Urophora quadrifasciata (Meig.)

INVASIVE SPECIES ATTACKED: Black knapweed (*Centaurea nigra*)
Brown knapweed (*C. jacea*)
Diffuse knapweed (*C. diffusa*)
Meadow knapweed (*C. debauxii*)
Spotted knapweed (*C. biebersteinii*)

TYPE OF AGENT: Seed feeding fly

COLLECTABILITY: Mass

ORIGIN: Eurasia

DESCRIPTION AND LIFE CYCLE

Adult:
The flies measure 1 - 3 mm long. They have black bodies and clear wings distinctly marked with a black 'UV' pattern. At rest, the adult will hold their wings in a tented formation similar to a 'V'. Females can be identified by their long, pointed, black ovipositor. Adults emerge in late June and July, which coincides with the development of the knapweed flower buds, and mating begins immediately. Females start to lay eggs in three days and will continue to do so for three weeks. Eggs are laid into the unopened flower buds that are more mature than those preferred by *Urophora affinis*. *U. quadrifasciata* can oviposit and develop in the same flower heads as *U. affinis*, but avoid doing so because of the misshapen or delayed bud development that occurs with *U. affinis* attack. When they do co-exist, they do so without harming the other. Second generation adults appear in mid to late August and will mate and oviposit. Adults are capable of dispersing 21 km in five years.

Fig. 1. *U. quadrifasciata* adult (credit Powell et al. 1994)

Egg:
The eggs incubate for 3 - 4 days.

Larva:
Creamy, white larvae penetrate into the flower bud and grow into a plump, 'barrel-like' shape. The entire larvae and pupae stages develop within galls inside the flower bud. The plant objects to the intruding larvae and reacts by producing a gall around each of them. By 15 days the galls will have maximized in size. The galls are lined with nutritious cells that the larvae feed on. The larvae will have consumed all but a paper thin outer layer of the gall in 20 or 25 days. At this time, they will begin to pupate. The larvae turn to face outward and pupate. Multiple *U. quadrifasciata* larvae can occur in each flower head.

Fig. 2. *U. quadrifasciata* larva (credit Powell et al. 1994.

Pupa:
Pupation occurs inside the seed head within the thin gall liner. Adults emerge in 5 - 6 weeks, usually in August.

Overwintering stage:
Most overwinter as mature larvae in seedhead galls and continue development the following spring.

Fig. 3. *U. quadrifasciata* general release habitat at Walhachin (Bunchgrass zone transition to Ponderosa pine zone)

EFFECTIVENESS ON HOST PLANT
Combined *U. quadrifasciata* and *U. affinis* can reduce seed production by 95%. The gall formation depletes the plant of nutrient reserves resulting in fewer floral stems.

HABITAT AND DISTRIBUTION

Native:
Its native distribution occurs in Eurasia.

North America:
Canada screened, petitioned and became the first to release *U. quadrifasciata.* The first release in Canada was made in B.C. via the efforts and funding through the group called the "Knapweed Action Plan Committee" in the early 1970s.

By 1979, *U. quadrifasciata* was found in the U.S.A. It was presumed the fly arrived accidentally with a cross-border shipment of seedheads containing the approved biocontrol agent *U. affinis*. *U. quadrifasciata* was eventually approved for redistribution in the U.S.A. in 1989. Since its arrival into the U.S.A., *U. quadrifasciata* has naturally spread onto bachelor's button (also known as corn flower) and several additional knapweed species occurring including brown, meadow, and squarrose.

In North America, *U. quadrifasciata* is established in B.C. and Alta. and it is considered to be more widespread in the eastern U.S.A. than in the western U.S.A.

U. quadrifasciata is adaptable to the wide variety of knapweed habitats. It is less tolerant of severe winter conditions and literature indicates that it requires considerably more protective snow cover than *U. affinis*. Diffuse knapweed is better suited to this species because it continues to produce suitable floral buds over a long period which coincides with the biocontrol agent's reproductive requirements.

British Columbia:
U. quadrifasciata has been found established and dispersed in the Bunchgrass, Coastal Douglas-fir, Coastal western hemlock, Interior cedar hemlock, Interior Douglas-fir, Ponderosa pine and Sub-boreal spruce biogeoclimatic zones.

Fig. 4. *U. quadrifasciata* dispersal site in Duncan (Coastal Douglas-fir zone)

Fig. 5. *U. quadrifasciata* dispersal area near Merritt (Interior Douglas-fir zone)

BRITISH COLUMBIA RECORD

Origin:
U. quadrifasciata populations released in B.C. originate from Russia where it occurred on *Centaurea sterilis*.

History:
The first *U. quadrifasciata* release in B.C. was made in 1972 on diffuse knapweed in the southern interior. By 1975, it had dispersed itself onto spotted knapweed. In 1987, it was released onto meadow knapweed. Early treatments established very well and have contributed to disperse. Assisted redistribution continued until 1995.

Field results:
U. quadrifasciata is quite common in the southern interior, co-existing with other seed and root feeding bioagents. The larvae have been found more frequently on spotted knapweed than on the diffuse and meadow varieties, but this may be a result of more dispersal sampling being done on spotted knapweed. As *U. affinis'* and *U. quadrifasciata's* populations merge across B.C. and occupy many of the same infestations, field collections and subsequent releases were often recorded as *Urophora spp*. When *U. quadrifasciata* occurs at the same site as *U. affinis*, *U. affinis* is usually the dominant species.

Collection for redistribution:
Adults can be swept and aspirated in June and July and again in August. Clipping knapweed stems with infested seedheads from September to October or from March to May is the most efficient method, for large collections, however this method can promote the spread of seeds. Tie new clipped stems to a stake for overwintering to prevent them from blowing away. Redistribution of flies is rarely necessary as this agent easily disperses and readily locates new host sites.

Fig. 6. *U. quadrifasciata* dispersal area near Kamloops (Ponderosa pine zone)

Fig. 7. *U. quadrifasciata* dispersal area at Seymour Arm (Interior Douglas-fir zone)

NOTES

- Each seed head feeder has specific requirements, allowing multiple biocontrol agents to exist in a single seed head. *U. quadrifasciata* disperses quicker than *U. affinis*, but when occurring on the same site it becomes less dominant. Nevertheless, they are more effective in conjunction with other agents than alone.
- Spotted knapweed produces fewer immature buds for *Urophora spp*. to produce its second generation within, whereas diffuse knapweed will continue to produce a succession of flowers until frost.

REFERENCES

1. Harris, P. 1986. Biological control of knapweed with *Urophora quadrifasciata* MG. Gov. of Can. Canadex Weed Control Beneficial insects 641.613.
2. Harris, P. 2006. Classical biological control of weeds established biocontrol agent *Urophora affinis* Frfld. and *U. quadrifasciata.* Agriculture and Agri-Food Canada. Updated August 3, 2005. http://res2.agr.ca/lethbridge/weedbio/agents/auropaffi_e.htm (Accessed January 26, 2007).
3. Harris, P. No date. Establishment of *Urophora affinis* Frfld. and *U. quadrifasciata* (Meig.) (Diptera: Tephritidae) in Canada for the biological control of diffuse and spotted knapweed. Agric. Can. Res. St. Regina, SK.
4. Powell, G. W., A. Sturko, B. Wikeem and P. Harris. 1994. Field guide to the biological control of weeds in British Columbia. B.C. Min. For. Res. Prog.
5. Turner, C.E., J.M. Story, S.S. Rosenthal and N.E. Rees. 1996. *Urophora quadrifasciata*. Sect. II, The knapweeds. In: Biological control of weeds in the west. N.E. Rees, P.C. Quimbly Jr., G.L.Piper, E.M. Coombs, C.E. Turner, N.R. Spencer, and L.V. Knutson, (editors). Western Soc. Weed Sci.
6. Winston, R., C. Bell, R. De Clerck-Floate, A. McCLay, J. Andreas and M. Schwarzlander. 2014. Biological control of weeds in the northwest. Forest Health Technology Enterprise Team.