidium draba*	4-1-LD-c	3	0	0	6	0	dried rossete	no	0
4	*Lepidium draba*	4-2-LD-c	3	0	0	0	0	dried plant	no	0
4	*Lepidium draba*	4-3-LD-c	3	4	0	0	0		no	0
4	*Lepidium draba*	4-4-LD-c	3	0	7	3	2		yes	1 P.w.
4	*Lepidium draba*	4-1-LD	1	0	0	0	0	dried rossete	no	0
4	*Lepidium draba*	4-2-LD	1	3	0	4	0		no	0
4	*Barbarea orthoceras*	4-1-BO	1	1	0	0	1	attack by weevil and	yes	1 P.w.;
4	*Barbarea orthoceras*	4-2-BO	1	1	0	0	1	flea beetle	yes	1 P.w.;
4	*Lepidium crenatum*	4-1-LC	1	3	0	0	0		no	0
4	*Lepidium crenatum*	4-2-LC	1	3	0	0	0		no	0
4	*Armoracia rusticana*	4-1-AR	1	3	0	0	0		no	0
4	*Armoracia rusticana*	4-2-AR	1	3	0	0	0		no	0

Distance: 1 = 30 cm; 3 = 5 cm

Tab. 2. Distance of planting in the second variant and the attack of the *P. wrasei* on plant

Plot	Plant sp.	Plant code	Distance	Atacked from rossete	Overground root	Underground root	Shoots	Remarks	keep plants for adult	*P. wrasei*
5	*Lepidium draba*	5-1-LD-c	3	3	0	0	0		no	0
5	*Lepidium draba*	5-2-LD-c	3	3	0	4	0		no	0
5	*Lepidium draba*	5-3-LD-c	3	0	5	2	1	dried rossete	yes	1 P.w.;
5	*Lepidium draba*	5-4-LD-c	3	15	0	4	5		yes	2 P.w.
5	*Lepidium draba*	5-1-LD	2	2	0	1	0		no	0
5	*Lepidium draba*	5-2-LD	2	0	1	2	1	dried rossete	yes	0
5	*Barbarea orthoceras*	5-1-BO	2	1+2small	0	0	0	attack by weevil	yes	0
5	*Barbarea orthoceras*	5-2-BO	2	1+1small	0	0	1	and flea beetle	yes	1 P.w.;
5	*Lepidium crenatum*	5-1-LC	2	6	0	0	0		no	0
5	*Lepidium crenatum*	5-2-LC	2	2	0	0	0		no	0
5	*Armoracia rusticana*	5-1-AR	2	8	0	0	0		no	0
5	*Armoracia rusticana*	5-2-AR	2	8	0	0	0		no	0
6	*Lepidium draba*	6-1-LD-c	3	4	1	1	3		yes	1 P.w.;
6	*Lepidium draba*	6-2-LD-c	3	0	2	0	1	dried rossete	yes	1 P.w.;
6	*Lepidium draba*	6-3-LD-c	3	0	0	0	0	dried rossete	no	0
6	*Lepidium draba*	6-4-LD-c	3	7	0	5	1		yes	1 P.w.
6	*Lepidium draba*	6-1-LD	2	0	0	0	0	dried plant	no	0
6	*Lepidium draba*	6-2-LD	2	0	0	2	0	dried rossete	yes	0
6	*Barbarea orthoceras*	6-1-BO	2	1+3small	0	0	1	attack by weevil	yes	2 P.w.; 2
6	*Barbarea orthoceras*	6-2-BO	2	1+2small	0	0	0	and flea beetle	yes	0
6	*Lepidium crenatum*	6-1-LC	2	3	0	0	0		no	0
6	*Lepidium crenatum*	6-2-LC	2	3	0	0	0		no	0
6	*Armoracia rusticana*	6-1-AR	2	5	0	0	0		no	0
6	*Armoracia rusticana*	6-2-AR	2	4	0	0	0		no	0
7	*Lepidium draba*	7-1-LD-c	3	0	3	3	3	dried rossete	yes	1 P.w.
7	*Lepidium draba*	7-2-LD-c	3	6	3	2	0		no	0
7	*Lepidium draba*	7-3-LD-c	3	5	0	0	4		yes	2 P.w.
7	*Lepidium draba*	7-4-LD-c	3	0	9	0	4	dried rossete	yes	1 P.w.;
7	*Lepidium draba*	7-1-LD	3	0	0	4	0	dried rossete	no	0
7	*Lepidium draba*	7-2-LD	2	0	0	0	0	dried plant	no	0
7	*Barbarea orthoceras*	7-1-BO	2	1+2small	0	0	0	attack by weevil	yes	0
7	*Barbarea orthoceras*	7-2-BO	2	1	0	0	0	and flea beetle	yes	0
7	*Lepidium crenatum*	7-1-LC	2	6	0	0	0		no	0
7	*Lepidium crenatum*	7-2-LC	2	3	0	0	0		no	0
7	*Armoracia rusticana*	7-1-AR	2	4	0	0	0		no	0
7	*Armoracia rusticana*	7-2-AR	2	12	0	0	0		no	0
8	*Lepidium draba*	8-1-LD-c	3	0	2	1	0	dried rossete	no	0
8	*Lepidium draba*	8-2-LD-c	3	2	0	0	1		yes	1 P.w.;
8	*Lepidium draba*	8-3-LD-c	3	0	6	0	0	dried rossete	no	0
8	*Lepidium draba*	8-4-LD-c	3	3	0	0	0		no	0
8	*Lepidium draba*	8-1-LD	2	0	0	1	0		no	0
8	*Lepidium draba*	8-2-LD	2	2	0	0	0		no	0
8	*Barbarea orthoceras*	8-1-BO	2	1	0	0	0	attack by weevil	yes	0
8	*Barbarea orthoceras*	8-2-BO	2	1	0	0	0	and flea beetle	yes	0
8	*Lepidium crenatum*	8-1-LC	2	1	0	0	0		no	0
8	*Lepidium crenatum*	8-2-LC	2	3	0	0	0		no	0
8	*Armoracia rusticana*	8-1-AR	2	7	0	0	0		no	0
8	*Armoracia rusticana*	8-2-AR	2	5	0	0	0		no	0

Distance: 2 = 15 cm; 3 = 5 cm

Tab. 3. Distance of planting in the thirt variant and the attack of the *P. wrasei* on plant

Plot	Plant sp.	Plant code	Distance	Atacked from rossete	overground root	underground root	shoots	Remarks	keep plants for adult	*P. wrasei*
9	*Lepidium draba*	9-1-LD-c	3	11	0	2	5		yes	1 P.w.
9	*Lepidium draba*	9-2-LD-c	3	0	0	7	0	dried rossete	no	0
9	*Lepidium draba*	9-3-LD-c	3	0	0	0	0	dried rossete	no	0
9	*Lepidium draba*	9-4-LD-c	3	0	0	4	0		no	0
9	*Lepidium draba*	9-1-LD	3	7	0	1	5		yes	1 P.w.;
9	*Lepidium draba*	9-2-LD	3	0	0	0	0	dried rossete	no	0
9	*Barbarea orthoceras*	9-1-BO	3	1+2smal	0	0	0	attack by weevil	yes	0
9	*Barbarea orthoceras*	9-2-BO	3	1	0	0	0	and flea beetle	yes	1 P.w.;
9	*Lepidium crenatum*	9-1-LC	3	3	0	0	0		no	0
9	*Lepidium crenatum*	9-2-LC	3	3	0	0	0		no	0
9	*Armoracia rusticana*	9-1-AR	3	5	0	0	0		no	0
9	*Armoracia rusticana*	9-2-AR	3	6	0	0	0		no	0
10	*Lepidium draba*	10-1-LD-c	3	10	0	2	0		no	0
10	*Lepidium draba*	10-2-LD-c	3	0	4	0	2		yes	1 P.w.
10	*Lepidium draba*	10-3-LD-c	3	0	6	0	1		yes	1 P.w.
10	*Lepidium draba*	10-4-LD-c	3	2	0	0	0		no	0
10	*Lepidium draba*	10-1-LD	3	4	1	0	3		yes	1 P.w.;
10	*Lepidium draba*	10-2-LD	3	3	0	5	0		no	0
10	*Barbarea orthoceras*	10-1-BO	3	1	0	0	1	attack by weevil	yes	1 P.w.;
10	*Barbarea orthoceras*	10-2-BO	3	2	0	0	0	and flea beetle	yes	0
10	*Lepidium crenatum*	10-1-LC	3	4	0	0	0		no	0
10	*Lepidium crenatum*	10-2-LC	3	4	0	0	0		no	0
10	*Armoracia rusticana*	10-1-AR	3	5	0	0	0		no	0
10	*Armoracia rusticana*	10-2-AR	3	6	0	0	0		no	0
11	*Lepidium draba*	11-1-LD-c	3	0	1	0	0	dried rossete	no	0
11	*Lepidium draba*	11-2-LD-c	3	4	1	0	4		yes	1 P.w.
11	*Lepidium draba*	11-3-LD-c	3	0	6	0	1	dried rossete	yes	1 P.w.;
11	*Lepidium draba*	11-4-LD-c	3	0	3	0	0	dried rossete	no	0
11	*Lepidium draba*	11-1-LD	3	11	0	0	4		yes	1 P.w.;
11	*Lepidium draba*	11-2-LD	3	0	1	2	1	dried rossete	yes	1 P.w.;
11	*Barbarea orthoceras*	11-1-BO	3	1	0	0	1	attack by weevil	yes	6 P.w.;
11	*Barbarea orthoceras*	11-2-BO	3	2	0	0	1	and flea beetle	yes	1 P.w.;
11	*Lepidium crenatum*	11-1-LC	3	1	0	0	0		no	0
11	*Lepidium crenatum*	11-2-LC	3	1	0	0	0		no	0
11	*Armoracia rusticana*	11-1-AR	3	6	0	0	0		no	0
11	*Armoracia rusticana*	11-2-AR	3	8	0	0	0		no	0
12	*Lepidium draba*	12-1-LD-c	3	4	0	1	3		yes	1 P.w.;
12	*Lepidium draba*	12-2-LD-c	3	0	0	2	0	dried rossete	no	0
12	*Lepidium draba*	12-3-LD-c	3	0	0	3	0	dried rossete	no	0
12	*Lepidium draba*	1-4-LD-c	3	0	3	0	2	dried rossete	yes	1 P.w.
12	*Lepidium draba*	12-1-LD	3	0	0	0	0	dried rossete	no	0
12	*Lepidium draba*	12-2-LD	3	0	0	3	3	dried rossete	yes	1 P.w.;
12	*Barbarea orthoceras*	12-1-BO	3	1	0	0	1	attack by weevil	yes	1 P.w.;
12	*Barbarea orthoceras*	12-2-BO	3	2	0	0	1	and flea beetle	yes	2 P.w.;
12	*Lepidium crenatum*	12-1-LC	3	4	0	0	0		no	0
12	*Lepidium crenatum*	12-2-LC	3	1	0	0	0		no	0
12	*Armoracia rusticana*	12-1-AR	3	3	0	0	0		no	0
12	*Armoracia rusticana*	12-2-AR	3	5	0	0	0		no	0

Distance: 3 = 5 cm

were attacked and the 32 test plants were attacked as follows: 5 *L. draba* plants and 8 *B. orthoceras* plants, of which *P. wrasei* attacked 6 plants and other weevils attacked 2 plants (Tab. 3).

Fig. 2. Analyzing plants in spring and registration *P. wrasei* attacked

Of the 48 centrally placed *L. draba* plants, 25 plants were attacked by *P. wrasei* (52.1% attacked plants) and 23 plants were not attacked. Of the 24 laterally placed *L. draba* plants, 10 plants were attacked by *P. wrasei* (41.6% attacked).

Of the 24 *B. orthoceras* plants, 12 plants were attacked by *P. wrasei,* representing 50%. *P. wrasei* did not attack the *L. crenatum* and *A. rusticana* plants.

The results are consistent with previous reports: *P. wrasei* can be used as biological control agent for *L. draba*.

Conclusions

Of the 48 centrally placed *L. draba* plants, 52.1% of the plants showed signs of attack, and of the 24 laterally-placed *L. draba* plants, 42% were attacked. In addition, 50% of *B. orthoceras* plants were attacked.

P. wrasei did not attack *L. crenatum* and *A. rusticana*, indicating that *P. wrasei* specifically attacks *L. draba* and *B. orthoceras*.

These results do not contradict previous evidence that oligophagous species *P. wrasei* controls the *L. draba*. *P. wrasei* is also a potential biologic control agent for *B. orthoceras* (American yellowrocket), which is native to North America, including much of Canada and the western United States, as well as parts of Asia, under cultivated quarantine conditions.

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