

New, Native Species of *Peristenus* (Hymenoptera: Braconidae) Parasitizing *Lygus hesperus* (Hemiptera: Miridae) in Idaho: Biology, Importance, and Description

W. H. DAY,¹ C. R. BAIRD,² AND S. R. SHAW³

Ann. Entomol. Soc. Am. 92(3): 370-375 (1999)

ABSTRACT *Lygus hesperus* Knight and *L. lineolaris* (Palisot) are important pests of numerous fruit, vegetable, fiber, tree, and seed crops in North America. We discovered *Peristenus howardi* n. sp., described in this article, parasitizing *L. hesperus* nymphs in alfalfa grown for seed in Idaho. Parasitism rates were surprisingly high, 81% in generation I (1998), and 44–51% in generation II (1997 and 1998). This braconid wasp may be a practical biological control factor for alfalfa and other seed crops, and further research is warranted. We found that *P. howardi* is a native species, is thelytokous, has three generations per year, and produces some diapausing parasites in each generation. The geographic range of this species is not yet known. *P. howardi* readily parasitized the eastern *L. lineolaris* in laboratory tests, so it is also a potential biocontrol agent for this related mirid species.

KEY WORDS *Lygus*, *Peristenus*, alfalfa, biological control, parasites

TWO SPECIES OF *Lygus* are significant pests of numerous agricultural crops over large areas of the United States and Canada—*Lygus lineolaris* (Palisot) (Kelton 1975, 1982), which is most important east of the Rocky Mountains, and *L. hesperus* Knight, which is a major pest west of the Rockies (Clancy and Pierce 1966; Kelton 1975, 1982). Both mirids are native species with very broad host ranges, which include fruit, vegetable, fiber, tree, and seed crops (Robinson 1954; Kelton 1975, 1982; Scott 1977; Young 1986; Schowalter and Stein 1987; Johnson and Lyon 1988).

The economic importance of these *Lygus* spp. has stimulated several attempts since the 1960s to develop classical biological control systems to reduce their numbers (Clancy and Pierce 1966, Van Steenwyk and Stern 1977, Craig and Loan 1987, Day 1987, Schuster 1987). Day et al. (1990) achieved the first permanent establishment of a European parasite of *Lygus* in North America, *Peristenus digoneutis* Loan, and Day (1996) later demonstrated that it had significantly reduced *L. lineolaris* numbers in forage alfalfa in New Jersey. This parasite has continued to thrive—it has dispersed into seven northeastern states (Day et al. 1998), and probably is also present in Quebec and Maine.

In the Snake River Valley of southwestern Idaho, where *L. hesperus* is an important pest of alfalfa and other seed crops, W.H.D. and C.R.B. began research in 1997 to determine if any native parasites of *L. hesperus* nymphs were present, and if so, to measure their impact. Earlier studies in the northeastern United

States found that native parasites were unimportant even though *L. lineolaris* is a native species, probably because the major crops attacked by this pest all had been introduced from other continents (Day 1996). Nevertheless, we subsequently discovered that a braconid parasite was killing a high percentage of *L. hesperus* nymphs in Idaho. And, although adults of this species superficially resembled two *Peristenus* spp. found in northeastern alfalfa, *P. pallipes* (Curtis) and *P. pseudopallipes* (Loan) (Day 1987), W.H.D. observed sufficient biological differences to indicate that the Idaho species was distinct. Later, adult parasites reared at Newark, DE, from Idaho hosts were examined by P. M. Marsh (USDA, retired) and S.R.S. and were determined to be a new species.

This article provides life cycle and preliminary field parasitism data for the Idaho parasite and describes it as a new species.

Materials and Methods

Field Samples. In 1997 and 1998, sweep net samples were periodically made in a seed alfalfa field at the University of Idaho Parma Research & Extension Center, in the Boise valley of southwestern Idaho. When *L. hesperus* nymphs were numerous, they were placed in USDA-BIRL insulated shipping containers, and sent via overnight express to the USDA Beneficial Insects Research Laboratory at Newark, DE. These samples were promptly counted, and divided into two unequal aliquots. One aliquot was reared (a total of 16 samples for 1997, at average of 9-d intervals, total 2,691 nymphs) in laboratory cages to obtain the adult parasites required for identification, and the other (16 samples for 1997, at same intervals, total 265 nymphs; and 261 nymphs in 15 samples, for 1998) was frozen for

¹ Beneficial Insects Research Laboratory, USDA, 501 S. Chapel Street, Newark, DE 19713.

² Parma Research & Extension Center, University of Idaho, Parma, ID 83660.

³ Entomology Section, Department of Renewable Resources, University of Wyoming, Laramie, WY 82071-3354.

Table 1. Parasitism of *L. hesperus* nymphs at Parma, Idaho, by dissection

Data	1997		1998		
	Gen. II 15 July-4 Aug.	Gen. III 4 Sept.-14 Oct.	Gen. I 20 May-8 July	Gen. II 15 July-5 Aug.	Gen. III 12 Aug.-23 Sept.
No. nymphs dissected	80	42	83	80	98
No. parasitized	35	7	67	41	5
Parasitism rate	44%	17%	81% ^a	51%	5%

Generation numbers were estimated, based on the relative abundance of *L. hesperus* nymphs in field samples. Gen, generation.

^a High parasitism rate may be a result of a low host population, caused by cool, wet weather (C.R.B., unpublished data).

later dissection to determine accurately the percentage of parasitism. Details on the methods used are in Day (1994, 1996). Because diapause will delay completion of the rearing procedure for the 1998 samples until mid-1999, these data are not included here.

Results and Discussion

Parasitism Level. The first three Idaho samples from alfalfa (July 1997) dissected at Newark had an average parasitism rate of 47%. This is six times higher than the average July (*Lygus* generation II) parasitism by native species in New Jersey alfalfa (8%; Day et al. 1990), so was unexpected. Now, after nearly 2 yr of sampling, it is obvious that parasitism is much higher in Idaho (Table 1) than by native parasites in New Jersey (8%) or Delaware (W.H.D., unpublished data).

The high parasitism rates in Table 1 suggest that considerable suppression of *L. hesperus* is occurring in unsprayed and unmowed seed alfalfa at Parma. Future research is needed to determine if this suppression is sufficient to maintain *L. hesperus* populations below the economic threshold.

These data also indicate that the new *Peristenus* is multivoltine, and show that the first two generations of *Lygus* (the most economically important) are both highly parasitized. As has been observed previously with other mirids (Day 1994), parasitism of duplicate samples in 1997 was much lower (6%, $n = 1,413$) using the rearing method.

Sex Ratio. On 16 October 1997, we randomly selected 11 parasites that had emerged from collections

at Parma. All subsequently pursued and oviposited in *Lygus* nymphs, indicating that all were females. This suggested that the new species was mostly or entirely thelytokous. This was later confirmed: of the 608 adult parasites reared through July 1998 (74 from Idaho field collections ex *L. hesperus* and 534 from Newark lab cultures ex *L. lineolaris*), only one (laboratory-reared) was a male, demonstrating that the new *Peristenus* is principally thelytokous, as is *P. conradi* (Table 2).

Peristenus howardi Shaw, new species

Description of Holotype Female. Body length ≈ 2.4 mm. Body color black, except antenna, maxilla, labium, legs, and wing venation brown; mandible reddish brown. Head (Fig. 1) mostly smooth, except frons shallowly punctate; median frontal carina distinct, nearly reaching median ocellus; face densely covered with silvery setae, otherwise head sparsely setose; eyes distinctly converging anteriorly; length of malar space equal to mandible width; flagellum (Fig. 2) with 18 flagellomeres, apical flagellomere 1.75 times longer than wide; eye-ocellus distance 3 times wider than lateral ocellus; occipital carina distinct and complete dorsally. Mesosoma extensively sculptured and sparsely but distinctly setose; pronotum (Fig. 3) rugose medially and laterally, otherwise smooth with scattered punctures; mesoscutum (Fig. 4) with notauli foveate, V-shaped, meeting posteriorly; median disc of mesoscutum smooth with scattered setose punctures, lateral disc smooth and with distinctly less setose

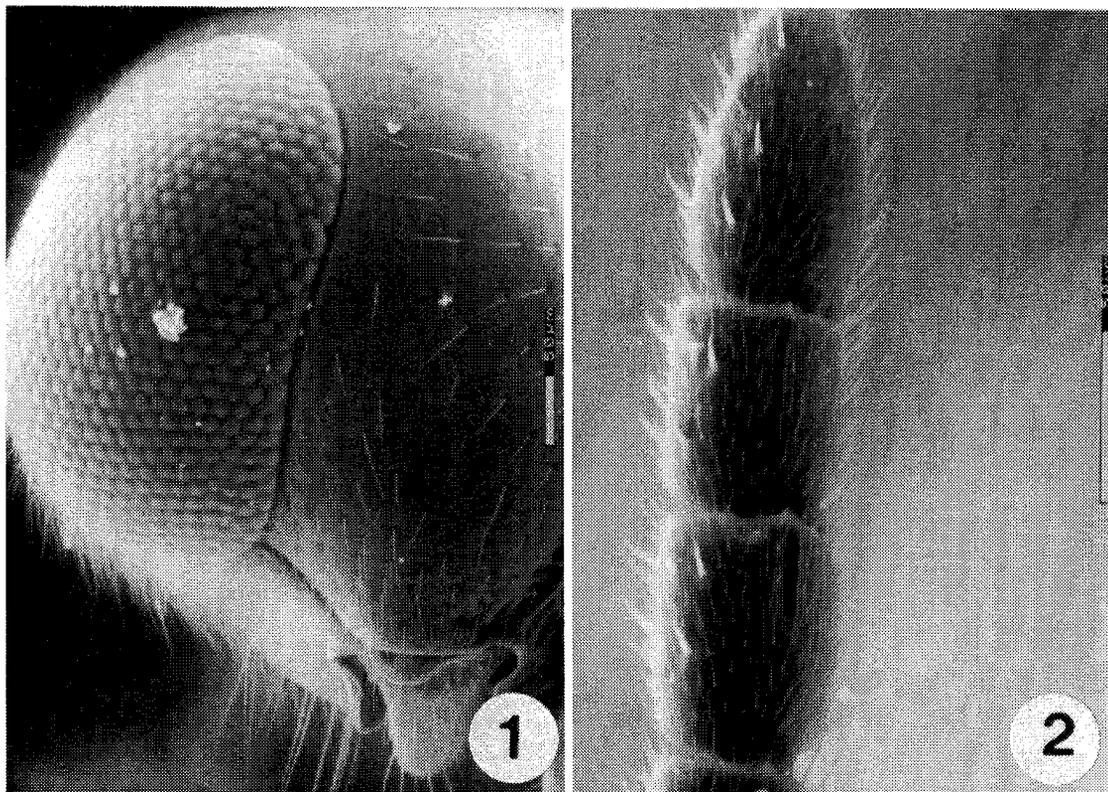
Table 2. Biological differences between braconid parasites that attack *Lygus* nymphs in the U.S.

Species	Native to North America	Known range	Principal hosts		% female	Generations/year
			Insects	Plants		
<i>Peristenus pallipes</i>	+	NE	MPB, SGGB	Grasses	50	1
<i>P. pseudopallipes</i>	+	NE	TPB	<i>Erigeron</i>	50	1
<i>P. howardi</i>	+	ID	WTPB	Alfalfa	99	2-3
<i>P. conradi</i>	-	^a	APB	Alfalfa	98	1
<i>P. digoneutis</i>	-	^b	TPB	Alfalfa	50	2-3
<i>Leiothron uniformis</i>	+	US	GFH	Alfalfa	50	2-3

NE, known from northeastern United States and southeastern Canada, but probably more widespread. US, probably present in all 48 contiguous states. ID, known only from Idaho, but probably occurs elsewhere. Although all six parasite species will attack *Lygus* spp. in nature, three species primarily parasitize other mirids, as noted here. These host preference data are based on rearings from over 22,500 field-collected mirid nymphs of eight species (W.H.D., unpublished data). The mirid hosts are MPB, meadow plant bug, *Leptopterna dolabrata* (L.); SGGB, slender green grass bug, *Trigonotylus caelestialium* (Kirkaldy); TPB, tarnished plant bug, *L. lineolaris* (Palisot); WTPB, western tarnished plant bug, *L. hesperus* Knight; GFH, garden flea hopper, *Halticus bractatus* (Say); APB, alfalfa plant bug, *Adelphocoris lineolatus* (Goeze).

^a Found in Delaware, New Jersey, and New York (Day et al. 1998).

^b Detected in Connecticut, Massachusetts, New Hampshire, New Jersey, New York, Pennsylvania, and Vermont (Day et al. 1998).



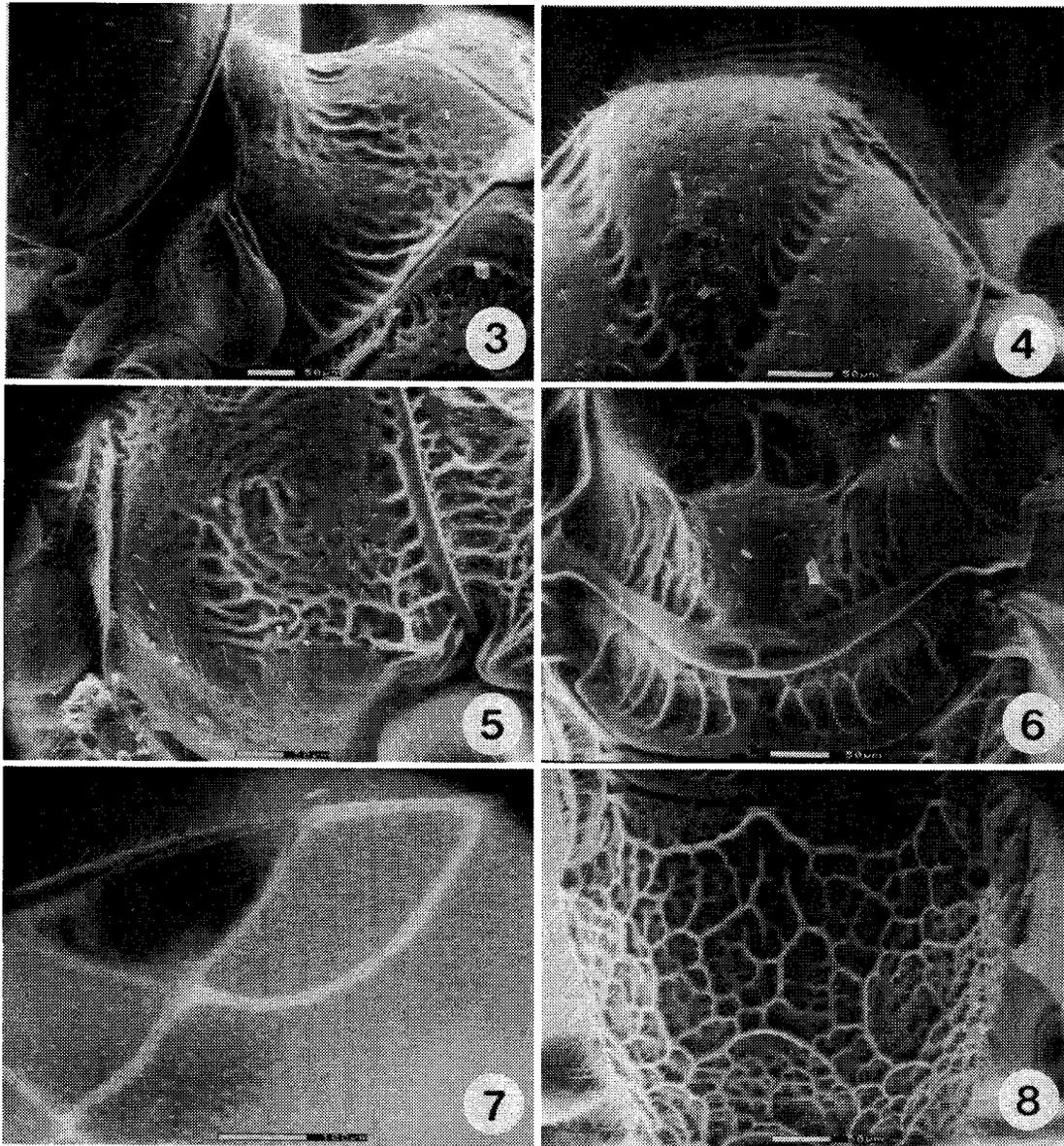
Figs. 1-2. (1) Lateral view of head, 200 \times . (2) Apex of flagellum, 495 \times .

punctures; mesopleuron (Fig. 5) with sternaulus indicated by coarse rugose to foveate sculpture, coarsely punctate dorsally, ventrally smooth with sparse setose punctures; scutellum (Fig. 6) with furrow 2-foveate, median disc smooth and sparsely punctate, lateral areas reticulate-rugose, and posterior margin smooth with two small submedial foveae; metanotum (Fig. 6) coarsely foveate, posterior margin smooth; forewing (Fig. 7) with stigma 2.2 times longer than wide; Rs vein emerging directly off stigma posteromedially with no trace of vein r, curving evenly toward anterior wing margin to form short marginal cell; marginal cell along wing margin 0.64 times as long as stigma; propodeum (Fig. 8) finely reticulate areolate. Metasoma (Figs. 9-11) with tergum 1 coarsely sculptured, otherwise entirely smooth and highly polished; petiolate tergum 1 narrow basally, 2 times wider posteriorly than at narrowest subanterior point; tergum 1 with foveate dorsopes (Fig. 9), sculpture mostly longitudinally rugose, irregularly foveate posteromedially and anterolaterally (Fig. 10), first metasomal spiracle situated slightly posterior to midpoint of segment; hypopygium (Fig. 11) densely setose medially and posteriorly; ovipositor (Fig. 11) very short, smooth, and slightly curved.

Variation, Paratype Females. Essentially as in holotype except flagellum with 18-19 flagellomeres; leg color varying from yellowish brown to dark chocolate brown; body length appearing to vary from 2.0-2.8 mm, depending on position of metasoma at death.

Type Data. HOLOTYPE female: IDAHO, Canyon County, Parma, 4 August 1997, C. R. Baird, host: *L. hesperus* nymph swept in alfalfa, emerged 3 September 1997. Deposited in University of Wyoming Insect Museum, Laramie. PARATYPES: 2 females, same data as holotype; 2 females, same data as holotype except emerged 2 September; 10 females, Delaware, Newark, laboratory reared ex. *Lygus lineolaris*, emerged November 1997 to January 1998, J. M. Tropp, original source: Parma, ID, ex. *L. hesperus*. Paratypes deposited at University of Wyoming Insect Museum, and U.S. National Museum of Natural History, Washington, DC.

Remarks. Terminology used in the description follows that of Sharkey and Wharton (1997). This new species is a typical member of the genus *Peristenus* and can be keyed to genus without difficulty using the key provided by Shaw (1997). In the key to North American *Peristenus* species by Loan (1974) this species keys with difficulty to couplet 3 along with *P. pseudopallipes* Loan, but it can be distinguished from that species by having darker brown legs, less coarsely punctate frons, no trace of vein r at junction of stigma and vein Rs, often fewer flagellomeres, and populations with no males. In *P. pseudopallipes* the legs are lighter and distinctly yellow, the frons is very coarsely punctate, there is a short but distinct stub of vein r at junction of stigma and vein Rs, flagellomeres vary from 17 to 22 in females, and males are normally present. Likewise, in the key to euphorine parasites of *Lygus* by



Figs. 3–8. (3) Lateral view of pronotum, 200 \times . (4) Dorsal view of mesoscutum, 280 \times . (5) Lateral view of mesopleuron, 200 \times . (6) Dorsal view of scutellum and metanotum, 250 \times . (7) Anterior margin of fore wing showing stigma, first marginal cell, and first submarginal cell, 185 \times . (8) Dorsal view of propodeum, 250 \times .

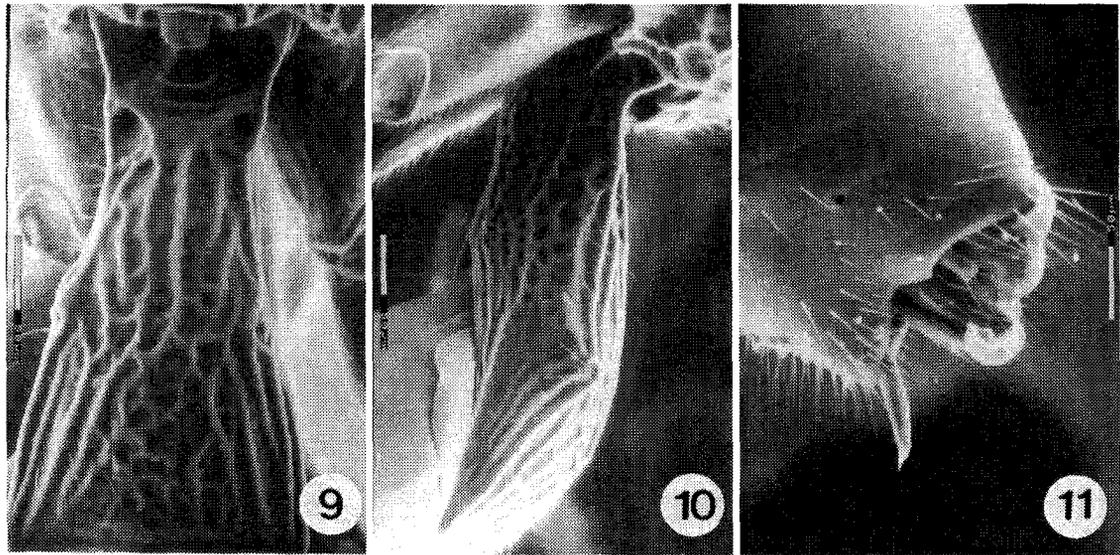
Loan and Shaw (1987) this species keys to *P. pseudo-pallipes* at couplet 7. In addition, to the above mentioned characters, careful comparison of Fig. 9 with Fig. 3B of Loan and Shaw (1987) indicates that the petiole is slightly narrower in *P. howardi*.

Etymology. This species is named in honor of Maurice L. Howard of Pueblo, CO, in recognition of his generous contributions to the development of the U.W. Insect Museum collections over the past several years.

Other Host Mirids. J. M. Tropp has successfully reared *P. howardi* at Newark on *L. lineolaris* since October 1997, so it is clear that this species will accept

another mirid in the same genus as its original host. All 6 parasite species studied at Newark to date predominantly attack only one or two mirids in nature (Table 2; Day, unpublished data).

Diapause. Three of the six parasite species known to attack *Lygus* nymphs in the United States (Table 2) have an obligate diapause, and thus produce only one generation per year. The Idaho species, however, is multivoltine; $\approx 30\%$ of 67 parasites reared from our 1997 field collections (eight samples, from 15 July to 8 September) did not diapause. Our first year of field observations suggest that this parasite has three generations per year at Parma. We do not yet have suf-



Figs. 9–11. (9) Dorsal view of petiolate tergum 1, 300 \times . (10) Lateral view of petiolate tergum 1, 250 \times . (11) Lateral view of apex of metasoma showing hypopygium and ovipositor, 300 \times .

ficient data to determine if the incidence of diapause increases as the season progresses. In laboratory tests at Newark, most (71%, $n = 113$) did not diapause, but this may have been caused by the different host (*L. lineolaris*) or by the long photoperiod of 16:8 (L:D) h.

Geographic Range and Host Plants. When the above description for *P. howardi* was written, this species had been reared only from *L. hesperus* nymphs collected on alfalfa, at Parma, ID. None had been detected in weekly *L. hesperus* samples from alfalfa in central California (240 miles to the south) by our cooperater (Fresno area, S. Mueller) during 1998. However, it appeared likely that this species might be present elsewhere in the Idaho–Oregon–Washington region, and perhaps also in southwestern Canada. Subsequently, four specimens reared from *L. hesperus* collected at Prosser, WA (on 19 September 1995 by E. Miliczky), were determined to be *P. howardi* by S.R.S. (Mayer et al. 1998). Additional research will be necessary to define the geographic range of this parasite, and to learn if it is significantly parasitizing *Lygus* on crops other than alfalfa in the Parma area.

Implications for the Future. The fact that the high mortality of *L. hesperus* nymphs discussed above (Table 1) is occurring in alfalfa grown for seed suggests several approaches for future research. Insecticide treatments for *Lygus* control in seed alfalfa fields (and perhaps in other seed crops) could be reduced or modified, to determine if parasitism of *Lygus* will increase sufficiently to adequately suppress plant bug damage. The risk of reduced pollination of alfalfa, caused by leafcutter bee mortality, might also be avoided if chemical controls were used less frequently.

It is instructive that this new parasite was not discovered until recently, despite the widespread economic importance of *L. hesperus* and the fact that the host and parasite are both native species. As Table 3

demonstrates, 67% of European (four of six) and North American (two of three) *Peristenus* species were only recently described. These data support the estimates of Packer and Taylor (1997) that about half of all insect species have not yet been described, and also suggest that other pests of crops may have significant natural enemies that have not yet been discovered, and might be of use in biological control programs.

Finally, the successful rearing of *P. howardi* on *L. lineolaris* at Newark, now in the F_4 generation, indicates that this parasite might be an effective biological control factor in the eastern United States. One is especially needed south of latitude 41° N, where *P. digoneutis* has failed to establish (Day et al. 1998). If

Table 3. Parasites of *Lygus* spp. and *Adelphocoris lineolatus* nymphs in the United States and western Europe

<i>Peristenus</i> species	Native to	Species described after 1972	Principal hosts
1. <i>adelphocoridis</i> Loan	Western Europe	+	APB
2. <i>conradi</i> Marsh	Western Europe	+	APB
3. <i>digoneutis</i> Loan	Western Europe	+	ETPB
4. <i>howardi</i> Shaw	North America	+	WTPB ^a
5. <i>pseudopallipes</i> (Loan)	North America	+	TPB
6. <i>rubricollis</i> (Thomson)	Western Europe	–	ETPB, APB
7. <i>stygius</i> Loan	Western Europe	+	ETPB
8. <i>pallipes</i> (Curtis)	Western Europe	–	unkn.
	North America ^b	–	MPB, SGGB ^b

ETPB, European tarnished plant bugs; *Lygus pratensis* (L.) and *L. rugulipennis* Poppius. Other abbreviations are explained in Table 2.

^a Based on preliminary data.

^b Although *P. pallipes* has been assumed to be an holarctic species, the clear preference of this parasite for these two accidentally introduced European mirids (W.H.D., unpublished data) suggests that *P. pallipes* may also have been introduced.

P. howardi became established and was effective here, it would increase the area where biological control is a practical alternative to insecticides for the suppression of this important pest of many crops.

Acknowledgments

We thank J. M. Tropp (Newark) for his conscientious technical assistance, P. M. Marsh (USDA-SEL, retired) for taxonomic advice, S. Mueller for field collections, and N. Brady for typing. R. A. Byers, A. T. Eaton, and an anonymous reviewer suggested significant improvements to the manuscript.

References Cited

- Clancy, D. W., and H. D. Pierce. 1966. Natural enemies of some lygus bugs. *J. Econ. Entomol.* 59: 853-858.
- Craig, C. H., and C. C. Loan. 1987. Biological control efforts on Miridae in Canada, pp. 48-53. *In* R. C. Hedlund and H. M. Graham [eds.], *Economic importance and biological control of Lygus and Adelphocoris in North America*. USDA-ARS 64.
- Day, W. H. 1987. Biological control efforts against *Lygus* and *Adelphocoris* infesting alfalfa in the United States, with notes on other associated species, pp. 20-39. *In* R. C. Hedlund and H. M. Graham [eds.], *Economic importance and biological control of Lygus and Adelphocoris in North America*. USDA-ARS 64.
1994. Estimating mortality caused by parasites and diseases of insects: comparisons of the dissection and rearing methods. *Environ. Entomol.* 23: 543-550.
1996. Evaluation of biological control of the tarnished plant bug (Hemiptera: Miridae) in alfalfa by the introduced parasite *Peristenus digoneutis* (Hymenoptera: Braconidae). *Environ. Entomol.* 25: 512-518.
- Day, W. H., R. C. Hedlund, L. B. Saunders, and D. Coutinot. 1990. Establishment of *Peristenus digoneutis* (Hymenoptera: Braconidae), a parasite of the tarnished plant bug (Hemiptera: Miridae), in the United States. *Environ. Entomol.* 19: 1528-1533.
- Day, W. H., J. M. Tropp, A. T. Eaton, R. F. Romig, R. G. Van Driesche, and R. J. Chianese. 1998. Geographic distributions of *Peristenus conradi* and *P. digoneutis* (Hymenoptera: Braconidae), parasites of the alfalfa plant bug and the tarnished plant bug (Hemiptera: Miridae) in the northeastern United States. *J. N.Y. Entomol. Soc.* 106: 69-75.
- Johnson, W. T., and H. H. Lyon. 1988. *Insects that feed on trees and shrubs*. Cornell University Press, Ithaca, NY.
- Kelton, L. A. 1975. The lygus bugs (genus *Lygus* Hahn) of North America (Heteroptera: Miridae). *Mem. Entomol. Soc. Can.* 95.
1982. Plant bugs on fruit crops in Canada. *Agric. Can. Monogr.* 24.
- Loan, C. C. 1974. The North American species of *Leiothron* Nees, 1818 and *Peristenus* Foerster, 1862 (Hymenoptera: Braconidae, Euphorinae) including the description of 31 new species. *Le Nat. Can.* 101: 821-860.
- Loan, C. C., and S. R. Shaw. 1987. Euphorine parasites of *Lygus* and *Adelphocoris* (Hymenoptera: Braconidae and Heteroptera: Miridae), pp. 69-75. *In* R. C. Hedlund and H. M. Graham [eds.], *Economic importance and biological control of Lygus and Adelphocoris in North America*. USDA-ARS 64.
- Mayer, D. F., C. R. Baird, and B. Simko. 1998. *Peristenus* (Hymenoptera: Braconidae) parasites of *Lygus hesperus* (Hemiptera: Miridae) in the Pacific Northwest. *J. Entomol. Soc. Br. Col.* 95: 53-57.
- Packer, L., and J. S. Taylor. 1997. How many hidden species are there? *Can. Entomol.* 129: 587-594.
- Robinson, R. W. 1954. Seed germination problems in the Umbelliferae. *Bot. Rev.* 20: 531-550.
- Schowalter, T. D., and J. D. Stein. 1987. Influence of douglasfir seedling provenance and proximity to insect population sources on susceptibility to *Lygus hesperus* in a forest nursery in western Oregon. *Environ. Entomol.* 16: 984-986.
- Schuster, M. F. 1987. Biological control of plant bugs in cotton, pp. 13-19. *In* R. C. Hedlund and H. M. Graham [eds.], *Economic importance and biological control of Lygus and Adelphocoris in North America*. USDA-ARS 64.
- Scott, D. R. 1977. An annotated listing of host plants of *Lygus hesperus* Knight. *Bull. Entomol. Soc. Am.* 23: 19-22.
- Sharkey, M. J., and R. A. Wharton. 1997. Morphology and terminology, pp. 19-38. *In* R. A. Wharton, P. M. Marsh, and M. J. Sharkey [eds.], *Manual of the New World Genera of the Family Braconidae*. Special publication No. 1. International Society of Hymenopterists, Washington, DC.
- Shaw, S. R. 1997. Subfamily Euphorinae, pp. 235-256. *In* R. A. Wharton, P. M. Marsh, and M. J. Sharkey [eds.], *Manual of the New World genera of the family Braconidae*. Special publication No. 1. International Society of Hymenopterists, Washington, DC.
- Van Steenwyk, R. A., and V. M. Stern. 1977. Propagation, release, and evaluation of *Peristenus stygicus*, a newly imported parasite of lygus bugs. *J. Econ. Entomol.* 70: 66-69.
- Young, O. P. 1986. Host plants of the tarnished plant bug, *Lygus lineolaris* (Heteroptera: Miridae). *Ann. Entomol. Soc. Am.* 79: 747-762.

Received for publication 10 November 1998; accepted 5 February 1999.