BRITISH COLUMBIA MINISTRY OF FORESTS AND RANGE

OPERATIONAL FIELD GUIDE

TO THE PROPAGATION AND ESTABLISHMENT OF THE BIOCONTROL AGENT *UROPHORA CARDUI* (CANADA THISTLE STEM GALL FLY)

December 2009

BRITISH COLUMBIA

Information contained in this Field Guide is comprised of fact and field observations as of December 2009. Site specific experiences may vary.

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Range Branch

Invasive Plant Program – Biocontrol Development

British Columbia Ministry of Forests and Range

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1. PURPOSE

This document summarizes information for the biocontrol agent *Urophora cardui*, a stem-galling fly of Canada thistle (*Cirsium arvense*), while it was classified as 'primary' and the responsibility of the Forest Practices Branch and thereafter the Range Branch as of June 2009. Primary is a management term for biocontrol agents within the British Columbia Ministry of Forests and Range (MFR) that are under development and not yet an operational treatment tool. The information herein is a combination of scientific facts and field observations. Intended as a field guide for those unfamiliar with *U. cardui,* the summary contains pertinent information for field propagation and establishment of the biocontrol agent as well as a historical background of its introduction into British Columbia (B.C.).

2. INTRODUCTION

The goal of invasive plant management in the MFR is to reduce target invasive plant populations to ecologically and economically acceptable levels and to prevent their encroachment into new areas. MFR Range Branch's Invasive Plant Program is responsible for early detection/ rapid response, inventory, treatments of invasive plants using mechanical, chemical and biological control methods and monitoring of these treatments. Biocontrol Development, a subset of the Invasive Plant Program, is responsible for enabling the screening research and carrying out the development of new (or rare in the province) biocontrol agents for B.C. Screening is the process of experimentally assessing the host range of the potential biocontrol agents to ensure they are specific to the target plant and will not inflict major damage to other Canadian plants of economic or environmental importance.

Screening research is a cooperative venture between the MFR (acting on behalf of the Ministries of: Agriculture and Lands; Transportation and Infrastructure (MTI); Environment (MOE); Integrated Land Management Bureau (ILMB); Energy, Mines and Petroleum Resources (MEMPR); Tourism, Culture and the Arts (MTCA); Aboriginal Relations and Reconciliation (MARR); Community and Rural Development (MCRD); and, the Oil and Gas Commission (OCG)), Agriculture and Agri-Food Canada (AAFC), Commonwealth Agricultural Bureau International (CABI-Europe) in Switzerland, as well as numerous other provincial and state agencies across western North America.

Implicit in the use of biocontrol methods is the acknowledgment that invasive plant eradication is not achievable. Rather, biocontrol agent species and host invasive plant species exist in predator-prey relationships where the invasive plants are intended to be held at acceptable population levels with self-sustaining agent populations.

3. CANADA THISTLE

Canada thistle is a widespread and problematic invasive thistle in Canada (Figure 1). It occurs in all Canadian provinces and, as of the 1970's, in the northern half of the United States (McClay et al. 2002; Maw, M.G. 1976). Originating from Europe, it spreads into a variety of habitats including rights of way, wastelands, agricultural lands, urban areas, pastures, and commonly into cutblocks in B.C. (McClay et al.

2002). See Appendix A for more information on Canada thistle. Appendix B displays Canada thistle sites by Biogeoclimatic (BEC) zone for B.C. that have been recorded in IAPP to December 2009. (The Biogeoclimatic Ecosystem Classification (BEC) system is an ecological classification grouping similar landscapes called ecosystems into hierarchical classifications. The BEC in B.C. is defined as a particular plant community and its associated physiography, soil and climate that occupy a segment of the landscape (Meidinger and Pojar 1991). For more information on BEC, go to http://www.for.gov.bc.ca/hre/becweb/)

As well as a threat to biodiversity, Canada thistle has caused economic losses in the country. For example, 25 shoots/y^2 and 18 plants/y^2 can reduce the yield of wheat by 60% and greatly reduce alfalfa production, respectively (Maw 1976). Additionally, 20 shoots/m^2 reduced yields by an estimated 34% in barley, 26% in canola, 36% in winter wheat and 48% in alfalfa seed. With shoot densities reaching up to 173 shoots/m2, the potential for negative impacts is significant (McClay et al. 2002). In B.C., Canada thistle is considered to be a nuisance to reforestation efforts in cutblocks.

Chemical and mechanical control of Canada thistle is difficult due to regrowth from the extensive root system (McClay et al. 2002). Multiple applications of herbicide are often required, making management of this invasive species expensive. Biological control agents were sought to manage this invasive thistle as a cost-effective alternative (Demers et al. 2006).

Figure 1 - Canada Thistle infestation

4. BIOLOGICAL CONTROL AGENTS FOR CANADA THISTLE IN BRITISH COLUMBIA

Efforts to acquire biological control agents for B.C. Canada thistle began in 1961 (Maw 1976). Since the 1970's, several insect agents have received petitioned approval by the Canada Food Inspection Agency (CFIA) to be imported and released into the country. The agents released into or adventive in the province to attack Canada thistle are (adventive biological control agents are those that have arrived into B.C. by their own means):

- *Altica carduorum* (foliar-feeding beetle) – 1964;
- *Hadroplontus litura* (stem and root crown-feeding weevil) – 1975;
- *Larinus planus* (adventive seed-feeding weevil) – 1988;
- *Puccinia punctiformis* (rust) is widespread in Canada (McClay et al. 2002);
- *Rhinocyllus conicus* (seed-feeding weevil) – 1979 (for nodding thistle);
- *Terellia ruficauda* (adventive seed-feeding fly) – first reported in 1931; and,
- *Urophora cardui* (stem gall-forming fly) – 1974.

Additionally, besides over 70 general feeders on Canada thistle (Harris 2003), there are several other insects that feed on this thistle in Canada. One of these insects has been approved for release as a biocontrol agent, four are adventive insects and one is a native butterfly. These are briefly mentioned here but not addressed further.

Lema cyanella (L.) (foliar-feeding beetle) was also approved for release in Canada in 1983, but, due to difficulties in rearing this insect, no releases were made in Canada until 1993. Between 1993 and 1997 four releases were made in Alberta, of which only one of four sites proved to be established with a low density of beetles. *L. cyanella* (L.) was subsequently found to attack some native *Cirsium* species. Due to concerns over the native *Cirsium* species and the lack of significant impact *L. cyanella* was having on the growth or reproduction of Canada thistle, no further releases of this insect were undertaken and the single established site was eradicated (McClay et al. 2002; R. Bourchier pers. comm., Dec. 2009).

Cassida rubiginosa (foliar-feeding beetle) is adventive in eastern North America. This beetle also feeds on burdock (*Arctium minus* (Hill.) Bernh.). It was first discovered in Canada in 1902 (Majka and Lesage 2008). It occurs in the provinces of Alberta, Saskatchewan, Manitoba, Ontario, Quebec and New Brunswick but had not been reported in B.C. (McClay et al. 2002) until 2009 when a specimen found near Kamloops was collected and subsequently confirmed as *C. rubiginosa*.

Cassida flaveola (foliar feeding beetle) is an adventive insect. The first report of this beetle in Canada was from Quebec in 1902 and Wisconsin, USA in 1916. It is reported to be widely spread in North America from the Yukon, Northwest Territories, B.C., east across Canada to Quebec and in the US from New Hampshire to Maryland and West Virginia then to Minnesota, North Dakota and Montana (Majka and Lesage 2008). This beetle has not been found to date in the province by MFR.

Cleonis pigra is a root crown weevil and *Dasineura gibsoni* is a small midge with yellow-orange larvae that feed on seed hairs (Harris 2003). These adventive agents are not known to occur in B.C. Whereas, the painted lady butterfly *Vanessa cardui* is often seen in B.C.

5. *UROPHORA CARDUI* INTERACTION WITH OTHER BIOLOGICAL CONTROL AGENTS

The six released or confirmed biological control agents on Canada thistle in B.C. (listed in Section 4) co-exist on the invasive plant. Their life cycle phases vary from agent to agent temporally (Appendix C) and in location on the plant.

ALTICA CARDUORUM – Foliar-feeding beetle

Altica carduorum are metallic blue-black, 4 mm long beetles (Lactin et al 1997). The adult beetles feed on the foliage of Canada thistle.

A. carduorum emerges from the soil in late spring or early summer to feed on young thistle leaves. The beetles occur on leaf surfaces that are exposed to sunlight and shade. After a pre-oviposition period, the females will lay eggs over a two month period onto the underside of thistle leaves. The eggs incubate for approximately one week then hatch. The larvae feed on the lower leaf surface. When they mature, they drop to the soil next to the host plant and bury themselves approximately 1 cm below the surface. The larvae overwinter and pupate in the soil in the spring (Lactin et al 1997).

To date, the establishment of *A. carduorum* has not been confirmed in B.C. However, the potential interaction between this agent and *U. cardui* is not a concern. The life cycle stages that attack Canada thistle do overlap temporally but their attack on their host plant is typically not competitive. The only situation that could be a conflict is if either agent diminishes the plant to the point that either leaves or stems are not present, but this is not expected.

HADROPLONTUS LITURA – Stem-feeding weevil

Hadroplontus litura are dark grey to black, 3-3.5 mm long weevils (Harris 2005a) (Figure 2). They are oval-shaped and have whitish hairs covering their bodies giving them a mottled-grey appearance (Harris 2005a; Rees et al. 1996). The most distinctive characteristic of their appearance is a white cross formation on their backs (Powell et al. 1994).

In warm climates, *H. litura* can remain active year long (Rees et al. 1996), however, in cooler climates the adults appear in early spring, from March to early June (Harris 2005a). Oviposition begins when thistle rosettes first appear in the spring, between March and mid May, and continues for 4 – 6 weeks (Harris 2005a). The females oviposit their eggs into the cavities they chew on the leaves or mid-vein. They prefer to oviposit on smaller host plants, typically up to 5 cm tall; beyond this height the plants usually become unsuitable (Rees et al. 1996). The larvae hatch, mine down the leaf vein into the plant stem. If the plant has bolted, they will mine up the stem and feed on the pith. This does not do much damage to the plant. If the larvae enter non-bolting plants they will mine downward and feed on the root crown and occasionally on the root. The plants react to the intruding larvae by producing “wound

tissue" (a callus growth), which the larvae feed upon. If multiple tunnels are present (six or more), the plant stem bases will swell and develop woody galls which can kill the host plant. Mature larvae then move to the soil to pupate. Pupation lasts 2 – 3 weeks before new adults emerge from mid-September to mid-October and feed on the upper stem and leaves. The adults overwinter in the soil and leaf litter, but, can tolerate some spring flooding (Harris 2005a).

The potential interaction between this agent and *U. cardui* likely is not a concern. The life cycle stages that attack Canada thistle, the gall and larval development of *U. cardui* and the mining of *H. litura* only partly overlap (Peschken and Derby 1992). If *H. litura* were to feed heavily on thistle rosettes, they can cause plant death. There would be no thistle into which the emerging *U. cardui* flies could oviposit. However, it is unlikely that all plants *H. litura* would have available to oviposit into would be unbolted rosettes or that their attack would kill all Canada thistle rosettes. Maw (1976) reports a decrease in Canada thistle density in Ontario following releases of *H. litura* in the 1960's. Conversely, the mines of *H. litura* and the galls of *U. cardui* were found to decrease the vigour of Canada thistle only slightly or not at all in a Saskatchewan study (Peschken and Derby 1992).

Figure 2 - *Hadroplontus litura* weevil

LARINUS PLANUS – Seed-feeding weevil

Larinus planus are dark brown, 5-10 mm long weevils (Powell et al. 1994) (Figure 3). Their bodies are oval-shaped and their wing covers are covered in hairs, punctures and furrows giving an appearance of grayish-white spots (Harris 2005b).

L. planus adults emerge from the leaf litter in mid June prior to bud set of Canada thistle (Powell et al. 1994). They begin feeding within 2-3 days, mating within 7-14 days and ovipositioning within 14-26 days after emergence when temperatures reach 22 ^{o}C. Females oviposit into male and female (preferentially) flower buds 4.5 – 7 mm in size, with a preference for 6 mm diameter buds, beyond which they are no

longer suitable. This ensures that eggs are laid into buds at the onset of rapid growth (McClay unpublished data 1989). The larvae feed on the entire seedhead contents, consuming developing reproductive plant parts. Typically only one egg is laid on a bud, but if more are laid, only one larvae will survive. Infested buds appear distorted and commonly fail to open (McClay unpublished data 1989). Mature larvae begin pupation in mid-summer and the next generation of adults emerges in August and September. These weevils overwinter in plant litter and debris until the following spring (Powell et al. 1994).

L. planus is established in many BEC zones across B.C. Again, the potential interaction between this agent and *U. cardui* likely is not a concern. The life cycle stages that attack Canada thistle temporally overlap slightly but their attack on their host plant can be conflicting. If *U. cardui* galls prevented terminal growth, flower buds would not be formed for *L. planus* to oviposit into. However, Canada thistle has multiple stems and flowerheads and likely would not experience a shortage of heads. Only extremely heavy attack by *U. cardui* could possibly inhibit *L. planus*.

Figure 3 - *Larinus planus* weevil

PUCCINIA PUNCTIFORMIS – (Rust)

Puccinia punctiformis is a systemic rust fungus that specifically attacks Canada thistle (Figure 4). This fungus is reported to be more common in eastern Canada where systemically infected plants can perish (Forsyth and Peschken 1986b). Infected thistles may have limited flowering and vegetative growth. The fungus is thought to be the first plant pathogen proposed as a biological control agent for Canada thistle or any other weed (Demers et al. 2006).

Teliospores of this pathogen are temperature- stratified as they overwinter in the soil and produce basidium in the spring as a result of Canada thistle emitting a chemical from the developing root buds when conditions are favourable (Demers et al. 2006). The basidium in turn produces spores which will germinate and can infect Canada thistle root buds. Secondary root shoots can also be infected by the fungus mycelium (Thomas et al. 1994). Systemically infected aerial shoots are spindly and often die before the plant flowers (Demers et al. 2006). The fungus causes a bleaching effect in these plants and their leaves and stems experience necrosis (Thomas et al. 1994). The leaves on these systemically infected shoots develop urediniospores which appear as black flecks at a distance and are blown to neighbouring healthy Canada thistle plants later in the season. These plants develop secondary infections resulting in localized lesions which bear new urediniospores. These plants do not develop growth abnormalities seen with systemically infected plants. Following seed production, the Canada thistle stalks begin to die and the urediniospores develop teliospores in preparation for winter. The teliospores and the mycelium overwinter in the rootstock (Demers et al. 2006).

The success of *P. punctiformis* varies partly due to the spread of teliospores throughout the soil that can lead to a low incidence of attack on Canada thistle root buds (Demers et al. 2006). Conversely, it has been demonstrated in a garden screening experiment that the physical contact of the oligophagous weevil *Ceratapion onopordi* (whose larvae feed inside above and below ground shoots) with the urediniospores can cause the spread of the rust when they visit other thistles (Wandeler and Bacher 2006).

The potential interaction between *P. punctiformis* and *U. cardui* likely is not a concern. *U. cardui* requires specific growing conditions in Canada thistle plants at a similar time when plants systemically infected with the rust would be experiencing stress. However, the co-occurrence of these species was not found to be investigated.

Figure 4 - *Puccinia punctiformis* infesting Canada thistle

RHINOCYLLUS CONICUS – Seed-feeding weevil

Rhinocyllus conicus are dark brown, 3 - 7 mm long weevils (Powell et al. 1994) (Figure 5). Their oblong bodies have patches of brown and light grey hairs (Harris 2005c). They can be distinguished from *L. planus* from their short rostrums.

R. conicus emerge from the soil and leaf litter in early May in B.C. and feed on foliage. Mating and oviposition occurs in early summer (Powell et al 1994). The females lay eggs individually onto unopened floral bud bracts and cover them with chewed plant material, forming protective caps that later turn an obvious light brown (Harris 2005c; Rees et al. 1996). The eggs hatch and the larvae enter the bud through the bracts (Powell et al. 1994). The larvae feed just beneath the seeds, or less preferred, beneath this area or into the stem. Thirty-nine – 46 days after hatching, the mature larvae pupate inside individual hard chambers made from feces and chewed plant material. Pupation takes 8 – 14 days after which new adults will remain in the chambers for several weeks before chewing an exit hole to escape. This new generation of weevils overwinters in soil litter (Harris 2005c).

R. conicus is established in many BEC zones across B.C. The potential interaction between this agent and *U. cardui* may be of concern for *R. conicus* in the same context as with *L. planus*, but, this too is unlikely. Only extremely heavy attack by *U. cardui* could possibly inhibit *R. conicus*.

Figure 5 -*Rhinocyllus conicus* weevil

TERELLIA RUFICAUDA – Seed-feeding fly

Terellia ruficauda are yellow-orange flies with a dull black mark on their thorax and four large black marks on their abdomen, making them appear almost completely black. The leading edges of their 3 to 5 mm long wings have three black marks along the edges and another vague mark is located near the center of the hindmost wing edges (Harris 2005d).

T. ruficauda flies emerge from previous year's seedheads in mid to late summer. The females will oviposit into many female flower buds one day before they open. Following oviposition, the females mark the flowerhead with a fluid to discourage further attack. Eggs deposited into younger or older heads produce smaller larvae with poor survival rates. Additionally, larger females produce more eggs. Larger offspring tend to develop when male and female plants occur on the same site. If the eggs are mistakenly deposited into male flowers, the larvae starve with the absence of seed. Once they hatch, the larvae take two weeks to grow 5-7 mg. The larvae consume seed in preparation for overwintering wrapped in seedhead pappus in the seedhead or in the receptacle when the flowers have few seeds (Figure 6). The flies pupate the following spring (Harris 2005d).

On average, 40% (or 70% according to Maw (1976)) of the seeds in attacked flowerheads are consumed. However, the female only oviposits into early flowers, resulting in the overall annual seed production only decreasing by 2% (Harris 2005d).

This adventive agent has been found in several BEC zones across B.C. The potential interaction between this agent and *U. cardui* may be of concern for *T. ruficauda* in the same context as with *L. planus*, but, this too is unlikely. Only extremely heavy attack by *U. cardui* could possibly inhibit *T. ruficauda*.

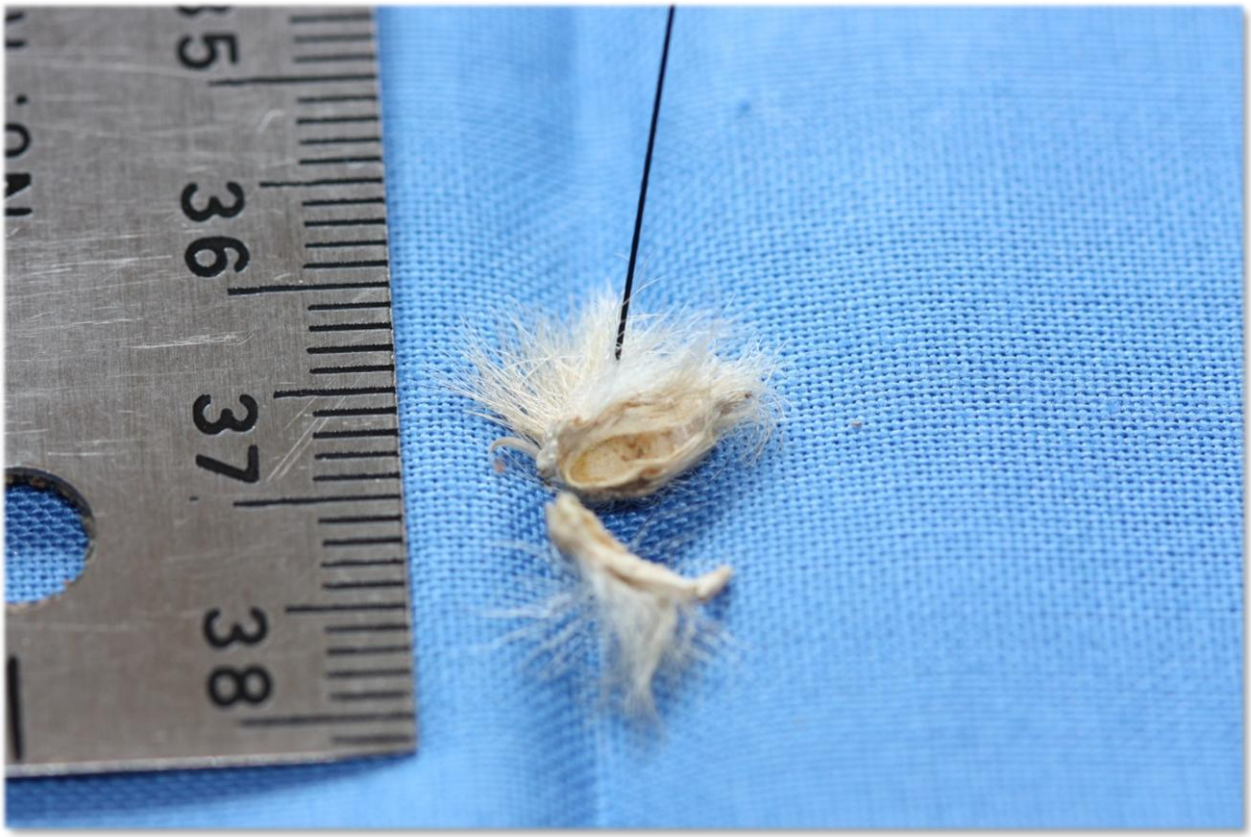

Figure 6 - *Terellia ruficauda* chambers in Canada thistle seedhead

6. *UROPHORA CARDUI*

Diptera: **Tephritidae**
Common name: Stem-gall fly

BIOLOGY

GENERATIONS PER YEAR: one per year

ADULT STAGE: Adult flies have black bodies and clear wings which have four distinct dark bands that form a "W" (Powell et al. 1994) (Figure 7). Female adult flies are slightly larger than the male flies, about 6.5 mm long compared to 5.5 mm long, respectively (Peschken and Harris 1975). The females can be identified by their prominent pointed ovipositor (Powell et al. 1994).

In Europe, the adult flies emerge from deteriorating galls mainly in late May to June, but can emerge as late as August (Peschken and Harris 1975). The adults generally do not feed but survive for 10-20 days on stored body fat. Mating begins immediately after emergence and in Europe this 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. Mating is preceded by courtship (Peschken and Harris 1975). 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 (Harris 2005e). 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 (Peschken and Harris 1975). Once mating is complete, the females lay one to several eggs. The eggs are deposited above the growing point of the main stem or auxiliary shoots between the immature leaves (Lalonde and Shorthouse 1982). The eggs are laid about 1mm beneath the tissue surface as the female uses her ovipositor to penetrate the tender leaves of the bud (Peschken and Harris 1975). 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 (Harris 2005e).

Figure 7 - *Urophora cardui* fly

EGG STAGE: The time required for incubation varies according to temperature. Under laboratory conditions, no eggs hatched at 7.5^{o}C but subsequent larvae emerged when the temperatures were increased, regardless of the time the eggs spent at 7-8^{o}C, however, the number of eggs that hatched were significantly less than those that were incubated entirely at 30 ^{o}C (Peschken and Harris 1975). Generally, incubation takes four days at 30^{o}C or 10 days at 19^{o}C (day) and 8^{o}C (night) (Harris 2005e). Like *U. jaceana* and *U. stylata*, *U. cardui* stays within the egg as a first instar larva. At this time their cephalo-pharngeal skeleton is visible and their mouth hooks move in a circular fashion (Peschken and Harris 1975). Although rare in nature, laboratory tests by Shorthouse and Lalonde (1986) showed that eggs

deposited into male thistle flowerheads can result in larvae development if the plant tissues are sufficiently immature.

LARVAL STAGE: *U. cardui* larvae hatch in their second instar (Peschken and Harris 1975). They bore into the stem tissues creating tunnels that are filled in by "rapidly proliferating callus cells". These tunnels are always visible when galls are cut open since the callus cells are irregular in shape as opposed to the surrounding cells which grow in vertical rows (Figure 8). When they stop tunnelling they feed only in one area. The gall is initiated as the cells next to the feeding area begin to proliferate (Lalonde and Shorthouse 1982). Gall initiation occurs 10 to 16 days after oviposition (Shorthouse and Lalonde 1988). As with other gall-inducing insects, *U. cardui* is able to "redirect the growth and differentiation of cells near their feeding sites into specific patterns which are foreign to the host plant, but of nutritional and protective value to the insect" (Shorthouse and Lalonde 1986). 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 (Lalonde and Shorthouse 1982). 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 (Shorthouse and Lalonde 1988). Immature galls are spherical to elongate and green (Forsyth and Peschken 1986a)**.** The larvae excrete a substance which reverses the vascular system of the plant, causing great nutrient losses to the plant during gall formation (Harris and Shorthouse 1996). The plant pores (stomata) are stretched during gall formation which prevents their closure and causes the plant to lose 47 % more moisture than the equivalent length of unaffected stem (Harris 2006). The gall matures from 37 to 60 days during which 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 (Shorthouse and Lalonde 1988). Mature larvae are plump, white and barrel-shaped with dark posteriors (Rees et al. 1996). In the fall, the callus tissue of the tunnel will have a spongy texture and remains attached to the rest of the gall. The hard woody gall and this callus tissue dry out when the host plant dies (Lalonde and Shorthouse 1982). The galls, which have been a shiny green until now (Figure 9), become a dull light brown colour (Figure 10). Moisture from melting snow and rain the subsequent spring soaks into the gall. The woody tissue remains hard but the callus tissue softens, degenerates and separates from the rigid gall. Once air reaches the mature larvae, pupation begins (Lalonde and Shorthouse 1982).

Figure 8 - *Urophora cardui* larvae and tunnels

Figure 9 - *Urophora cardui* green gall

Figure 10 - *Urophora cardui* brown gall

PUPAL STAGE: Pupation occurs within the woody gall. This stage takes 8 – 9 days following exposure to air (Harris 2005e). If the gall is large, larvae near the center may not receive air and may not pupate (Lalonde and Shorthouse 1982). The puparium are dark reddish-brown (Rees et al. 1996) (Figure 11).

Figure 11 - *Urophora cardui* pupa

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 (Gordh and Headrick 2005)) 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 or fail to pupate in chambers near the center of large galls (Lalonde and Shorthouse 1982).

DISPERSAL METHOD: Adult *U. cardui* fly to reach their mates and host plants.

7. HISTORY OF INTRODUCTION

The *U. cardui* populations released in Canada originate from Austria, Germany, France and Finland (Harris 2005e). 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 until 1991. 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 AAFC in 1991. Appendix E displays the sequential release of U. cardui in the province from 1974 to 2009.

B.C. redistributions typically involve collecting and releasing galls and these activities are ongoing. Boundary Bay has been the main population used to establish further sites in the province, including other collection sites (35 of 60 sites to date). 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 and these agents would then not experience as significant a habitat change as those originating from the coast. Many early releases of galls coming from the coast did not produce populations of the fly at interior sites (34% of coast collections released in the interior established, however, only 33% of coast collections released at the coast established). The Kamloops site did not become collectable until 2002. Seventy-one percent of the interior collections released in the interior have established.

Since 1974, only 33% (17/51 sites, as nine of the 60 sites have not been monitored) of the releases made in B.C. to 2009 have shown establishment to date. Of these, eight have been found established in the first year following release but the flies, nor their galls, have been found in subsequent years of monitoring (Appendix F). Establishment then might be only 18%. This is considered a low level of establishment success by MFR staff. However, Appendix F also shows variability in monitoring results over a number of years for some sites so it is difficult to say that a site marked as established will continue to be so or rule out establishment of sites determined as not, to date.

The number of galls released was investigated to see if this explains the low establishment level. It is proposed that the release of low numbers of galls may affect establishment (Figure 12). In some instances, assumptions within the data in Appendix E and subsequently in Figure 12 have been made as practitioners were not consistent when recording data for this agent. For example, at times the number of galls released was recorded. Other times the number of galls was multiplied by the average number of estimated larvae each gall contained and the total number of estimated larvae was recorded. The

average number of estimated larvae varied in these calculations, dependent on the source of information. Often, the records did not distinguish whether the number of agents released referred to galls, larvae or flies.

It is also noteworthy to mention that monitoring of sites for this agent has not been consistent over time. Of the 60 releases, 24 were put on provincial government Crown land and in parks or road rights-of-way also administered by the government. The remaining 36 releases were placed on some form of private land. Repetitive monitoring of the private land sites over the past thirty five years has been inconsistent, somewhat due to changes in land management and in ownership and access allowed.

Figure 12 - Establishment success for the number of Urophora cardui galls used in releases

Number of galls	Positive Establishment[a]	% Positive	Negative Establishment[a]	% Negative
<=40	2	17	10	83
>=41 to 80	5	42	7	58
>=81 to 120	3[b]	43	4	57
>=121 to 160	2	50	2	50
>=161 to 200	1	33	2	67
200+	5[c]	56	4	44

a – The total number of sites in this table does not include all sites in the province as some were not monitored and some releases were made with either larvae or adults and, therefore, were not counted in this table.

b– cage used on one release.

c – cage used on two releases.

8. *UROPHORA CARDUI* HABITAT

Native (European) Distribution

Urophora cardui's native distribution occurs up to 900 m elevations in western and central Europe to Crimea, Siberia and south Scandinavia (Harris 2005e).

U. cardui does best in Canada thistle stands growing along copses and in wet meadows. As the thistle stems often fall over or lodge against one another or surrounding vegetation, the moist leaf litter in these areas would ensure a higher likelihood that the galls would receive sufficient moisture in the spring for *U. cardui* emergence (Lalonde and Shorthouse 1982). The galls are even able to float and disperse along the edges of water bodies (Harris 2005e).

Predicted North American Distribution

As noted above, *U. cardui* is found in a wide range of habitat conditions and, therefore, is believed to have little difficulty in establishing in Canada (Peschken and Harris 1975).

British Columbia Habitat

U. cardui has been released into the Bunchgrass (BG), Boreal white and black spruce (BWBS), Coastal Douglas-fir (CDF), Coastal western hemlock (CWH), Interior cedar hemlock (ICH), Interior Douglas-fir (IDF), Montane spruce (MS), Ponderosa pine (PP) and Sub-boreal spruce (SBS) Biogeoclimatic zones. Short term establishment has occurred in all these zones except the Montane spruce zone. 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 in the lower mainland and Vancouver Island climates, but, has been slow to populate elsewhere in the province. The most northern site, consistently established site to date is near Barriere. By 2008, *U. cardui* had been found to disperse only on one site, in the ICHxw. Appendix D displays a map of all *Cirsium arvense* sites listed in IAPP for B.C., *U. cardui* release sites and the single dispersal location to 2009. Figure 13 attempts to display the habitat preference of *U. cardui* by BEC derived from monitoring data in Appendix E and subsequently Appendix F, however, the dataset is small and has many inconsistencies as explained in Section 5. No conclusions could be drawn from these investigations.

Figure 13 - Site Establishment by BEC Zone

BEC	Total Treatment Sites	Positive Establishment Sites	Percent Establishment per BEC
BG	2	2	100%
BWBS	2 [a]	1	50%
CDF	6	2	33%
CWH	8	1	12.5%
ICH	11	3	27%
IDF	10	5	50%
MS	2	0	0%
PP	3 [b]	2	67%
SBS	15 [c]	1	7%
TOTAL	**59**		

a - One of 2 sites not monitored.
b – One of the 3 sites not monitored.
c – Five of the 15 sites not monitored.

It has been suggested that *U. cardui*'s difficulty in establishing in Western Canada is due to insufficient moisture at the time of callus decay. Insufficient moisture may cause: a lack of breakdown of callus plugs; a partial breakdown of callus plugs over time if available moisture is not consistent, therefore, trapping some agents in the galls or causing the emergence of flies to be spread out over time so mating is hindered; or, the emergence of the flies may not be synchronized with the availability of susceptible host plant tissues (Lalonde and Shorthouse 1982). It is imperative that ovipositioning and larvae feeding

are synchronized with the availability of susceptible host plant tissues in order for the larvae to control the morphogenesis of the cells to create the gall (Shorthouse and Lalonde 1986).

Habitats are required to have sufficient moisture to breakdown the callus plugs and allow emergence of the flies from their galls in the spring (Lalonde and Shorthouse 1982). 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. with established fly populations, the Bunchgrass zone, are located very close to water sources - Vaseux Lake (where the thistle can be in standing water during high water levels) (Figure 14) 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 is in a microhabitat that consists of a marsh with cattails along an irrigation distribution line and is surrounded by riparian species of willow (*Salix* spp.) (Figure 15). Poplar trees (*Populus balsamifera* L. or *P. tremuloides*) are also commonly found at established sites. This is similar to the European habitat *U. cardui* does well in as mentioned previously. Therefore, 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.

Figure 14 - Vaseux Lake release site

Figure 15 - Park Rill Creek release site

Sites with some protection from wind appear be favoured. A lone site on the prairies in Echo Valley Provincial Park is recorded as having the fly survive. Its particular habitat, near water and sheltered by trees, has been noted to be well suited to *U. cardui* (McClay et al. 2002). 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 nearest 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 because of 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.

Sites that are not cultivated nor have heavy grazing are recommended (Agriculture Canada 1986).

9. FIELD APPLICATION OF *UROPHORA CARDUI*

Redistribution of agents is a critical part of a biocontrol program. However, to date *U. cardui* has not caused a documented change in Canada thistle populations. It is important for invasive plant managers to determine whether resources should be allocated to redistributing this agent whose effectiveness for controlling Canada thistle in B.C. has not yet been seen.

To ensure efficient distribution throughout *U. cardui's* potential provincial range, invasive plant managers should endeavour to recollect from established field sites and make releases into new sites. For general information regarding redistribution of biological control agents, please refer to Module 1.9 Biological Treatment & Monitoring of the IAP Reference Guide which is located at http://www.for.gov.bc.ca/hra/Publications/invasive_plants/IAPP_Reference_Guide/Module%201.9.pdf. For more detailed information on collecting, shipping and releasing methods and equipment, please refer to the document "Biocontrol Agent Handling Techniques, for the collecting, shipping and releasing in B.C., November 2008" which is located at http://www.for.gov.bc.ca/hra/Plants/downloads/HandlingTechniquesV2.pdf.

FIELD COLLECTION

How to collect

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, 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 green. Galls are often found on the fringes of the thistle infestations or on the outside of dense plant material. Plants 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 sites as new growth will come from roots, root crowns and seeds the following spring.

Even with careful observation, some galls are missed. Autumn collection at a site in 2007 yielded 120 galls when the plants were clipped and slowly turned and inspected. The plants were then piled on the ground for further inspection the following spring. An additional 18 galls were subsequently found, or, 15 % of the yield from those stems. As with all biocontrol efforts, it is important to leave sufficient agents at the collection site to replenish the population for future collections. When calculating a sufficient number of galls to leave behind, keep in mind that likely it was not possible to collect all existing galls. 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, establishment of the initial

release should first be confirmed or the releases made annually in order to ensure the populations are not starting from zero each time.

Additional Considerations

Piling Canada thistle plants may provide increased values for rodents such as shelter, food from the galls, and nest material. Figure 16 shows rodent feeding on a green gall in the fall and Figure 17 shows a rodent nest found the following spring on the above mentioned pile of Canada thistle plants.

Figure 16 - Rodent feeding on green *Urophora cardui* gall

Figure 17 - Rodent nest in pile of Canada thistle stems

Where to collect

The following are suggested collection site criteria which are also applicable to potential release sites:

- **Site size:** If a site is too large, it is difficult to locate the galls, less than 0.5 ha is recommended. Typically, if a site is too small, although establishment of the agent can be readily assessed, it is possible the plant population may not be able to sustain a continual population of the agent. However populations of *U. cardui* have not yet grown to a size that this is a concern. As a general rule of thumb, a good size for a collection site ranges between 0.25 and 0.5 ha;

- **Plant density:** *U. cardui* does not appear to be affected by the density of Canada thistle plants as long as other features are present (see also Competing vegetation this section). High density plant stands may act as a windbreak for the agents. High density plants may also retain moisture over winter, especially when they lodge on the ground, possibly providing moisture to break down the callus tissue and allow the agent an easy exit in the spring. When collecting, a site should have enough plants with potential galls to make the effort worthwhile;

- **Location on the plant:** The top half of the plant often yields the most galls, however, at a single site, when the plants were greater than 4 ft, the galls were observed to be on the lower half of the plant. It is speculated that this may be a reflection of the height of the plant at the time of oviposition, or the female seeking protection from the wind when ovipositing;

- **Ground cover:** Ground cover does not appear to be a factor for this plant or agent;

- **Competing vegetation:** Canada thistle does well with other vegetation such as tall grasses (for example, smooth brome (*Bromus inermis*)) or shrubs such as rose bushes (*Rosa* spp.), snowberry (*Symphoricarpos albus*) and willows (Salix spp.). *U. cardui* also is found on sites with these types of competing vegetation, for example, poplar trees (*Populus balsamifera* L. or *P. tremuloides*) are also found at most sites established with the fly. However, the galls are mainly found on the fringes of thistle patches. They are generally not found within dense stands of thistles nor on thistles surrounded by dense vegetation;

- **Shade:** In heavy shade, Canada thistle plants are spindly. It has been observed that galls are not found on these spindly plants, but, rather are found on plants in full sun and filtered shade;

- **Slope:** Canada thistle does grow on steep slopes with sufficient moisture, but, generally not on dry, water-shedding slopes. *U. cardui* has not shown a particular preference for slope as it has been found at level and sloped locations, however, sufficient moisture is required to soften gall tissue in the spring so dry slopes are not recommended. For efficient collection, flat or gentle slopes are best while steep slopes may be reserved strictly for biocontrol;

- **Aspect:** There appears to be no preference for aspect for either the host plant or the agent;

- **Elevation:** *U. cardui* can be found in a range of elevations. To date, the lowest to highest elevations are sea level to 1060 m, respectively;

- **Moisture regime**: *U. cardui* is reported in the literature and appears to do well in B.C. in sites near water, standing or fast-running;

- **Temperature**: *U. cardui* has not yet been found established for more than two years in the cooler climates of B.C. The northernmost established site to date is near Barriere which has a maximum and minimum temperature since January, 2001 to October, 2009 of 40.4^{o}C and minus 27.7^{o}C, respectively (The Weather Network 2009).

- **Cold air drainage:** Generally for biocontrol, for initial establishment, sites receiving cold air drainage may be poor choices, especially if they are within or at the mouth of a ravine, or relatively flat or depressed, allowing cold air to pool;

- **Soil texture:** Soil texture does not affect the flies. Canada thistle exists in all types of soil but does best in clay soils (Moore 1975);

- **Soil moisture:** Canada thistle plants normally are established in soils that either retain moisture or are in a water receiving location;

- **Snow cover:** Generally snow cover is preferable to provide protection against extreme cold and fluctuating winter temperatures. Heavy or wet snow fall increases the likelihood that the plants will lodge on the ground, creating further insulation. Additionally, snow will provide early spring moisture as it melts and helps to soften the galls for *U. cardui* emergence; and

- **Disturbance:** When other, desirable, vegetation is scarce, cattle will graze on Canada thistle. This can negatively affect the *U. cardui* life cycle.

Sites that to date have been found collectable are: Boundary Bay (IAPP Site ID 104092); Kamloops AAFC property – permission required (IAPP Site ID 101715); Barriere (IAPP Site ID 112011); and Sirdar (IAPP Site ID 114231). Other sites thought to be promising for future collection are: Park Rill Creek (Nature Trust - private land) (IAPP Site ID 6635; and Deer Creek north of Castlegar (IAPP Site ID 113982). The Paul Lake Road site (IAPP Site ID 101712) and a Vancouver Island release (IAPP Site ID 243949) should be monitored for potential collection as well.

When to collect

Time of Year

The collection period occurs either in spring (March, April or early May) or in autumn (late September through to November and even through the winter in southern coastal sites). Both collection periods have yielded positive establishment.

The decision to collect in either time period should consider:

- The maturity of autumn galls. Galls collected in the autumn must be mature before they are removed from the plant in order for the larvae to have sufficient resources and time to

complete necessary feeding prior to their winter dormancy. A general rule of thumb would be to collect brown galls;

- The availability of a cold, dry (to prevent mold), secure location (from predation), for winter storage of the galls, if necessary;
- The availability of and access to a release site and resources to place the galls at the site, and, more importantly for spring releases, whether these factors would be available early enough in the spring to ensure sufficient moisture is available for the galls;
- If a release can be made in the fall it would allow the agents to synchronize with the new site conditions, susceptible host plant material (Lalonde and Shorthouse 1982), and potentially with existing *U. cardui* on the site or with agents in galls newly transported to the site from a variety of sources. If releases are to be made in the spring they should be made early to ensure some synchronicity and the availability of late winter melt/spring moisture to soften the galls' callus plugs consistently, allowing maximum emergence of flies;
- Whether the galls are meant to supplement an existing population of flies. If a generation of flies has passed through a full life cycle at the site, following mortality and other population dynamics, there may not be enough flies to sustain the population unless supplemental galls are added. In the case of supplementing, the addition of further galls should be placed to allow for synchronicity or, if not possible, to take place when the new flies can mate with existing flies; and
- Whether the collected galls are infested with parasites. Storing the galls overwinter allows an opportunity to find and destroy the parasites (Agriculture Canada, 1986).

The data in Appendix E pertaining to when the galls were collected and released was summarized and collated to determine if any apparent trends would reveal the optimum timing to promote *U. cardui*'s (Figure 18) establishment. However, as the dataset is small and has many inconsistencies (for example, the collected date recorded was often the same as the release date, implying error), no conclusions could be drawn from these investigations.

Figure 18 - Timing for collection and release of galls

Collection season	Release season	Galls stored overwinter[a]	Establishment	Quantity	Percent
Fall	Fall	No	Positive	14	23
Fall	Fall	No	Negative	21	34
Fall	Spring	Yes	Negative	1	2
	Summer	No - Assumed spring collection	Negative	4	7
Spring	Spring	No	Positive	5	8
	Spring	No	Negative	8	13
Not monitored				8	13
TOTAL				61[b]	

a – Storage in paper bags in outdoor shed, winter temperatures, no moisture.

b – Two sites had supplemental releases, therefore, the number of releases is greater than the number of sites.

Time of day

The time of day is not a factor for collecting galls.

SHIPPING

Although galls range in size and shape, generally up to 100 *U. cardui* galls can be packaged into 1 litre bulk food containers. These should be released as soon as possible, prior to when the females should be actively emerging from the galls in spring releases. When green, Canada thistle leaves are quite succulent and water transpiration can be heavy, creating measurable water beading and pooling when held for several hours, even when kept below room temperature. Transport the galls without leaves or excess stems, or allow the leaves to wither during storage, and package the galls in either paper bags or in containers with paper towel to absorb excessive moisture which could cause mold. However, when brown galls are shipped in the spring, some moisture is helpful, particularly if the galls are field collected in the spring and, therefore, would have received moisture in the field causing the tissues to start to break down. Drying the galls out at this stage may cause the agents to fail to emerge. In this case, shipping and releasing the galls as fast as possible can help to prevent significant mold. Do not ship any aerial plant parts which may encourage oviposition if flies emerge during transport or can carry other biological control agents or parasites.

FIELD RELEASE

Prior to any releases, check for previous *U. cardui* or other biocontrol agent releases or dispersal (although to date, *U. cardui* is not readily distributing itself) in the Invasive Alien Plant Program (IAPP) Application found at http://www.for.gov.bc.ca/hra/Plants/application.htm (click the "Go to the Map Display Module" link) as well as in the field prior to opening the containers. Addition of more galls to a site with existing *U. cardui* or other Canada thistle agents would only serve to benefit the fly's population or add to the complex of agents on the plant, but, as the supply of the agent is limited, new galls should be released at strategic, potentially new, sites. Release sites should be large enough and contain enough Canada thistle to support a viable insect population with corridors of thistle available for movement to other locations.

A potential release site needs to meet certain criteria to ensure success and longevity. It must meet program needs from a logistic standpoint i.e. travel distance, land tenure and accessibility. It must also be conducive to agent survival and establishment. Criteria for release sites are the same as those of collection sites (see Where to collect section). Dispersal of the fly from a release site has only been witnessed at one site in the province to date. Most sites consist of finite patches of thistle and they are often on or are surrounded by private lands or roads. Consider the neighbouring plants in the area to provide the opportunity to disperse and ease of future monitoring for dispersal.

Releasing galls in a metal mesh cage has been a recent method pursued in order to prevent predation rather than distributing galls on the soil surface among plants. Traditionally, releases made in the autumn are done so by scattering the galls over a small area on the ground amongst Canada thistle plants. The galls are scattered in order to not provide a cache of food for rodents under the snow during winter months. 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 are made with mesh large enough to allow plenty of moisture and air flow but small enough to make feeding by rodents, etc. difficult. The material to build the cage may vary depending on location of the release site. In areas with significant numbers of bears and cattle, a heavy metal cage has been used to prevent being ripped open by the bear and the contents fed upon or being trampled by the cattle (Figure 19). These cages can also be anchored to the ground with steel pins and attachment of a chain and lock to a solid object if necessary. In other instances, a light-weight metal mesh (hardware cloth) cage may suffice (Figure 20). The holes in the mesh should be sufficient to keep the galls in while restricting access to rodents and allow the flies to escape. The cages are approximately 45 cm x 35 cm x 10cm in size to easily accommodate up to 300 galls.

Releases should be made with a minimum of 40 galls (at sites with the same habitat). Higher numbers are recommended (see Figure 12). For consistency, ensure the number of galls released at a site is recorded.

Figure 19 - Heavy weight metal cage to prevent predation

Figure 20 - Light weight hardware cloth cage to prevent predation

10. MONITORING OF *UROPHORA CARDUI* SITES

AGENT

U. cardui flies are small and difficult to find. However, sites can be monitored for the fly in late May until the end of June. In Kamloops, adults were observed in the last week of May.

Sites are generally monitored for the presence of galls in the spring or fall. It is possible to find last year's galls on old Canada thistle stalks later into the summer but the surrounding vegetation is usually thick, making it difficult to see them, especially on stalks on the ground. Monitoring in early spring before new Canada thistle stalks are bolting makes it easier to see last years' plants, but, winter lodging of the stalks and other vegetation may not allow accurate counts without manipulating the stalks. Previous year's stalks and galls are grey-brown. New galls may be observed as early as the beginning of July, but often they are small and can take more time to find, hence, it is more efficient to monitor for the galls when they are larger. Fall monitoring is easiest to move about a site and see the stalks from various angles before they fall over later in the season. If monitoring takes place when the plants are still green (generally until late September) it may take practice to spot them as they blend in well with the rest of the plants. The galls are still green at this point, and can appear shiny when sunlight contacts them. Often during fall monitoring, the competing vegetation has begun to dry and turn brown so it is not as visually distracting when viewing Canada thistle which remains green longer. When it comes time to

collect, typically in October, the stalks and galls have turned brown. The size and shapes of galls varies significantly (Figure 21).

Figure 21 - Varying shapes and sizes of *Urophora cardui* galls

The location of galls varies per site for a few reasons (see British Columbia Habitat section for more details). For example, as outlined in the B.C. Habitat section, look for galls in areas protected from, or at least not subject to, wind. As well, height, or perhaps the vigour of plants may affect oviposition. In Barriere, the very tall thistles (> 1.5 m) rarely had galls, but the living, lodged plants had significantly more galls. At individual sites, galls can be found in close proximity to one another. In most instances, if one gall is located on a plant, usually more are found on either the same plant or on nearby plants.

The success of finding galls would, in part, be a result of how many flies would have emerged at the site as a result of the release. This would be affected by how many flies the galls carried and how many emerged. Galls from four release sites were removed the following year after release, once the flies would have emerged. These galls were observed for exit holes (Figure 22) and dissected to determine the potential population of flies emerged at these release sites (Figure 23). For example, the Blue River (2008) site received galls that had an average of 3.24 chambers versus 4.34 at Tenas Lake. Additionally, only 18.3% of the galls from Blue River (2008) had visible exit holes as opposed to the 96.6% at Tenas Lake. Tenas Lake, therefore, should have a better opportunity to establish with a larger quantity of flies available and less agents remaining behind in the galls.

Figure 22 - *Urophora cardui* gall with exit holes.

Figure 23 - Dissection of previously released *Urophora cardui* galls

Site/gall characteristics	Holmes River 2003 Site No. 112084	Hwy 5, Avola to Blue River 2007 Site No. 242637	Hwy 5, Avola to Blue River 2008 Site No. 242637	602 Road, Bulkley 2008 Site No. 250544	Tenas Lake, Kispiox 2008 Site No. 250546
Release date	May 8, 2003	October 24, 2007	October 15, 2008	November 7, 2008	November 7, 2008
Gall removal date	September 19, 2003	October 15, 2008	August 17, 2009	August 27, 2008	August 19, 2009
Site BEC	ICH mm	ICH mw	ICH mw	ICH mc2	ICH mc2
Elevation (m)	905	636	636	629	313
Slope	6	0	0	0	0
Aspect	155	0	0	0	0
Gall source	Kamloops AAFC	Barriere	Barriere	Sirdar	Sirdar
Total # of galls dissected	32 (293 released)	101 (105 released)	71 (72 released)	69 (87 released)	59 (88 released)
Gall length range cm	No data	0.7 – 4.5	1.2 - 3.8	1.4 - 6.0	1.3 - 8
Average length cm	No data	2.1	2.2	3.0	3.0
Gall width range cm	No data	0.5 – 2.0	0.8 - 2.4	0.9 - 2.8	0.6 - 2.5
Average width cm	No data	1.2	1.4	1.8	1.7
% galls with exit holes	No data	55	18.3	87	96.6
Range of number of empty larvae casings	0 - 8	No data	No data	No data	No data
Average # of empty larvae casings	120/32	No data	No data	No data	No data
Range of number of chambers	0 - 15	1 - 7	0 - 8	1 - 11	1 – 9
Average number of chambers	169/32 = 5.28	306/101 = 3.0	230/71 = 3.24	286/69 = 4.14	256/59 = 4.34
Number of galls with dead larvae[a]	5 (15.6 % of dissected galls)	13 (12.8 % of dissected galls)	14 (19.7 % of dissected galls)	2 (2.9% of dissected galls)	6 (10.2% of dissected galls)

Number of galls with dead pupae[b]	0 (0% of dissected galls)	35 (34.7 % of dissected galls)	9 (12.7 % of dissected galls)	4 (5.8 % of dissected galls)	14 (23.7 % of dissected galls)
Number of galls with live larvae[c]	19 (59.4 % of dissected galls)	0 (0% of dissected galls)	0 (0 % of dissected galls)	0 (0 % of dissected galls)	0 (0 % of dissected galls)
Number of galls with live pupae[d]	0 (0 % of dissected galls)	1 (1% of dissected galls)	7 (9.9 % of dissected galls)	2 (2.9 % of dissected galls)	3 (5.1 % of dissected galls)

a – maximum number of dead larvae in one gall is 2.
b – maximum number of dead pupae in one gall is 3.
c – maximum number of live larvae in one gall is 5.
d – maximum number of live pupae in one gall is 2.

The productivity and variability between collection sites can also be determined by these methods. For example, the Kamloops AAFC site located in the BGxh2, yielded a higher average number of larvae chambers per gall than the other sites, located in the IDFxh2 (Barriere) and the ICHxw (Sirdar), respectively. However, monitoring at the same sites in different years has resulted in observations of varying gall sizes. For example, multiple, massive galls measuring up to 8 cm long were observed at Sirdar (ICHxw) in 2007. This same location was monitored again in 2008 and the galls were approximately half the size (gall length range was 1.3 - 8 cm, but, the average length was 3 cm). Galls from the Barriere site (IDFxh2) were also collected in 2007 and 2008. The gall length range was 0.7 – 4.5 cm and 1.2 – 3.8 cm and the average gall length was 2.1 and 2.2, respectively.

PLANT

Canada thistle plants do not appear obviously altered by the presence of the fly, except when gall growth occurs at the terminal end of the stem or has caused a twist in the stem, which is not frequent. For example, in 2009, two plants were found with galls at the terminal end of the main stem and both plants were stunted to less than 30 cm tall.

Plants in B.C. have not been investigated to determine if gall presence affects the height (and hence the vigor) of the thistles.

11. EFFECTIVENESS OF UROPHORA CARDUI ON CANADA THISTLE CONTROL

Galls resulting from insect feeding on host plants are known to be physiological sinks (Harris and Shorthouse 1996). However, if *U. cardui* dies in the initiation phase of the gall, development of the gall stops, and if the agent dies in the growth phase, the gall stops growing and the primary nutritive tissues disappear (Shorthouse and Lalonde 1988).

Galls on the main stems harm the growth and development of the plant moreso that galls on side shoots (Peschken and Derby 1992). Although not commonly found in B.C., two plants with terminal galls found at a site near Barriere, B.C. were stunted. The majority of galls appear 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 delayed and reduced flowering by up to 66% (Agriculture Canada 1986). 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 (Peschken and Derby 1992).

A study in Saskatchewan in a cultivated field where the thistle did not have any competition, the height, dry root weight, the number of seed heads and the root distance did not differ between galled and ungalled plants. When a similar trial was conducted in Quebec where thistles experienced competition from other vegetation, the shoots were shorter on galled versus ungalled plants. Another study showed this reduction occurred only in plants with galls on the main shoots (Peschken and Derby 1992).

Additionally, consideration has been given to the potential of critically low numbers of available flies for mating and contributing to a sustainable population. Despite habitat conditions, resulting numbers of flies are affected by such factors as mortality, both within the galls or upon emergence, or lack of synchronization with possible mates or available plant tissue.

Since its release in 1974, *U. cardui* has not had a noticeable effect on the populations of Canada thistle in B.C. 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 *R.conicus* and *L.planus* coexist with *U. cardui* on Canada thistle along with significant competing vegetation and the population of the thistle 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 perss comm., Dec. 2001).

12. SUMMARY/RECOMMENDATIONS

To date, *U. cardui* has not caused a noticeable effect on its host plant Canada thistle in B.C. The literature also contains varying results with respect to the effectiveness of this agent. Invasive plant managers must determine whether resources can be allocated to redistributing this agent.

Current collection sites are diminishing in the number of plants for a variety of reasons, in part due to contrasting land use and management techniques, for example: at the AAFC Kamloops site, the area in the vicinity of the site is regularly sprayed with herbicide; at Barriere, disturbance by road realignment and machinery bulldozing occurs on the site; however, at Sirdar where there are currently few plants and some scattered patches nearby, but, not a lot of infestations in the area, there is agricultural activity that may promote some thistle growth. It is optional to attempt establish of new sites, but, if done, should focus on establishing collection sites. Some parameters to consider are:

- New colonies should be established on secure sites as the population of flies can take a number of years to build;
- Particular attention should be paid to release habitats as this agent appears sensitive to various features;
- Efforts to establish this fly further north should involve interior collection sites and ideal habitat release sites and/or the slow progression of collecting from the most northern collection site and moving them incrementally towards the Northern Interior;
- It is also recommended that supplemental releases are made on particular sites with the intent of building populations of the flies with new and surviving populations; and

- Record data consistently, for example, record the collection date in addition to the release date to denote handling method and ensure the correct number of agents is recorded. For consistency, it is recommended that the number of galls is recorded.

Additionally, monitoring of sites should continue to learn more about habitat preference;

- When investigating whether the fly will adapt to an area, it is best to keep as many factors consistent as possible and to document what has taken place; and
- Galls are small and sometimes Canada thistle plants can be scattered. Sites should be regularly monitored for potential missed sightings.

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APPENDIX A: Target invasive Plant Canada thistle (*Cirsium arvense*)

The plant

Canada thistle is a perennial, introduced from Europe in the 17th century. The thistle stands up to 1.2 m tall on a smooth (unwinged), green, glabrous stem (Figure 24). The alternate leaves have deep, irregular, spiny lobes and grow from 4 to 21 cm in length. The underside of the leaf has white hairs while the surface is dark green and shiny. It spreads by a horizontal creeping root system and by wind-blown seeds. Aerial shoots, developing into what appears to be individual plants above ground, can originate from either the main vertical root which extends down to the water table, the horizontal roots or from root pieces as small as 8 mm in length. In Canada, the thistle blooms in mid-June to early July and continues until September (Moore 1975). The rose-purple, pink or even white flowers occur in clusters of small, nearly spineless, heads (Powell et al 1994) (Figure 25). Canada thistle is the only native or introduced thistle in the country that has separate male and female flowers (Figure 26). The flowers are insect pollinated and the sexes must be in close proximity (33 m for good results) for seed production to occur. Under optimal conditions, male flowers may produce some seed. Female flowers, however, are the main producers of seed. Seeds are spread by wind when it catches the pappus, but, also by different means when the pappus readily breaks off the seeds. Canada thistle is able to hybridize with select *Cirsium* species. A possible hybrid exists between a rare native of B.C. and Alberta, *C. hookerianum* and was reported to exist in B.C. (Moore 1975). Canada thistle is also known to hybridize with *C. palustre*, (marsh plume thistle), (Moore 1975) which was thought to be rare in Canada but has recently been increasing rapidly in B.C.'s Prince George Forest Region.

Habitat

Canada thistle is widespread throughout B.C. Infestations in the Peace River are more extensive and the plants are larger and more robust than in the rest of the province (Figure 27).

Growing conditions

Canada thistle occurs in a wide range of habitats, in most biogeoclimatic zones in BC and in open mesophytic areas. Generally, Canada thistle exists within the mean temperature range of –22°C to –7°C for January and 10°C to 20°C for July. The annual precipitation within its habitat ranges from 300 to 1000 mm. The plant requires long days but cannot withstand extreme high summer temperatures. It does not do well in full shade. Canada thistle exists in all types of soil but does best in clay soils. It can grow in very dry areas but struggles in wet soils where its root development is shallow (Moore 1975). Generally, Canada thistle is found along roadsides, in cultivated fields and pastures and in waste places.

Figure 24 - Mature Canada thistle plant

Figure 25 - Canada thistle flowers with nearly spineless heads

Figure 26 - Male and female flowers of a Canada thistle plant - Suskwa River site in Prince Rupert Region (ICHmc^2)

Figure 27 - Large Canada thistle seedheads

APPENDIX B: Canada thistle surveys in BC to 2009

BEC	1900[a]	1964	1968	1969	1975	1976	1984	1987	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	Total	% of Total
BAFA																								1			1		2	0.02
BG	10												1	1		4				4				3	21	3	12	40	99	0.80
BWBS	26								1	1		4	34	24	4	5	10	9	15	5	3	6	20	95	397	290	324	297	1570	12.76
CDF		1		1																8		6	3	259	624	332	38	217	1489	12.10
CMA																								3	1				4	0.03
CWH			1		1	2		1					1		3	1		2	3	9	1	5	97	1068	419	369	82	213	2278	18.51
ESSF	1									1							1						7	3	3	2	8	22	48	0.39
ICH	12										25	14	46	1	16	13	7	2	3	7	6	1	12	83	124	195	114	233	914	7.43
IDF	52										8	54	21	20	3	100	4	4	46	78	1940	4	42	146	290	174	111	428	3525	28.64
MH																								3	2	1			6	0.05
MS														1		5			6	1			10	7	14	8	33	85	170	1.38
PP															4	2			2	11	2	7	29	8	60	19	36	92	272	2.21
SBPS																										2		20	22	0.18
SBS	24						1		1	2	53	24	113	18	6			30	14	82	40	38	20	153	456	132	166	535	1908	15.50
Total	125	1	1	1	1	2	1	1	2	4	86	96	216	65	36	130	22	47	89	205	1992	67	240	1832	2411	1527	925	2182	12307	

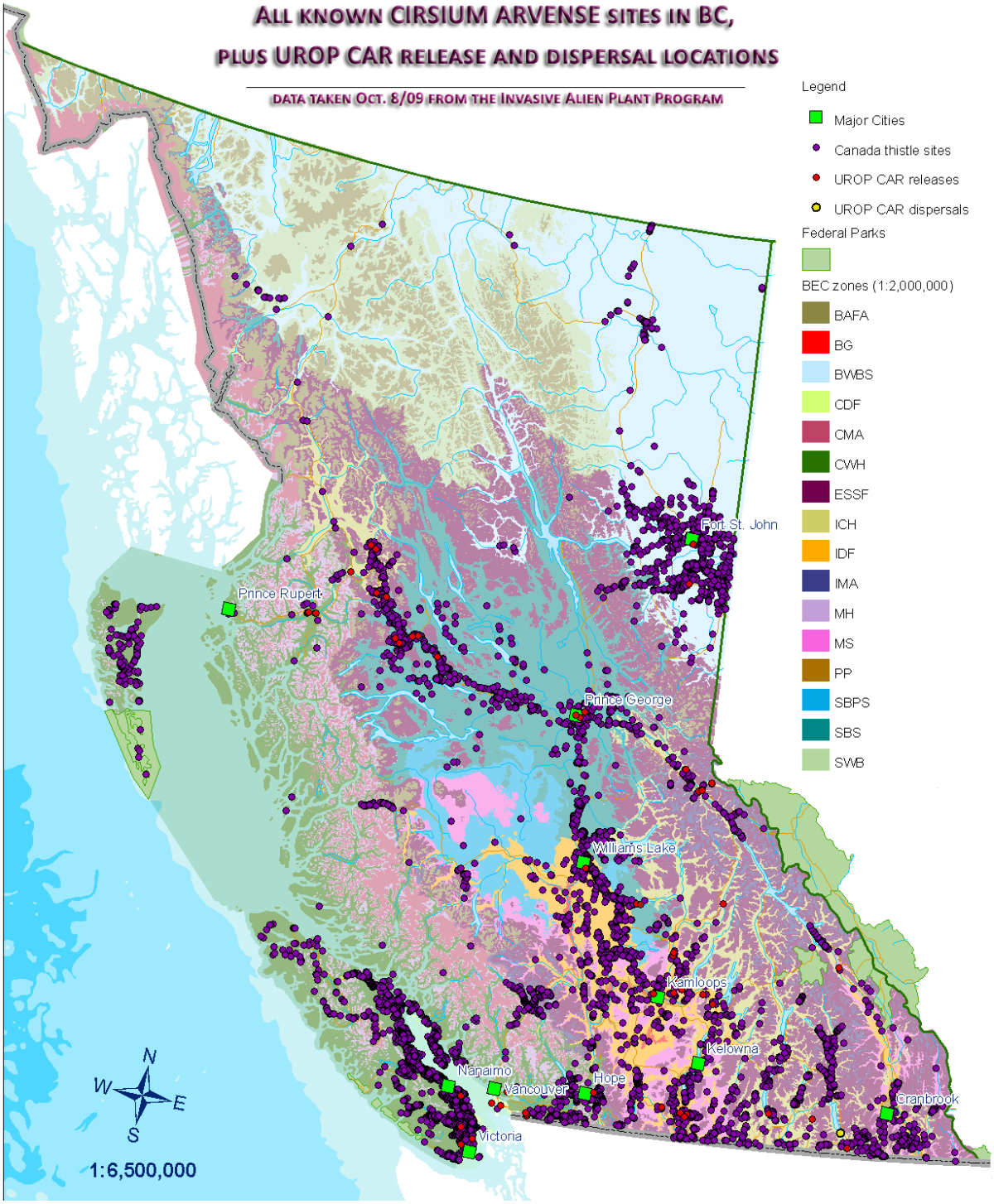
a 1900 is the default year for records with a missing date.

APPENDIX C: Canada thistle agents' life cycle handling matrix

Biocontrol agent	Activity Of interest	Apr		May		Jun		Jul		Aug		Sep		Oct		Nov		Dec*	
		1-15	16-30	1-15	16-31	1-15	16-30	1-15	16-31	1-15	16-31	1-15	16-30	1-15	16-31	1-15	16-30	1-15	16-31
Altica carduorum	**Life cycle**	adult/larva					adult			overwintering adult									
	monitor					adult/larva				adult									
	collect					adult/larva				adult									
Hadroplontus litura	**Life cycle**	larva			larva/pupa		pupa	adult											
	monitor	adult			larva			larva/pupa			adult								
	collect	adult																	
Larinus planus	**Life cycle**	adult		larva/pupa		adult		overwintering adult											
	monitor						adult	larva/pupa		adult									
	collect						adult	larva/pupa											
Rhinocyllus conicus	**Life cycle**	adult			larva		pupa	adult		adult moves into hibernation									
	monitor				adult		egg	larva/pupa		adult									
	collect				adult		egg			adult									
Urophora cardui	**Life cycle**	pupa		adult						larva									
	monitor	larva/pupa				adult					larva								
	collect	larva/pupa												larva					

*The months January to March have been removed from the table for simplicity. The life cycle stages the agents enter the winter in continue until spring.

APPENDIX D: Map of Canada thistle and *Urophora cardui* releases and dispersals in BC to 2009



APPENDIX E: *Urophora cardui* treatment results to 2009

Site No.	Year of Release[a]	BEC	# of Agents (galls, unless designated otherwise)[b]	Collection date[c]	Release date	Galls over wintered?	Source	Release location	Jurisdiction	Established	Unknown
101800	1974	CDFmm	146 adults	August 6	August 6	Unknown	Germany	Westham Island, Canadian Wildlife Service property	Fed PR		1
103990	1975	CWHxm1	98 assumed to be adults	June 16	June 16	Unknown	Germany	Abbotsford, Echo Rd.	Not recorded		1
103991	1976	CWHxm1	96 assumed to be adult	June 16	June 16	Unknown	Germany	Abbotsford, Echo Rd.	Not recorded		1
103992	1976	CWHxm1	99 assumed to be adults	June 27	June 27	Unknown	Germany	Abbotsford, Echo Rd.	Not recorded		1
103993	1987	CDFmm	667 adults	May 27	May 27	Unknown	Finland/ Regina	Duncan	PR		1
103994	1987	CWHxm1	665 assumed to be adults	May 27	May 27	Unknown	Finland/ Regina	Brentwood Bay, Vancouver Island	PR	1	
115089	1989	ICHxw	9g (1/2 pupae killed in extraction) 40 flies in make shift tent	May 1	June 12	Unknown	Unknown source, in the 70s and in 1987 the releases came from overseas (adults) which explains why this person tried to extract adults	Diking system at Creston, bought by Creston area First Nations	IR		1
101719	1991	BWBSmw1	87 adults	May 31	May 31	Likely?	Burnaby	Near Peace River	PR		Not monitored to date
104092	1991	CDFmm	150 galls	No date	April 2	Likely	AAFC	Boundary Bay Research area	Not recorded	1 (1 has legacy info) - find	
103996	1991	CWHdm	320 adults	May 30	May 30	Likely	New Brunswick	SFU	MOT/MU		1
101713	1991 &+ 2007	IDFdk1	202 galls (estimated 750 larvae) & 120 galls supplement in cage	April 11 & October 17	April 11& October 18	1991-yes & 2007-no	1991 Echo Valley, Sask.& 2007 AAFC Kamloops dike	Fleet Mt. Road Paul Lake	CR	1 after supplement	1 Before supplement
101720	1994 & 1995	SBSdh1	50 & 150	October 31 & October 1	October 31 & December 6	No	Cloverdale & Boundary Bay, Delta	Old mill adjacent to Fraser River	CR		Not monitored to date
101715	1994	BGxh2	500 assumed to be galls	October 4	November 3	No	Boundary Bay	Kamloops - AG Can Dike	Fed PR	1 - used for collection	
108587	1994	ICHmc2	80	October 12	October 27	No	Boundary Bay	Edge of field near creek, near Kispiox	PR		1
101721	1994	ICHwk3	50 assumed to	October 31	October 31	No	Cloverdale	Landing	CR		1

			be galls								
101714	1994	IDFmw2	250	October 8	October 8	No	Boundary Bay	Barriere	PR		Not monitored to date
108586	1994	SBSdk	19	No date	March 4 & October 12 10 galls released in fall soon after collection, 9 held over until spring, due to snow	50/50	Boundary Bay	Smithers, Gramophone	PR	1	
108592	1994	SBSdk	8	March 17	March 17	Likely	Boundary Bay	Johnny David Creek	CR		1
101716	1995	IDFmw1	150 assumed to be galls	October 27	October 27	No	Boundary Bay	Enderby	PR		1
101712	1995	SBSdw1	1	November 1	November 1	No	Boundary Bay	Canim Lake IR	PR, IR		1
101711	1995	SBSdw1	1	November 1	November 1	No	Boundary Bay	Canim Lake IR	PR, IR		1
101722	1995	SBSmh	150 assumed to be galls	October 11	October 11	No	Boundary Bay	Prince George	MU		Not monitored to date
103997	1996	CDFmm	200 assumed to be galls	September 19	September 19	No	Boundary Bay	Mudge Island, north west side	PR	1 (legacy presence)	
103998	1996	CDFmm	200 assumed to be galls	September 19	September 19	No	Boundary Bay	Mudge Island, north side	PR		1
103999	1996	CDFmm	400 assumed to be galls	September 20	September 20	No	Boundary Bay	Hwy 17 and McTavish – Saanich/Victora	MOT		1
108589	1996	CWHws1	60	January 1	January 22	No	Boundary Bay	Terrace, farm	PR	1 (legacy info – correct?)	
108590	1996	CWHws1	60	January 30	January 30	No	Boundary Bay	Terrace, campground	MU		1
115895	1996	ICHdw1	30 (150 estimated larvae)	September 23	October 3	No	Boundary Bay	South of Nelson, abandoned rail line, now a trail system	CR, MOT		1
101725	1996	ICHmm	20 galls	September 23	November 1	No	Boundary Bay	3 k Holmes FSR	CR		1
113982	1996	IDFun	30 galls (200 estimated larvae)	September 23	October 2	No	Boundary Bay	Deer Creek FSR	CR	1	
115906	1996	MSdk2	300 galls	October 11, 1995	April 17	Yes	Boundary Bay	Golden, CP Rail	PR – CP		1
101724	1996	SBSdh1	30 galls	September 23	November 1	No	Boundary Bay	Holmes/Fraser	CR		Not monitored to date
101726	1996	SBSdh1	10 galls	September 23	November 1	No	Boundary Bay	1 k Holmes FSR	CR		Not monitored to date
108593	1996	SBSdk	20 galls	May 23	May 23	Likely	Boundary Bay, Delta	Morice Telkwa FSR	CR		1
101728	1996	SBSdw3	30 assumed to be galls	November 15	November 15	No	Boundary Bay	Moore's Meadow, PG	MU		1
224896	1997	CWHds1	200	October 22	October 23	No	Boundary Bay	Coquihalla	MOT		1

								highway, near Othello area			
108588	1997	ICHmc2	30 galls	April 18	April 18	Likely	Boundary Bay	Kitwanga junction	MOT		1
108591	1997	SBSdk	30 galls	April 7	April 7	Likely	Boundary Bay, Delta	Decker Lake Community,	MOT		1
108594	1999	SBSdk	50	November 24	November 24	No	Boundary Bay, Delta	Houston on hwy	MOT		1
114231	2000	ICHxw	100 galls	October 18	November 3	No	Chilliwack	Sirdar, collection site and also a gall dissection record site	CR – wildlife area	1	
103168	2000	IDFdk2	125 galls BD	November 8	November 8	No	Chilliwack airport	Heffley Louis Creek Rd.	CR	1	
103167	2000	IDFmw2	125 BD	November 8	November 8	No	Chilliwack airport	Eileen Lake FSR	CR		1
103166	2000	MSxk1	100	November 1	November 1	No	Chilliwack airport	Mascot mine	IR		1
108595	2000	SBSdk	63 galls	September 18	November 17	No	Cedar, Nanaimo	Highway 16, near Houston	MOT		1
112088	2001	BGxh1	50 assumed to be galls, other 01 rel were noted to be 50 galls	No date	October 12	No	Boundary Bay	Vaseaux Lake	Park?	1	
112009	2001	IDFdk2	100 BD	November 18	November 18	No	Boundary Bay/Ladner	Heffley Louis Creek Road	PR	1	
112300	2001	IDFxh2	75	October 31	November 9	No	Boundary Bay, Delta	Skimikin Road	PR		1
6635	2001	PPxh1	50	November 7	November 7	No	Boundary Bay, Delta	White Lake/Park Rill Creek	PR	1	
6633	2001	PPxh1	50	November 7	November 7	No	Boundary Bay, Delta	White Lake	PR		Not monitored to date
112089	2001	PPxh1	50	No date	October 16	No	Boundary Bay, Delta	White Lake/Willowbrook	PR	1	
242037	2001	SBSmh	100 galls (estimated 350 larvae)	September 19	September 19	No	Boundary Bay	Shelley, Beaver Forest Road	MU		1
112011	2002	IDFxh2	275 galls	May 23	May 23	No	MFRPF, Kamloops dike	Pull out north of Barriere	MOT	1	
112097	2002	IDFxm	75	October 6	December 14	No	Boundary Bay, Delta	Scout Island, Williams Lake.	Park		1
112084	2003	ICHmm	300 galls (caged)	May 8	May 8	No	AAFC Kamloops - dike	22.2 Holmes FSR	CR	1	
242637	2007 & 2008	ICHmw3	105 galls &72 galls supplement (caged both years)	October 10 & October 14	October 24 & October 15	No	Barriere	Avola, near Finn Creek FSR	MOT		1
245235	2008 & 2009	BWBSmw1	60 galls (estimated 240 larvae) & 241 gall supplement (caged)	April 17 & October 16	April 30 & November 2	No	AAFC Kamloops – dike & Barriere	Groundbirch	CR	1	

250544	2008	ICHmc2	87 galls (caged)	October 7	November 7	No	Sirdar	2.1 k on 602 Rd	CR		1
250546	2008	ICHmc2	88 galls (caged)	October 7	November 7	No	Sirdar	Tenas Lake	CR	1	
218997	2009	CWHxm1	119 galls (caged)	November 9	November 16	No	AAFC Kamloops - dike	Hwy 19 North of Cook Creek Rd. exit	MOT		Not monitored to date
		TOTAL								**18**	**41**

a Galls were released within cages from 2007 to 2009.

b Releases made prior to 2002 often have questionable numbers of agents released; an estimate of the number of larvae inside the gall was multiplied with the number of galls released. This number was often recorded without the explanation of whether it was the actual number of galls released or a calculation of larvae. (e.g 5 galls x 10 larvae/gall = 50).

c This date is frequently inaccurate, particularly when it is the same as the release date. The release date was often applied as the default collection date.

APPENDIX F: Monitoring history of positively established *Urophora cardui* releases to 2009

Site No.	Release Date	BEC	Release Location	Monitoring Dates	Established
103994	1987	CWHxm1	Brentwood Bay - farm	1998-01-01 2003-08-18	Yes No
104092	1988	CDFmm	Boundary Bay Research area	2007-08-23 2008-04-15	Yes No
101713	1991 2007 new release	IDFdk1	North of Paul Lake	2000-07-13 2000-09-27 2001-10-01 2005-05-02 2007-09-27 2007-09-28 2008-08-12	No No No No No No Yes
101715	1994	BGxh2	AAFC Kamloops	1999-01-01 2000-07-01 2000-09-07 2001-10-12 2001-11-01 2002-04-30 2002-05-22 2003-04-06 2003-04-09 2003-05-15 2003-09-23 2004-08-25 2005-05-06 2005-05-26 2005-07-08 2006-04-24 2007-10-17 2008-04-17 2009-06-29	No No No Yes Yes Yes Yes Yes Yes No No No No Yes Yes Yes Yes Yes Yes
108586	1994	SBSdk	Houston IPMA, Smithers, Gramaphone Creek	1995-01-01 1996-07-11 1998-01-01 2008-09-26	Yes No No No
103997	1996	CDFmm	North-west side of Mudge Island	2003-09-12 2008-10-28	Yes No
113982	1996	IDFun	850 m up Deer Creek Ranch	1999-07-09 1999-08-06 1999-08-19 2005-08-09	No No Yes Yes
103168	2000	IDFdk2	6.2 km Heffley/Louis Cr. Rd.	2002-05-01 2002-10-09 2003-04-06 2003-09-15	Yes No Yes No

				2006-09-07	No
114231	2000	ICHxw	2.9 km north of Sirdar	2001-10-26 2002-06-04 2006-10-03 2007-08-15 2008-10-06	Yes No Yes Yes Yes
6635	2001	PPxh1a	White Lake/Park Rill Creek	2006-10-05	Yes
112009	2001	IDFdk2	6.5 km Heffley/Louis Cr. Rd.	2002-01-01 2003-04-06 2006-09-07	Yes Yes Yes
112088	2001	BGxh1	Vaseux Lake, north end	2006-10-05 2008-09-30	Yes No
112089	2001	PPxh1	Willowbrook, 1 km south of Mahoney Lake	2006-10-06	Yes
112011	2002 (May)	IDFxh2	7.5 km north of Barriere @ pullout	2002-10-09 2002-06-01 2003-04-09 2004-08-17 2006-08-22 2007-09-06 2007-10-10 2008-04-29 2008-10-14 2009-10-18	No Yes Yes Yes Yes Yes Yes Yes Yes Yes
112084	2003 (May)	ICHmm	22.2 km on Holmes FSR - caged	2003-09-19 2005-09-09 2006-08-11 2007-08-16	Yes No No No
245235	2008	BWBSmw1	267 Rd., Hart Hwy, Peace FD	2008-09-24 2009-05-01 2009-10-20	Yes No No
250546	2008	ICHmc2	Tenas Mountain Rd.	2009-08-19 2009-08-27	Yes No