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Review Article

Assessment of potential risks for introducing European *Peristenus* species as biological control agents of native *Lygus* species in North America: a cooperative approach

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Abstract

The pest status of *Lygus* species in North America is outlined. The history of European collections and importations of *Peristenus* species into North America is described. Current host specificity testing procedures for potential weed and arthropod biocontrol agents are compared. Strategies and methods for host specificity testing of parasitoids are outlined, and discussed in relation to the selection of non-target and native *Lygus* species for testing with *Peristenus* parasitoids. European *Peristenus* species are identified and their life histories outlined. The current status of the taxonomy of the European *Peristenus* species is discussed, and the importance of accurate identification of these species is noted. Literature on the host range and non-target effects of *Peristenus* species in the field and laboratory, respectively, is reviewed. It is concluded that cooperative research in Europe and North America is needed to assess the potential risks for the introduction of European *Peristenus* species for control of *Lygus* species in North America, and suggested topics are listed.

Introduction

Natural enemies are important mortality factors of arthropod pests. The introduction of parasitoids and predators from one region to control arthropod pests in another region (classical biological control) has been practised for over a century (Greathead, 1986) and more than 5220 insect natural enemy introductions against economically important insect pests have been made (Waage, 1990; Godfray & Waage, 1991; BIOCAT Database (see Greathead & Greathead, 1992), updated November 1997). Economic globalization will ensure that increasing numbers of insects are transported from region to region, occasionally resulting in the establishment of new pests, providing targets for classical biological control (Mills, 1994). Also, increasing numbers of native insects such as *Lygus* spp. (Het., Miridae) attain pest status as they are presented with monocultures of high quality food plants. Pest management programmes that utilize biological control are viewed favourably by the public because the agents are non-toxic and usually self-sustaining (Kauffman & Nechols, 1992). Classical biological control also appeals to producers because there is real potential to reduce input costs through reduced insecticide use. However, concerns have been raised regarding the impact of introduced agents on non-target species (Howarth, 1991; Simberloff, 1992). Although potential risks to non-target species are recognized and attempts are being made to determine the nature of this impact (Andow *et al.*, 1995; Hopper, 1995), documentation of such side effects has generally been poor and some reports even disputed (Funasaki *et al.*, 1988). Additionally, regulatory agencies are responding to concerns of non-target impacts by requiring

more rigorous testing and a high degree of host specificity of candidate biological control agents before granting permission for release. To address these issues future biological control programmes will need to assess carefully the potential impact of introduced agents on non-target species and on ecosystems as a whole.

Tests with exotic biological control agents should be conducted in quarantine prior to release in order to determine their potential host range and to assess the significance of any development on non-target hosts or prey (Sands, 1997). Procedures for testing the specificity of agents for weeds have been developed (Wapshere, 1974, 1989; Wapshere *et al.,* 1989, Clement & Cristofaro, 1995; Cruttwell McFadyen, 1998; Marohasy, 1998) and are increasingly practised in weed biological control programmes (D. Schroeder, pers. comm., 1998). However, Sands & Papacek (1993) noted that tests on agents for arthropod pests have not received the same attention. Recently, guidelines for biological control projects (Waterhouse, 1991; FAO, 1997) have been altered to include host specificity procedures for testing agents for both weed and arthropod targets. With respect to the safety of biological control, the Code of Conduct for the Import and Release of Biological Control Agents (FAO, 1997) recommends that governments should evaluate information on each candidate biological control agent including: (1) accurate identification of the biological control agent; (2) a summary of all available information on its origin, distribution, biology, natural enemies and impact in its area of origin; and (3) an analysis of the host range expansion of the biological control agent and any potential hazards posed to non-target hosts. An important impediment to fulfilling these recommendations is the major difference in the status of systematic knowledge between weeds and insects. Whereas the taxonomy and phylogenetic relationships of plant species are relatively well-known, far less is known about these relationships for insects. Therefore, systematics must be an integral component of biological control programmes targeting insect pests.

The *Lygus* bug complex (Het., Miridae) at many sites in North America causes economic damage to a wide variety of agricultural crops and is the focus of numerous research projects. *Lygus* can best be suppressed using parasitoids in unsprayed non-cropping situations as well as in crops where pollination is important for maximizing yields. *Peristenus digoneutis* Loan (Hym., Braconidae), a European parasitoid of *Lygus*, has recently been established in the eastern USA (Day, 1996). The success of this project has stimulated interest in research into the potential for the establishment of additional European species of *Peristenus* for biological control of pest *Lygus* species in several regions in North America. This paper proposes that a cooperative study be initiated to assess potential risks associated with introducing European *Peristenus* species as biological control agents of North American *Lygus* species.

Pest Status and History of European Collections and Importation of *Peristenus* Species

Schwartz & Foottit (1992) reported that regionally the most important *Lygus* pests are the tarnished plant bug, *Lygus lineolaris* (Palisot de Beauvois), which is distributed continent-wide and is the only species causing economic damage in eastern North America, on seed alfalfa (lucerne), cotton, mustard, vegetables, and fruit crops, and *Lygus hesperus* Knight, the western tarnished plant bug, which occupies approximately the same ecological niche as *L. lineolaris* in the East, but is more prevalent than it on alfalfa and cotton in western North America (Day, 1987). The pale legume bug, *Lygus elisus* van Duzee, distributed in western North America, is a serious pest of oilseed rape (canola) in the Prairie Provinces (Butts & Lamb, 1991a). Development of new crops and varieties of existing crops can lead to new associations that result in the emergence of new pest species. In the Prairie Provinces a burgeoning rapeseed oil industry has planted large acreages of rape (Lamb, 1989), and *Lygus borealis* (Kelton), a well-known pest of seed alfalfa, has risen to pest status on rape (Butts & Lamb, 1991b). All species of *Lygus* feed preferentially on either the developing reproductive organs (buds, flowers, and developing seed) or on the apical meristematic and leaf primordial tissue (Strong, 1970). It is the concentration of feeding on reproductive parts that makes *Lygus* spp. some of the most insidious pests of seed crops (Schwartz & Foottit, 1992).

Extensive studies of the parasitoid complexes of *Lygus* species in Europe and North Africa were carried out by the USDA European Parasite Laboratory in the 1960s and '70s, and simultaneously several *Peristenus* species were introduced and released in the United States (see Hedlund & Graham, 1987; Day, 1996). Additional information on the distribution (D. Coutinot, unpublished data) and seasonal incidence (K. Hopper, unpublished data) of *Peristenus* species will be forthcoming. Day (1996) suggests that *Peristenus stygicus* Loan may be a 'southern' species, while *P. digoneutis* is a 'northern' species.

In 1977, Agriculture Canada requested the International Institute of Biological Control (IIBC), European Station, Delémont, Switzerland, to make mass collections of plant bugs from alfalfa, rear parasitoids to the cocoon stage and ship these to Canada for direct release in western Canada (Carl & Mason, 1996). Collections were continued until 1985, with emphasis shifting from the collection of *Lygus rugulipennis* Poppius to that of the alfalfa plant bug *Adelphocoris lineolatus* (Goeze) (Het., Miridae) in 1980 (see Craig & Loan (1991) for a brief summary). Carl & Mason (1996) reported that this was a collect and ship programme which allowed only some incidental observations on parasitoid interactions, diapause requirements, etc. In 1995, project work was started again. Since 1997, pre-release studies of *Peristenus* species were designed and carried out in the field and in the laboratory to get a better understanding of the *Lygus–Peristenus* interactions and their implications for biological control.

General Technical Guidelines of Non-target Tests of Parasitoids

For a long time there was little concern about the fate of alternative hosts of the natural enemies of arthropod pests unless obviously valuable species were at risk – e.g. bees, lac insects, silk worms. Now, there is increasing awareness of the need to conserve species of aesthetic value (e.g. butterflies), beneficial species (insect natural enemies and biological control agents), endangered species, and indeed all native fauna and flora (Greathead, 1997). As a result of the earlier lack of concern for non-target arthropods, host specificity screening of arthropod natural enemies was non-existent or perfunctory until the last decade. Consequently, there are no established protocols but some scientists adapted the weed insect protocols as a first step. For some agents they provide useful indications of host range but the natural enemies of insects are less likely than phytophagous species to behave

normally under laboratory or field cage conditions (Greathead, 1995) and many false positive results are produced. The reason for this is that the host finding and acceptance behaviour of insect parasitoids is often more complex than that of plant feeding species and because habitat frequently has a more important role (see Godfray, 1994 and Quicke, 1997). Thus, if safe, potentially valuable natural enemies are not to be rejected unnecessarily, different approaches are required to investigate host selection behaviour (Kitt & Keller, 1998).

Before carrying out any host specificity tests, it is essential to have a clear understanding of the taxonomic identity and basic life history information of the candidate agent so as to design appropriate screening tests. For example, a knowledge of the stage attacked enables the correct stage of the test organism to be chosen. Species for inclusion in the tests should be chosen using a phylogenetic scheme as used for weed control agents (Wapshere, 1974) and should include unrelated species of economic or conservation importance.

No-choice and multiple choice tests can be carried out with parasitoids, as for weed control agents, but it is important to present the correct stage of the test organisms under the circumstances that they would be found in the field – on or in their usual host plants – because host acceptance is frequently affected by physical and chemical characteristics of the host plant and the position of the host on or in it. Host finding by parasitoids starts with detecting the host niche, i.e. detecting the right host plant in the right microclimate. Therefore, a parasitoid would not search in the wrong place so that non-targets in the wrong microenvironment will not be at risk. Thus, the cages used in these screening tests should be of sufficient size to contain the food plant as well as the test organism and be furnished, as far as possible, to resemble field conditions. The candidate agent must be provided with its normal adult food and be exposed to the test organisms only when it is known to contain mature eggs and be ready to oviposit. Many parasitoids require nectar and pollen for maturation but some also need to feed on the host (Jervis *et al*., 1996).

Observations should be made on the behaviour of the candidate agent, noting whether it is attracted to the test organism and whether normal oviposition behaviour takes place. After exposure some hosts should be dissected to determine if eggs were laid and others held until the time when parasitoids would be expected to emerge if oviposition has been confirmed. If no progeny are obtained, the hosts should be dissected to determine the fate of any parasitoid eggs – did they hatch and, if so, were the larvae encapsulated or killed, and at which developmental stage.

Kairomones produced by the host, host substrate, or a combination of the two are frequently used by parasitoids to locate their hosts (Mohyuddin *et al.*, 1981). The role of odours in this process can be investigated using an olfactometer (van Alphen & Jervis, 1996). At its simplest this consists of a Y-shaped tube with the two branches connected to sources of odour (or one odour and a control of clean air) and a pump attached to the stem. Test organisms are placed in the stem and their behaviour observed. More complicated designs enable the comparison of more than two odours at one time and can provide a more natural environment by simulating odour gradients. Care is required in carrying out these experiments to ensure that test organisms are not affected by uneven light intensity or the movement of observers. Thus, such experiments should be replicated sufficiently to allow statistical analysis of the results. In each replicate the position of the odour sources must be changed to overcome the effects of extraneous stimuli and a control included. Responses should be calibrated by comparing the response to the normal host with the response to humid air. The results should only be used to support host specificity statements when analysis shows that they are highly significant. The results of olfactometer tests are not always reliable. Therefore, the results should be confirmed by observing the behaviour of test arthropods exposed to different combinations of test species in cages.

Selecting Non-target and Native *Lygus* Species for Testing with *Peristenus* Parasitoids

Sands (1997) suggested that Wapshere's (1974) centrifugal (phylogenetic) approach for the selection of non-target and native species for host specificity testing with exotic agents is equally applicable in weed and arthropod programmes. However, collection and maintenance of native and target arthropod species for testing with exotic agents poses difficulties. Regarding potential test arthropods, there is a lack of biological and ecological information which often prevents culture of appropriate stages required for testing. In weed biological control programmes (e. g. weed biological programmes performed at CABI Bioscience), it is not uncommon to test 50-100 or more non-target plant species with candidate biological control agents (A. Gassmann, pers. comm., 1998). However, this extensive testing approach might be impractical and often unnecessary in arthropod biological control programmes due to practical problems indicated above. When selecting a centrifugal range of species related to a target pest species, information on the taxa related to the target species in its native range is most useful. However, Sands (1997) indicated that if tribes are not designated for target species, it may be difficult to associate genera or species in groups according to their taxonomic relationship. In addition, Sands (1997) pointed out that "...when testing agents on native species, selected taxa closely related (family, subfamily, tribe or genus) to the target, or in certain cases, those morphologically similar, are often sufficient to provide adequate information on the host specificity of an agent, rather than testing extensive lists of species of distantly-related taxa". Determining the host range of candidate agents in their native system can provide an indication of the range of non-targets that should be tested in the target region.

In the Canadian provinces many species of *Lygus* are morphologically similar, taxonomic character differences are subtle, and in some species there is a wide range of ontogenetic and geographic variation (Schwartz & Foottit, 1992). This variation may reflect recent adaptations and evolution in changing natural and agricultural environments in North America. Additionally, the genus itself and its relationships to other related genera have been difficult to define. Although a comprehensive systematic study of *Lygus*, involving classical and molecular approaches, has just been published (Schwartz & Foottit, 1998), there is a need to determine the genetic variability within *Lygus* species and between populations to determine better the relationships. Taxonomic characters are characterized as primitive or advanced and used to produce a branching diagram (cladogram) which represents the relationships among the species. These cladograms have aided in the recognition of natural groups of *Lygus* species and are useful for defining non-target species to test. Cladograms also provide other types of practical information, for example, that the major pest species, such as *L. lineolaris* and *L. elisus*, are not necessarily closely related. The knowledge of these

relationships is important when attempting to search for biological control organisms for target species of *Lygus* (Foottit & Schwartz, 1996).

For the Palaearctic region, several good references can be used to identify genera and species of *Lygus* (Henry & Lattin, 1987). Southwood & Leston (1959) provide a key to the species and genera of the tribe Mirini found in the British Isles. Stichel's (1958) publication is one of the best for the European species of Miridae. Wagner's (1970-71) key to the Miridae of the Mediterranean region, although still using the name *Exolygus* instead of *Lygus*, is the most recent and comprehensive European reference. However, the systematics of European *Lygus* species needs improvement so it can serve as the basis to define which species have to be sampled in the European environment for non-target studies.

European *Peristenus* Species

An accurate identification of the *Peristenus* species has to be made before considering the release of *Peristenus* species as biological control agents for *Lygus* bugs in North America. There are four *Peristenus* species which attack nymphs of *Lygus* species in alfalfa in western Europe. These include *P. digoneutis*, *P. stygicus*, *Peristenus rubricollis* (Thomson), and *Peristenus conradi* Marsh (Loan, 1974a). Of these *P. digoneutis* and *P. stygicus* are known to be bivoltine (unpublished IIBC Annual Report, 1983). In Poland *P. rubricollis* and *P. digoneutis* attack first generation *L. rugulipennis* in late May or early June, *P. rubricollis* then diapauses (June-July) while *P. digoneutis* continues development and attacks second generation nymphs of *L. rugulipennis* (Loan & Bilewicz-Pawinska, 1973). During a study of the bivoltine alfalfa plant bug, *A. lineolatus*, by IIBC from 1977 to 1985, it was noted that parasitism of *A. lineolatus* by *Peristenus* spp. was higher during the first generation than during the second generation. It was suggested that some of the parasitoid species (i.e. *P. rubricollis*) are univoltine and may attack only the first generation (unpublished IIBC Annual Report, 1982). The following year it was further noted that with the exception of *Peristenus adelphocoridis* Loan which attacks only *A. lineolatus,* the *Peristenus* species also attack *L. rugulipennis* (and possibly other *Lygus* species, i.e. *Lygus pratensis* (L.)) and may switch from *A. lineolatus* to *L. rugulipennis* in August (unpublished IIBC Annual Report, 1983).

Taxonomic reviews of *Peristenus* are available for species from North America (Muesebeck, 1936; Loan, 1974b) and from Europe (Richards, 1967; Loan & Bilewicz-Pawinska, 1973; Loan 1974a). New name combinations were provided (Loan, 1974b) because of the separation of *Peristenus* from *Leiophron* (Loan & Bilewicz-Pawinska, 1973). *Peristenus* larvae have specific characters of setae and head sclerites (Waloff, 1967; Bilewicz-Pawinska, 1974), but their taxonomy is not refined enough to permit identifications to either genus or species. Among current taxonomic problems is the species complex of *Peristenus pallipes* (Curtis), *Peristenus pseudopallipes* (Loan), and *Peristenus adelphocoridis* Loan. Studies should assess the validity of *P. adelphocoridis* and also the status of the North American *P. pallipes* (Loan, 1974b). Although *P. pseudopallipes* is nearly inseparable morphologically from *P. pallipes*, its temporal separation is evidence of species isolation (Loan, 1970). Recently the morphology of *P. digoneutis* was described in detail by Carignan *et al.* (1995).

Host Range of *Peristenus* in the Field and Preliminary Studies on Non-target Effects of *Peristenus* in the Laboratory

Loan & Shaw (1987) reported that the genus *Peristenus* is known to be host specific to the family Miridae. Reared insects are rare and the parasitoids are not well known, although their plant bug hosts are the commonest of the Heteroptera. For example in the British Isles, six species of *Peristenus* have been associated with hosts (Brindley, 1939; Richards, 1967; Waloff, 1967; Loan & Bilewicz-Pawinska, 1973). In North America, hosts are known for 14 species of *Peristenus* (Loan 1980). In a comprehensive Polish study by Bilewicz-Pawinska (1982) in 1976-1979, over 20,000 plant bugs were collected belonging to five Mirini species. The *Peristenus*–host associations determined by Bilewicz-Pawinska (1982) are compiled in Table 1. Loan (1980) concluded that of the few host-associated *Peristenus* species all have a restricted host range, some are monophagous and others attack a small number of species on the same plant or type of plant growth.

Table 1: *Peristenus*-host associations determined in a Polish field study by Bilewicz-Pawinska (1982). In total, over 20,000 plant bugs belonging to five Mirini species were collected in 1976-1979. (For collection and rearing methods see Bilewicz-Pawinska (1982).)

Peristenus species	Host species *Lygus rugulipennis* Poppius	*Stenodema virens* (L.)	*Trigonotylus coelestialium* Kirkaldy	Notostira erratica (L.)	*Leptopterna dolobrata* (L.)
P. rubricollis (Thomson)	X				
P. digoneutis Loan	X				
P. stygicus Loan	X		X		
P. stenodemae Loan		X			
P. pallipes (Curtis)			X	X	X
P. obscuripes Thomson			X		X

Condit & Cate (1982) carried out a study entitled "Determination of host range in relation to systematics for *Peristenus stygicus*, a parasitoid of Miridae" in the laboratory. This study examined *P. stygicus* behaviour and determined its potential both on insects attacked by related parasitoids, and insects related to *Lygus* bugs, and to assure its safety on beneficials commonly associated with *Lygus*. *Lygus rugulipennis*, *Adelphocoris* sp., and *Polymerus unifasciatus* (F.), all in the subfamily Mirinae, were recorded as hosts for this parasitoid in Europe and Asia Minor (Condit & Cate 1982). Therefore, Condit & Cate (1982) hypothesized that its hosts may all be related within the subfamily Mirinae. Species selected for experiments represent each subfamily of Miridae and the family Lygaeidae (Table 2). The lygaeids were included since they are known hosts of *Euphorus* and *Euphoriana* (Braconidae: Euphorinae), which are both close relatives of the genus *Peristenus* (Condit & Cate 1982).

Table 2: The potential host range of *Peristenus stygicus*, as determined in a laboratory study by Condit & Cate (1982).

Mirid species tested	Number of hosts exposed	Number of hosts attacked	Number of *Peristenus* larvae emerged
Mirinae			
Lygus lineolaris (Palisot de Beauvois)	680	223	125
Lygus hesperus Knight	60	14	7
Polymerus basalis (Reuter)	2	1	1
Taedia johnstoni (Knight)	14	0	0
Dichrooscytus spp.	78	53	0
Orthotylinae			
Lindbergocapsus geminatus (Johnston)	186	6	2
Phylinae			
Microphylellus maculipennis (Knight)	73	8	0
Pseudatomoscelis seriatus (Reuter)	180	61	23
Bryocorinae			
Halticotoma valida (Reuter)	134	0	0
Hesperolabops gelastops Kirkaldy	80	0	0

The results reported by Condit & Cate (1982) are summarized in Table 2. Condit & Cate (1982) stated that all representatives selected of the subfamily Mirinae were acceptable for attack except *Taedia johnstoni* (Knight). Parasitoid larvae developed in each of these acceptable species, although they failed to emerge from *Dichrooscytus* spp. specimens. In addition it was reported that Orthotylinae and Phylinae are acceptable hosts for *P. stygicus*. The attack of *Microphylellus maculipennis* (Knight) and the 2nd orthotyline (undetermined!) was regarded in these experiments as acceptance. In fact, this may have been a recognition response, not actual oviposition. In general Condit & Cate (1982) concluded that Mirinae, Phylinae and Orthotylinae belonged to the host range of *P. stygicus*. The response of the parasitoid to the mirid species was independent of the type of plant, and Condit & Cate (1982) concluded that the host insect species itself plays a larger role in acceptability to the parasitoid.

Conclusions

In recent years, there has been growing concern about the potential or actual threat posed by alien entomophagous biological control agents to populations of native non-target arthropod species (Goldson & Phillips, 1990; FAO, 1997). The use of polyphagous, highly dispersive insects, such as some entomophagous biocontrol agents, has been seen to pose risks of reducing non-target hosts to low levels or extinction (Horn, 1991; Howarth, 1991; Samways, 1994). Some information is available on native, non-target hosts utilized by exotic agents but very little information is available on their influence on the density of these host populations. However, there are no recorded examples of monophagous or narrowly oligophagous agents changing their host range to cause damage to beneficials, native plants or non-target insects (Waterhouse, 1991). Information on the host species attacked in the native habitat of the parasitoid is needed to determine the adaptation potential of an agent in a particular habitat. Thus, procedures for assessing the risks presented to non-target organisms have become an essential part of agent selection to be considered prior to release (Field & Darby, 1991; Goldson *et al*., 1992).

Sands (1993) identified that there are difficulties in interpretation of results from laboratory screening tests for entomophagous insects. It is extremely difficult to reproduce accurately the cues and stimuli that influence the behaviour of a parasitoid in a natural environment. Furthermore, during laboratory screening tests for entomophagous insects, the potential biological control agent may accept a broader range of hosts than in nature, over-estimating field host range (Loan & Holdaway, 1961). However, Shaw (1994) pointed out that the host range of an apparently strictly monophagous parasitoid species may not be constant, either in space or time. It could expand in environments with higher diversity and hence a larger number of new potential hosts to switch to. Often small containers are used for biological control agents to induce oviposition, feeding, or development in arthropod hosts. Sands & Papacek (1993) reported that restricted space often leads to an inaccurate assessment of host specificity by disrupting host recognition and acceptance; for example, oviposition in hosts normally not supporting their development, or development within hosts normally not accepted in the field. Other studies (Field & Darby, 1991) indicated that choice tests with arthropod target and non-target species exposed to an agent at the same time should be interpreted with caution leading to the recommendation from Sands & Papacek (1993) that choice tests are better avoided when alternative methods are available.

How will the predicted host range correspond with the observed host range after release in the field? There are, as yet, insufficient studies on the laboratory host range of parasitoids that have been compared with field observations to have absolute confidence in predictions. As noted above, laboratory tests will suggest a wider host range than that actually observed in the field, which is why laboratory cultures of some parasitoids can be established on hosts other than those normally observed in the field. One can also extrapolate from studies on weed biological control agents, where laboratory-based host specificity testing has been shown to be a reliable but conservative predictor of field host range (i.e. more potential hosts are found in laboratory tests than are observed in the field).

The assessment of potential risks for introducing European *Peristenus* species as biological control agents of *Lygus* species in North America requires a cooperative study in Europe and North America. It would be favourable to coordinate different working groups and to work on scientific questions arising. There is an opportunity to work on the following topics:

European Requirements

- clarification of the biology and ecology of *Peristenus* species in Europe;
- assessment of the potential host range of *Peristenus* by using field collected mirids in different European crop systems;

Taxonomic Requirements

- clarification of the taxonomy of European *Lygus* species by using cladograms;
- phylogeny and identification of European and North American *Peristenus* species;
- preparation of keys for identification of nymphs of European *Lygus* and identification keys for larvae of *Peristenus*;

Rearing Requirements

- testing of rearing methods for *Peristenus* species;
- development of rearing techniques for potential non-target mirid species of *Peristenus*;

Risk Assessment Requirements

- development of suitable techniques for host specificity determination of *Peristenus* on selected native North American *Lygus* species in quarantine;
- assessment of non-target hosts of *P. digoneutis* after establishment in the northeastern United States and southeastern Canada;
- construction of a final experimental protocol to assess non-target host species of each *Peristenus* species and to fulfil requirements associated with obtaining a permit for introduction and release in North America;
- assembling a dossier providing all available information to assess the risks, which ultimately is the decision of the receiving state – consulting with its neighbours as appropriate – to balance the potential benefits against the potential costs and make the decision whether to proceed or not with release of *Peristenus* species.

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