1.2 Risks and Benefits of Accidental Introductions of Biological Control Agents in Canada

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Introduction of natural enemies associated with invasive alien species is probably more common than conventional wisdom suggests. Such introductions are usually detected well after the host has established in new regions, sometimes even during or after host range studies have been initiated. In Canada, during the last 30 years, at least seven accidental introductions of natural enemies have occurred in arthropod pest systems (Table 1.2.1). Some introductions have resulted in unforeseen benefits to management of invasive alien species, but also pose potential risks to native biodiversity. Here we focus on two examples of accidental natural enemy introductions of arthropod pests that have had positive effects and potential risks.

Table 1.2.1. Accidental introductions of natural enemies associated with arthropod pests reported in agricultural systems in Canada during the last 30 years.

Agent	Probable year of introduction	Host
Euxestonotus error (Fitch)	1800's	*Sitodiplosis mosellana*
Macroglenes penetrans (Kirby)	1800's [1954 MB; 1984 SK]	*Sitodiplosis mosellana*
Synopeas myles (Walker)	2000's [2015 SK; 2016 ON]	*Contarinia nasturtii*
Platygaster demades (Walker)	2016 BC	*Dasineura mali*
Trichomalus perfectus (Walker)	2009 ON, QC	*Ceutorhynchus obstrictus*
Mesopolobus gemellus Baur & Muller	2007 ON, QC	*Ceutorhynchus obstrictus*
Necremnus tidius (Walker)	1998 BC; 2003 AB, SK; 2007 ON, QC	*Ceutorhynchus obstrictus*

Macroglenes penetrans (Kirby) (Hymenoptera: Pteromalidae) is a key parasitoid that reduces populations of orange wheat blossom midge, *Sitodiplosis mosellana* (Géhin) (Diptera: Cecidomyiidae), in western Canada. First reported in the 1950's after a wheat midge outbreak in Manitoba and later in the 1980's after a major outbreak in Saskatchewan, conservation of *M. penetrans* has had economic and environmental benefits by reducing

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pesticide use. Although formal host range studies have not been conducted, *M. penetrans* appears to be specific to wheat midge (Doane *et al.*, 2013).

Management of wheat midge incorporates *M. penetrans* parasitism levels (25-46% in Saskatchewan, Doane *et al.*, 2013) into models (Fig. 1.2.1) that provide growers with forecasts of potential crop damage during the growing season. Thus, the accidental introduction of *M. penetrans* has provided benefits through reduced input costs, fewer pesticides being applied, and adoption of practices that conserve natural enemies.

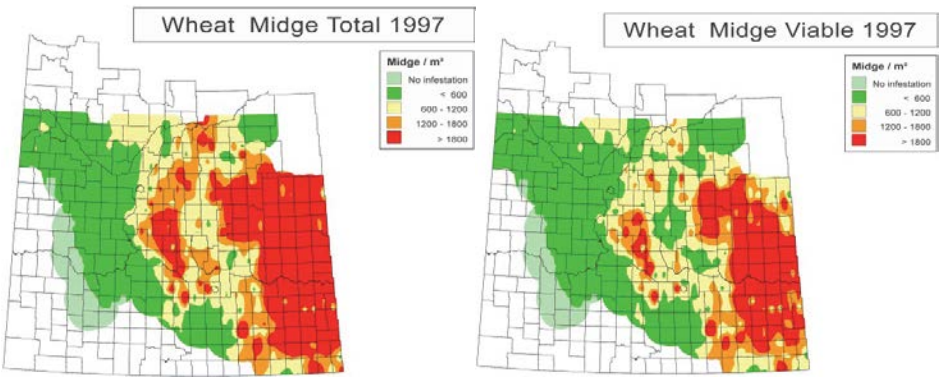

Fig. 1.2.1. Forecast models of wheat midge area infested before (left) and after (right) data where viable cocoons were reduced by *Macroglenes penetrans* to below economic threshold levels (<600/m^2).

Trichomalus perfectus (Walker) (Hymenoptera: Pteromalidae) is an important parasitoid of the cabbage seedpod weevil, *Ceutorhynchus obstrictus* (Marsham) (Coleoptera: Curculionidae), in its native European range and was the focus of more than 15 years of intensive research to assess its potential as a biological control agent. *Trichomalus perfectus* attacks the larval stages of hosts that are concealed within developing siliques of Brassicaceae plants. Non-target species for testing potential impacts of candidate biological control agents were chosen using a multi-criteria selection method (Haye *et al.*, 2015). Parasitism levels (host acceptance by parasitoids) varied among *Ceutorhynchus* spp. and feeding niche (Table 1.2.2). Of the 17 non-target species tested in no-choice laboratory experiments, parasitism by *T. perfectus* of four species was similar to that of the target host *C. obstrictus*. Parasitism of a further five species was lower than that of *C. obstrictus*, and six other species were not attacked at all. Ecological host range surveys in Europe corroborated the prediction that *T. perfectus* would attack *C. cardariae* at similar levels to *C. obstrictus*.

In North America, *T. perfectus* was first discovered in 2009, attacking *C. obstrictus* in Quebec and Ontario and more recently, in a field population of the native weevil *C. omissus*, confirming the prediction that this species is a suitable host. Therefore, based on host range studies, accidental introduction of *T. perfectus* poses a medium to high risk to native *Ceutorhychus* spp., particularly those feeding in the siliques of *Brassica* plants.

Table 1.2.2. Risk of attack by *Trichomalus perfectus* females to non-target weevil species in Europe and North America based on percentage of non-target and target larvae accepted (parasitized) in small arena no-choice tests (host acceptance was compared using Fisher's Exact Test, P< 0.05 (see Haye *et al.*, 2015): high = ns; medium = P<0.05 – P<0.0001; low = P<0.0001; nil = not attacked).

Non-target hosts	Feeding niche	Risk of attack
Europe		
Ceutorhynchus typhae (Herbst)	seeds in silique	medium
Ceutorhynchus constrictus (Marsham)	seeds in silique	medium
Ceutorhynchus turbatus Schultze	seeds in silique	high
Ceutorhynchus peyerimhoffi Hustache	seeds in silique	nil
Mogulones borraginis (Fabricius)	seeds in nutlet	nil
Ceutorhynchus pallidactylus (Marsham)	stem tissue	low
Ceutorhynchus alliariae H. Brisout	stem tissue	nil
Ceutorhynchus roberti Gyllenhal	stem tissue	nil
Ceutorhynchus erysimi (Fabricius)	stem leaf vein tissue	nil
Ceutorhynchus cardariae Korotyaev	stem & leaf vein gall tissue	high
North America		
Ceutorhynchus americanus Buchanan (on *Rorippa palustris*)	stem tissue	low
Ceutorhynchus americanus Buchanan (on *Sinapis arvensis*)	stem tissue	medium
Ceutorhynchus neglectus Blatchley	seeds, foliage	low
Ceutorhynchus omissus Fall	seeds in silique	high
Ceutorhynchus sp. nr. *nodipennis* Dietz	seeds in silique	medium
Ceutorhynchus querceti (Gyllenhal)	seeds in silique	high
Mononychus vulpeculus (Fabricius)	seeds in pod	nil

Furthermore, *C. constrictus* and *C. cardariae* – which are candidates for introduction as biological control agents of weeds – are also at risk. Thus, although *T. perfectus* may be narrowly oligophagous, monitoring its impact on species at risk will be essential to refine predictions and develop new hypotheses with regards to risks associated with adventive introductions of arthropod biological control species.

Adventive introductions of biological control agents carry both benefits or risks. Understanding the host range of key natural enemies and monitoring them once they are present in the invaded region is essential in managing invasive alien species.

References

Doane, J.F., Olfert, O.O., Elliott, R.H., Hartley, S. and Meers, S. (2013) *Sitodiplosis mosellana* (Géhin), orange wheat blossom midge (Diptera: Cecidomyiidae). In: Mason, P.G. and Gillespie, D.R. (eds.) *Biological control Programmes in Canada 2001–2012*. CAB International, Wallingford, UK, pp. 272–276.

Haye, T., Mason, P.G., Gillespie, D.R., Miall, J.H., Gibson, G.A.P., Diaconu, A., Brauner, A.M. and Kuhlmann, U. (2015) Determining the host specificity of the biological control agent *Trichomalus perfectus* (Hymenoptera: Pteromalidae): the importance of ecological host range. *Biocontrol Science and Technology*, 25, 21–47.