Urophora cardui (L.)

INVASIVE SPECIES ATTACKED: Canada thistle (*Cirsium arvense* (L.) Scop.)

Operational Field Guide: *Urophora cardui* – Operational Field Guide, B.C., Ministry of Forests and Range.

TYPE OF AGENT: Stem gall-forming fly **COLLECTABILITY:** Limited

ORIGIN: Austria, France, Germany, Finland

DESCRIPTION AND LIFE CYCLE

Adult:

Adult flies have black bodies and clear wings which have four distinct dark bands that form a "W"[10]. Female adult flies are slightly larger than the male flies, about 6.5 mm long compared to 5.5 mm long, respectively[9]. The females can be identified by their prominent pointed ovipositor[10]. The adult flies emerge from deteriorating galls mainly in late May to June, but can emerge as late as August. The adults generally do not feed but survive for 10-20 days on stored body fat. Courtship begins immediately after emergence followed by mating which in Europe generally occurs in June when the Canada thistle has reached an approximate height of 50-100 cm and the flower buds are starting to form[9]. During the courtship, the male flies claim their territory by marking thistles with a scent that discourages the intrusion of other males, but, does not attract the females. The odour is detectable by humans and attracts parasites[5]. Aggression can result when two males encounter one another on a plant and the flies will fight until only one is left. It is possible that under severe crowding, fly longevity, the number of eggs laid per female and the number of eggs hatched may decrease, but, relatively dense populations of the fly are expected to function well[9]. Once mating is complete, the females lay one to several eggs above the growing point of the main stem or auxiliary shoots between the immature leaves[7]. The eggs are laid about 1mm beneath the tissue surface as the female uses her ovipositor to penetrate the tender leaves of the bud[9]. Females will oviposit into one or more buds and then disperse, possibly up to 10 km, but, generally within the same thistle stand. Females lay an average of 130 eggs[5].

Fig. 1. *U. cardui* adult

Egg:

The time required for incubation varies according to temperature. Generally, incubation takes four days at 30°C or 10 days at 19°C (day) and 8°C (night)[5]. *U. cardui* stay within the egg as first instar larvae[9].

Fig. 2. *U. cardui* galls

Larva:

U. cardui larvae hatch in their second instar[9]. They bore into the stem tissues creating tunnels which are filled in by callus cells that multiply quickly[7]. Gall initiation occurs 10 to 16 days after oviposition[12]. Each larva becomes isolated inside its own chamber within the gall. Galls typically contain one to ten larvae each. The stem begins to expand laterally[7]. This is visible about 16 days after oviposition. The growth of the gall occurs from 17 to 36 days during which time the second instar larvae lightly feed. The gall matures from 37 to 60 days. Within this time the cells of the gall become woody, except for the paths of callus tissue. Also, during gall maturation, nutritive tissue is formed on the inside of the larval chamber which acts as the food source for the third instar larvae. Third instar larvae, the stage during which 98% of larval growth takes place, occur only when the gall is mature, and these nutritive tissues are available. The larvae take about 60 days to consume the nutritive tissue, after which they become dormant until spring[12]. Mature larvae are plump, white and barrel-shaped with dark posteriors[2]. In spring, callus tissues begin to soften, allowing air through the tunnels. Once air reaches the mature larvae, pupation begins[7].

Pupa:

Pupation occurs within the woody gall. This stage takes 8 – 9 days following exposure to air[5]. If the gall is large, larvae near the center may not receive air and may not pupate[7]. The puparium is dark reddish-brown[2].

F1 Adults:

The adult flies use their ptilinum (a modified organ on the forehead of teneral flies that aids in emergence from puparium and burrowing to the soil surface and that later hardens and becomes invisible[4]) to open the puparium and work their way through the softened callus plug. Not all adults are successful at emerging from the galls, but instead become trapped between the hard gall and callus tissues as they work their way along the emergence tunnel[7].

Overwintering stage:

Mature larvae overwinter in woody galls[5].

Fig. 3. *U. cardui* larvae, tunnels and pupae

EFFECTIVENESS ON HOST PLANT

Galls resulting from insect feeding on host plants are known to be physiological sinks[6].

Galls on the main stems harm the growth and development of the plant moreso that galls on side shoots[8]. The majority of galls appears on side shoots and infrequently very tiny galls appear in the axils, above the side shoot or stem leaf. In laboratory conditions, main shoot galls decreased root weight and root bud production by up to 25% and 23%, respectively. Under field conditions, galls production delayed and reduced flowering by up to 66%[3]. It has also been noted that the most stress occurs on short Canada thistle plants, but little stress occurs on plants 15 – 20 cm tall at the time of oviposition[8].

Since its release in 1974, *U. cardui* has not had a noticeable effect on the populations of Canada thistle in B.C. on its own. However, in combination with the other biological control agents, the fly creates stress on the plant that, along with competing vegetation, may decrease thistle vigour. At a site near Barriere, the agents *Rhinocyllus conicus* and *L. planus* coexist with *U. cardui* on Canada thistle along with significant competing vegetation and the thistle population appears to be decreasing. In 2001, Montana was seeing their best decrease in Canada thistle from a combination of *U. cardui* and a seed-feeding weevil, but, was only experiencing 50% control (R. Moehring pers. comm., Dec. 2001).

Fig. 4. *U. cardui* discarded pupal case

HABITAT AND DISTRIBUTION

Native:

Urophora cardui's native distribution occurs up to 900 m elevations in western and central Europe to Crimea, Siberia and south Scandinavia[5].

Suitable *U. cardui* habitat occurs where Canada thistle stands grow along copses and in wet meadows[7]. Low elevation sites along rivers and lakes with open tree canopy are preferred[10]. The galls are able to float and disperse along the edges of water bodies[5].

North America:

During the screening process, *U. cardui* was found in a wide range of habitat conditions and was believed to have little difficulty in establishing in Canada[9]. By 2005, *U. cardui* was common in N.S. and near Guelph, Ont.[5].

In Canada, *U. cardui* was first released in B.C. (near Ladner) and Alta. in 1974, with populations originating from Austria, France and Germany[13, 14]. In 1987, another strain of *U. cardui* was introduced to Canada via Finland and released in B.C. In the U.S.A., *U. cardui* was first released in 1977 with populations originating from Austria and France and later in 1996, subsequent populations were shipped to Canada[13].

In Canada, *U. cardui* is considered established with variable results across the country with confirmed establishment in B.C., N.B., N.S., Ont., P.E.I., Que., and Sask.[5,13]. In the U.S.A., *U. cardui* was released in Calif., Colo., Idaho, Mont., Nev., Oreg., Utah, Wash., and Wyom.[14].

Fig. 5. Established *U. cardui* release site near Barriere. Interior Douglas-fir zone

British Columbia:

U. cardui has been released into the Bunchgrass, Boreal white and black spruce, Coastal Douglas-fir, Coastal western hemlock, Interior cedar hemlock, Interior Douglas-fir, Montane spruce, Ponderosa pine and Sub-boreal spruce biogeoclimatic (BEC) zones. Survival has occurred in all these zones except the Montane spruce zone to date. However, long term establishment has only occurred in the Bunchgrass, Coastal Douglas-fir, Coastal western hemlock, Interior cedar hemlock, and Interior Douglas-fir biogeoclimatic zones. *U. cardui* readily establishes and proliferates in the lower mainland and Vancouver Island climates, but, populations have been slow to establish and increase elsewhere in the province. The most northern, consistently-established and gall-yielding site (for the purpose of collection and subsequent release) to date is near Barriere[1].

Fig. 6. Established *U. cardui* release site at Vaseux Lake, Bunchgrass zone

Ideal habitat will have sufficient moisture to breakdown the callus plugs and allow emergence of the flies from their galls in the spring[7]. This moisture typically comes in the form of snow melt and spring precipitation. Of interest, the two sites in the driest zone in B.C., the Bunchgrass zone, with established fly populations are located very close to water sources - Vaseux Lake (where the thistle can be in standing water during high water levels) and a small reservoir created by man-made dikes. Additionally, the established release made in the Ponderosa pine zone (next driest BEC zone) near Park Rill Creek (Okanagan Falls) is in a microhabitat that consists of a marsh with cattails along an irrigation distribution line and is surrounded by riparian species of willow. Poplar trees are also commonly found at established sites. Although *U. cardui* may be expected to establish over a wide range of habitats, conditions found in microsites may prove very important for this agent. Sites that are not cultivated nor have heavy grazing are recommended[3].

Fig. 7. Established *U. cardui* release site in Okanagan near Okanagan Falls, Ponderosa pine

BRITISH COLUMBIA RECORD

Origin:

The *U. cardui* populations released in Canada originate from Austria, Germany, France and Finland[5].

History:

The first *U. cardui* treatment made in B.C. was in 1974 near Ladner. Releases continued with flies from Europe or from other Canadian provinces and from the U.S.A. until 1996. Only two sites established in B.C. from these early releases: Brentwood Bay on Vancouver Island with agents from Finland in 1987; and Boundary Bay on the lower mainland with galls from Agriculture and Agri-Food Canada (AAFC) in 1991. Boundary Bay has been the main population used to establish further sites in the province, including other collection sites. However, many early releases of galls coming from the coast did not produce populations of the fly at interior sites. A large number of galls were placed in the southern interior of the province at Kamloops in 1994 with the hope that this site would subsequently yield enough galls for collection and redistribution to other sites in the interior. Agents supplied from Kamloops would in turn not experience as significant a habitat change as those supplied from the coast. The Kamloops site did not become collectable until 2002.

Fig. 8. Established *U. cardui* release area near Boundary Bay airport, Coastal Douglas-fir zone

Field results:

By 2019, 70 *U. cardui* releases had been made at 63 sites in B.C. Of these sites, 20 (32%) have shown establishment[1]. It is noteworthy to mention that monitoring of sites for this agent has not been consistent over time. Additionally, many early releases were made with very small numbers of infested galls and onto sites that were potentially too dry.

Fig. 9. Established *U. cardui* release site in Kamloops, Bunchgrass zone

Wind appears to affect oviposition and, therefore, the location of galls. In Barriere, no galls were found nearest the highway where regular wind is generated by heavy traffic. Galls are most prevalent at the base of slopes, among heavy deciduous shrubs, and nearest other notable protective locations that shield the host plants from wind. Galls have also been found on steep slopes when Canada thistle grew amongst shrubs.

Galls are frequently located on plants growing under open canopy and infestations that border deciduous trees (poplar species). Some observers have noticed more galls in shaded conditions, for example, within the drip line of mature trees than beyond it (D. Ralph pers. comm., May 2006). However, no galls have been found on Canada thistle plants that are spindly due to lack of light. In large, dense stands of Canada thistle, the galls appear to be more predominant on the fringes of the invasive plant patches. On flat open sites, thistle plants have galls when surrounding competing vegetation was vigorous and taller than the Canada thistle. Fewer galls are typically found on plants growing in the open with little adjacent vegetation.

Collection for redistribution:

Since *U. cardui* is a small, fragile fly, field collection involves gathering infested galls which house the larvae and pupae of the bioagent. This is a simple procedure of walking through a patch of Canada thistle in autumn or very early spring, locating the mature galls on the plants, clipping the main and lateral stems around the galls and placing the galls into a container or paper bag. Although simple, it can take some practice to readily spot the galls on the plants. It may be more efficient to walk a grid over the site and look at the plants from different sides and angles as the galls blend well with the rest of the plant parts, particularly in the early autumn when the galls, stems and leaves are still partially green. Senescent plants (or close to) may also be cut at their base and held up to slowly turn and view them from many angles. This does not affect the longevity of the Canada thistle on sites as new growth will come from roots, root crowns and seeds the following spring, however, if the plants are cut too early there may be insufficient food developed for larvae within the galls.

As with all biocontrol efforts, it is important to leave enough agents at the collection site to replenish the population for future collections. A minimum of 40 galls is recommended for a release when the galls are being placed into similar habitats. It is always preferable for the agents to be collected and redistributed within the same type of habitat. If the recipient site is within a different habitat/BEC zone, it is advisable to use larger numbers for transfer to compensate for the stress on the population as much as possible. Supplemental releases may also be useful to help increase existing populations, however, the site should first be surveyed to determine survival and/or subsequent establishment of the initial release to ensure resources are not wasted and potentially provide some insight into habitat suitability. Ideally, supplemental releases should be made annually to ensure the populations are not starting from zero each time.

Releasing galls in a small field cage has been a recent method pursued in order to prevent predation. Traditionally, releases made in the autumn were done so by scattering the galls over a small area on the ground amongst Canada thistle plants. The galls were scattered to not provide a cache of food for rodents under the snow during winter months. Rodent feeding on galls has been observed. However, the galls cannot be scattered too far or the emerging flies would need to fly further to detect and find a mate. The cages (or envelopes) can be made with pliable steel mesh large enough to allow plenty of moisture and air flow but small enough to make feeding by rodents, etc. difficult. These cages can also be anchored to the ground with steel pins and/or attachment of a chain and lock to a solid object if necessary, as movement by curious cattle and bears is possible. The cages are approximately 45 cm x 35 cm x 10cm in size to easily accommodate up to 300 galls.

Fig. 10. *U. cardui* dispersal area near Creston, Interior Cedar hemlock

NOTES

- In transfer test studies, *U. cardui* larvae also developed on nodding thistle[5].
- Although rare in nature, laboratory tests by Shorthouse and Lalonde showed that eggs deposited into male thistle flowerheads can result in larvae development if the plant tissues are sufficiently immature[11].

Fig. 11. Assortment of gall shapes and sizes collected from one site

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