Bulletin of Insectology **65** (1): 81-87, 2012
ISSN 1721-8861

Distribution and abundance of nymphal parasitoids of *Lygus rugulipennis* and *Adelphocoris lineolatus* in northwestern Italy

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Abstract

The European tarnished plant bug *Lygus rugulipennis* Poppius and the alfalfa plant bug *Adelphocoris lineolatus* (Goeze) (Rhynchota Miridae) are widespread in Italy and in many other European countries, where they are often noxious to several crops. Since the chemical control of these plant bugs is difficult, a three-year study was carried out in Piedmont (NW-Italy), to assess the presence of nymphal parasitoids, and evaluate their efficacy in controlling pest infestations. From May to September in 2001, 2002 and 2003, plant bug populations were sampled on different crops (alfalfa, meadow habitat, peach orchard groundcover, strawberry, sunflower, wheat). Overall 4092 and 1529 nymphs of *L. rugulipennis* and of *A. lineolatus*, respectively, were field-collected and reared in the laboratory to allow parasitoid development. Parasitism levels varied in relation to the year and the crop, but it was generally lower than 10%; higher percentages, between 10 and 30%, were found for *L. rugulipennis* nymphs collected on alfalfa, meadow habitat and wheat. *Peristenus digoneutis* Loan (86.0%) and *Peristenus relictus* (Ruthe) (9.9%) (Hymenoptera Braconidae) emerged from parasitized plant bug nymphs. In the surveyed agroecosystems *P. digoneutis* completed three generations as did its host *L. rugulipennis*: after overwintering in the cocoons in the soil, adults emerged in late March. In spring they attacked plant bug nymphs mainly on winter cereals; adults of the new generation emerged in late May-early June, and migrated to other plants in search of hosts. Subsequent adult emergences overlapped over the summer.

Key words: European tarnished plant bug, alfalfa plant bug, *Peristenus digoneutis*, *Peristenus relictus*, parasitism, field surveys.

Introduction

Among the insect pests belonging to the family Miridae (Rhynchota Heteroptera), the European tarnished plant bug (ETPB) *Lygus rugulipennis* Poppius, and the alfalfa plant bug (APB) *Adelphocoris lineolatus* (Goeze) are reported as the most noxious and widespread species in Italy and in many other European countries. Both are polyphagous, since *L. rugulipennis* can live and reproduce on a large host range even if it prefers herbaceous plants belonging to Fabaceae, Asteraceae, and Brassicaceae (Holopainen and Varis, 1991), while *A. lineolatus* prefers mainly *Medicago sativa* L. and *Trifolium* spp. (Fabaceae) (Craig, 1963; Accinelli *et al.*, 2002). The two species show major differences in their life cycles. In northwestern Italy, *L. rugulipennis* completes 3-4 generations a year and overwinters as adults, whereas *A. lineolatus* has only 2 generations a year and overwinters as eggs (Cravedi and Carli, 1987; Rancati *et al.*, 1996; Accinelli *et al.*, 2002).

In Europe, these two mirid species with their feeding activity can often become noxious to several crops, both herbaceous and arboreous plants, such as peach and nectarine (Pansa *et al.*, 2008), apple (Culatti *et al.*, 1992), kiwi fruit (Carli *et al.*, 1987), strawberries (Easterbrook, 2000; Pansa and Tavella, 2009), sunflower (Colazza and Bin, 1990), and lettuce (Accinelli *et al.*, 2005).

Chemical control of these insect pests and of mirids in general is very difficult because of their high polyphagy, their extreme mobility and the high density of their populations. These characteristics make them extremely adaptable to different types of environment and able to easily colonize the crops (Accinelli *et al.*, 2002). Therefore, special attention has been recently addressed to their biological control with the fungus *Beauveria bassiana* (Balsamo-Crivelli) Vuillemin (Noma and Strickler, 2000), and several arthropod predators (Hagler, 2011) and parasitoids (Day, 1996; Williams *et al.*, 2003a).

In particular, among the parasitoids of plant bugs, some species of Mymaridae and Braconidae (Hymenoptera), including egg and nymphal parasitoids respectively, have been the subject of various investigations aimed at improving the knowledge of their biology, and using them in conservation and augmentative biological control strategies against plant bugs. The main egg-parasitoids are *Anaphes fuscipennis* Haliday in Europe (Bilewicz-Pawińska, 1983), and *Anaphes iole* Girault in the United States (Williams *et al.*, 2003a) and Canada (Sohati *et al.*, 1989). This latter species has been mass-reared and released in cotton to reduce insecticide pressure with inundative biological control of plant bugs (Williams *et al.*, 2003a). Nymphal parasitoids belonging to the genera *Peristenus* and *Leiophron* (Hymenoptera Braconidae) are widespread throughout Europe, Africa and North America (Clancy and Pierce, 1966). The most studied species are *Peristenus digoneutis* Loan and *Peristenus relictus* (Ruthe) (= *Peristenus stygicus* Loan) (Haye *et al.*, 2006; Pickett *et al.*, 2007). Other European *Peristenus* species are *Peristenus rubricollis* (Thompson), *Peristenus conradi* Marsh, *Peristenus pallipes* (Curtis), *Peristenus adelphocoridis* Loan (Kuhlmann *et al.*, 2000), and *Peristenus varisae* van Achterberg (Varis and van Achterberg, 2001). With the exception of *P. adelphocoridis* and *P. conradi* which attack only *A. lineolatus*, the other *Peristenus* species parasitize

Table 1. Crops and localities of northwestern Italy surveyed to monitor nymphal parasitoids of plant bugs in 2001-2003.

Year	Crop/plant	No. of surveys	Locality
2001	alfalfa	6	Savigliano
	meadow	6	Boves, Saluzzo, Savigliano
	groundcover in peach orchard	5	Saluzzo, Savigliano
	sunflower	3	Savigliano
2002	alfalfa	4	Savigliano
	meadow	4	Saluzzo, Savigliano
2003	alfalfa	11	Trinità, Boves, Robilante
	meadow	11	Trinità, Robilante
	groundcover in peach orchard	8	Saluzzo
	strawberry	10	Trinità, Boves, Robilante
	wheat	4	Saluzzo

nymphs of species in both *Adelphocoris* and *Lygus* genera (Kuhlmann *et al.*, 2000).

Among *Peristenus* species, the palaearctic *P. digoneutis* has been considered the most important nymphal parasitoid, and for this reason it was introduced successfully into North America to improve control of the nearctic *Lygus* species, *Lygus hesperus* Knight and *Lygus lineolaris* (Palisot de Beauvois) (Coutinot and Hoelmer, 1999; Day, 1999; Pickett *et al.*, 2007). This parasitoid is now established in several states of the northeastern United States and in southeastern Canada, and it is still constantly spreading (Day *et al.*, 2008). Another palaearctic species *P. relictus* was introduced for biological control of native *Lygus* plant bugs into California (Pickett *et al.*, 2007). Unfortunately, the impact of these parasitoids is sometimes reduced by the hyperparasitoid *Mesochorus curvulus* Thomson (Hymenoptera Ichneumonidae), as observed in Canada (Ashfaq *et al.*, 2005). This species probably native to Europe was accidentally introduced into North America along with parasitized grass-feeding mirids (Day, 2002). A further contribution to plant bug biological control is provided by *Phasia obesa* (F.) (Diptera Tachinidae), which emerges from field-collected overwintering adults of *L. rugulipennis* and *Lygus pratensis* (L.) in Sweden (Rämert *et al.*, 2005).

Since the parasitoid complex associated with *L. rugulipennis* and *A. lineolatus* in northern Italy has been poorly investigated, the research objective was to assess the presence and abundance of parasitoids of the nymphal stages of *L. rugulipennis* and *A. lineolatus* in different crops of the Piedmont (northwestern Italy), and to evaluate their efficacy in controlling plant bug populations in the surveyed areas.

Materials and methods

Field sampling

A three-year study on nymphal parasitoids was undertaken in the province of Cuneo (Piedmont, NW-Italy) at five sites: Savigliano (44°36'N 7°34'E, 358 m a.s.l.), Boves (44°21'N 7°32'E 564 m a.s.l.), Saluzzo (44°37'N 7°30'E 357 m a.s.l.), Trinità (44°30'N 7°45'E 374 m a.s.l.) and Robilante (44°18'N 7°29'E 736 m a.s.l.). Throughout the growing season, generally from May to September, populations of *L. rugulipennis* and *A. lineolatus* were first sampled on different crops (table 1), then nymphs were collected to determine presence and parasitism levels by nymphal parasitoids. *L. rugulipennis* nymphs were collected from 2001 to 2003, while *A. lineolatus* nymphs were collected from 2002 to 2003. In 2001, sampling was carried out fortnightly from early July to mid-September on alfalfa, sown meadow, sunflower, and groundcover herbs in peach orchards. The sown meadow generally consisted of a mixture of Italian ryegrass *Lolium multiflorum* Monnet de la Marck ssp. *italicum* Volkart ex Schinz *et* Keller, orchardgrass *Dactylis glomerata* L. (Poaceae), and white clover *Trifolium repens* L. (Fabaceae). In 2002, sampling was conducted monthly from mid-May to mid-August on alfalfa and meadow habitat, at locations where numerous nymphs of *L. rugulipennis* were found in the previous year. In 2003, nymphs were collected every 10 days from early May to mid-September on wheat, alfalfa, strawberries, meadow habitat, and peach orchard groundcover.

Plant bugs were sampled using a 300-mm-diameter sweep net on crops and wild plants, a part from strawberries and sunflower, on which individuals were collected by tapping vegetation over a white tray (350 × 250 mm). Population levels of *L. rugulipennis* and *A. lineolatus* were initially assessed in the surveyed crops by means of five sets of 10 sweeps each, or shaking 50 flowers or 50 plants on sunflower and strawberries, respectively. Then, collection in each crop lasted 1 hour with the aim to catch high numbers of plant bug nymphs. Second- to fourth-instar nymphs were transferred to the laboratory and maintained in glass vials (length 120 mm, Ø 25 mm), with plant material in order to provide appropriate food and humidity.

Rearing of plant bug nymphs

In the laboratory, field-collected nymphs were reared to the adult stage or until the egression of parasitoid larvae. All nymphs were separated according to crop and instar, and placed in cohorts of 10 individuals in Petri dishes (height 30 mm, Ø 120 mm), containing on the bottom a 15 mm-height layer of damp substrate, composed of a mixture of turf and sand (1:1) to allow the parasitoid to pupate. The nymphs were supplied with French bean pods (*Phaseolus vulgaris* L., Fabaceae) as food, usually replaced every three days. The Petri dishes were maintained in climate chambers at 25 ± 1 °C, 70 ± 5% RH and 16:8 L:D, and checked every two days: both emerged and dead mirids due to parasitoids or other causes were recorded and removed, and the presence of parasitoid cocoons on the bottom of each dish was recorded. After all host individuals had been removed, the Petri dishes were monitored for a minimum of three weeks in order to remove and record any non-diapausing parasitoid adults that emerged.

In early autumn, all dishes containing cocoons from which parasitoids were not yet emerged were moved to an outdoor insectary, and maintained until the following spring in order to allow the diapausing parasitoids to overwinter. Early the following summer, the substrate of each dish was sifted to recover all parasitoid cocoons; those without emergence were then dissected to obtain parasitoids, which were stored in ethanol 70%.

To evaluate the relationship between parasitism and host densities in the surveyed crops, the numbers of the field-collected and parasitized nymphs in each sampling date were analyzed with the non-parametric Spearman correlation because normality of the data was not always achieved (SPSS version 12.0; SPSS Inc., Chicago, IL, USA).

Rearing and identification of nymphal parasitoids

To assess their longevity, the parasitoids emerged from nymphs of *L. rugulipennis* and *A. lineolatus* were transferred individually into glass vials (length 120 mm, Ø 25 mm) plugged with cotton. The vials were maintained at room temperature and periodically supplied with drops of honey on the inner side and with strips of moist blotting paper in order to provide suitable food and adequate humidity, respectively. The parasitoids were checked every two days, and dead individuals were transferred into glass vials (length 60 mm, Ø 8 mm) containing 70% ethanol.

All adult parasitoids were sexed and identified to species level using the keys in Loan and Bilewicz-Pawińska (1973), Loan (1974; 1979), Varis and van Achterberg (2001), and comparing them with reference specimens determined by C. van Achterberg.

Results

Plant bug population densities and nymphal parasitism

Seasonal abundance of *L. rugulipennis* and *A. lineolatus* was quite variable during the three years and in the surveyed crops. *L. rugulipennis* was generally more abundant than *A. lineolatus*. In particular the highest population levels were observed on alfalfa (43.5 ± 8.9 individuals sampling^{-1} in 2002) and on sunflower (38.0 ± 14.3 individuals sampling^{-1} in 2001) for *L. rugulipennis*, and in meadow habitat (25.3 ± 6.6 individuals sampling^{-1} in 2002) for *A. lineolatus*. During field surveys, both nymphs and adults were nearly always collected. Throughout the growing season the ratio between nymphs and adults fluctuated often going close to 1:1.

Parasitism levels of *L. rugulipennis* and *A. lineolatus* nymphs in the agroecosystems of northwestern Italy are summarized in table 2. The parasitism of *L. rugulipennis* was variable throughout the three years and in relation to the crop on which nymphs were collected, reaching a maximum of 15.6% on alfalfa in 2001, 27.6% on meadow habitat in 2002, and 10.2% on wheat in 2003. The overall parasitism recorded on alfalfa was similar in the three years in spite of the different numbers of plant bugs sampled on this crop. In contrast, the overall percentage was more variable, from 4.2% in 2003 to 27.6% in 2002, in the meadow habitat, where mirid populations were quite constant during the three-year surveys. Moreover, sunflower was one of the most attractive host plants for *L. rugulipennis*, but not for its nymphal parasitoids: in fact, the lowest parasitism was recorded on this crop. The parasitism levels for *A. lineolatus* were

Table 2. Parasitism levels of *L. rugulipennis* and *A. lineolatus* nymphs collected in the agroecosystems of northwestern Italy surveyed in 2001-2003.

Year	Crop	*Lygus rugulipennis*				*Adelphocoris lineolatus*			
		No. of collected nymphs	% emerged adults	% parasitized	Spearman rho	No. of collected nymphs	% emerged adults	% parasitized	Spearman rho
2001	alfalfa	340	47.35	15.59	0.89*				
	meadow	819	59.46	7.81	0.81*				
	orchard groundcover	223	53.81	6.28	n.s.				
	sunflower	110	58.18	0.91	n.s.				
2002	alfalfa	292	62.33	15.41	0.95*	34	70.59	5.88	n.s.
	meadow	145	41.38	27.59	1.00**	289	66.78	6.57	n.s.
2003	alfalfa	613	46.33	9.79	0.71*	574	44.95	3.48	n.s.
	meadow	624	41.67	4.17	n.s.	417	47.48	4.56	n.s.
	orchard groundcover	153	26.80	2.61	0.89*	87	36.78	2.30	n.s.
	strawberry	89	48.31	2.25	n.s.	14	42.86	0.00	n.s.
	wheat	394	71.32	10.15	1.00**	114	84.21	1.75	n.s.

* $P < 0.05$; ** $P < 0.01$; n.s. = not significant ($P > 0.05$).

generally little lower than for *L. rugulipennis*; the overall parasitism never reached 10%.

In the three-year surveys, the parasitism of *L. rugulipennis* fluctuated throughout the season, often showing a slight correlation with plant bug population dynamics. The relationship between the numbers of the collected nymphs and of the parasitized nymphs was significant in alfalfa in 2001, 2002 and 2003, in the meadow habitat in 2001 and 2002, and in orchard groundcover and wheat in 2003 (table 2, figures 1 and 2). In 2003 parasitized *L. rugulipennis* nymphs were found first in wheat, where they were collected during the first sampling in early May. On alfalfa and meadow habitat the parasitized nymphs were found from late May to early September, while on strawberries and orchard groundcover they were collected only occasionally during the growing season (July 10 in strawberries; July 10 and August 21 in orchard groundcover).

Unlike *L. rugulipennis*, the parasitism of *A. lineolatus* was never correlated with its population dynamics. In 2003, parasitized nymphs of *A. lineolatus* were also collected first in wheat starting from the second sampling in mid-May, whereas they were usually present on other crops starting from June (figure 3), except strawberries, on which they were never found (table 2).

Parasitoids emerged from plant bug nymphs

In 2001-2003 three species of *Peristenus* were obtained from the field-collected nymphs of *L. rugulipennis* and *A. lineolatus*: *P. digoneutis*, *P. relictus* and *Peristenus picipes* (Curtis). Among these species, more than 86.0% of the emerged adults belonged to *P. digoneutis*, and about 9.9% to *P. relictus*; independently of their abundance both species were obtained from

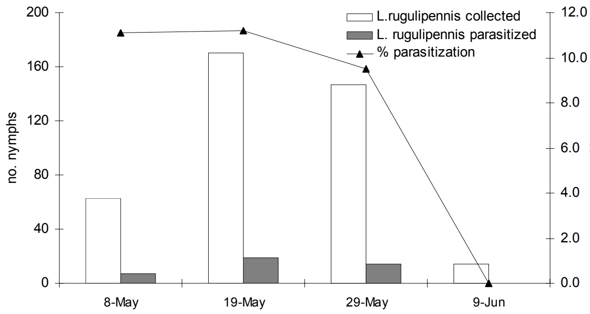

Figure 1. Parasitization by *Peristenus* spp. of *L. rugulipennis* nymphs collected on wheat in northwestern Italy in 2003.

nymphs collected on different crops throughout the season. By contrast, only one individual of *P. picipes* (0.5%) was obtained from an *A. lineolatus* nymph collected on alfalfa in Savigliano on August 2, 2002 (table 3). Only one individual of a *Leiophron* sp. (0.5%) emerged from a *L. rugulipennis* nymph collected on alfalfa in Trinità on July 10, 2003. Furthermore, some individuals of the hyperparasitoid *Mesochorus* sp. (2.3%) egressed from *L. rugulipennis* nymphs (table 3). The emergence of adult parasitoids from cocoons obtained from *L. rugulipennis* nymphs varied from 64% to 74% in 2001 and 2002, respectively, whereas it did not reach 40% in 2003. The same trend was also observed for adult parasitoids obtained from *A. lineolatus* nymphs: from the pupated larvae 81% and 21% adults emerged in 2002 and 2003, respectively. Overall, the ♀:♂ *sex ratio* was 1.15:1 and 0.47:1 for *P. digoneutis* and *P. relictus*, respectively (table 3).

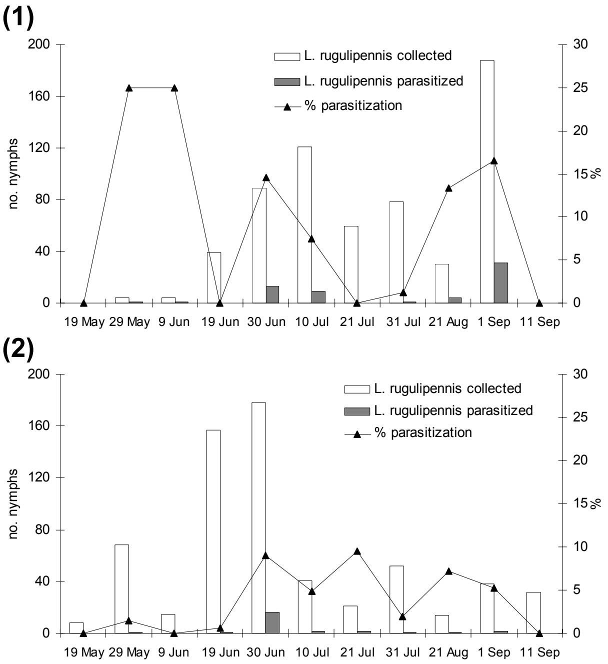

Figure 2. Parasitization by *Peristenus* spp. of *L. rugulipennis* nymphs collected on alfalfa (1) and on meadow (2) in northwestern Italy in 2003.

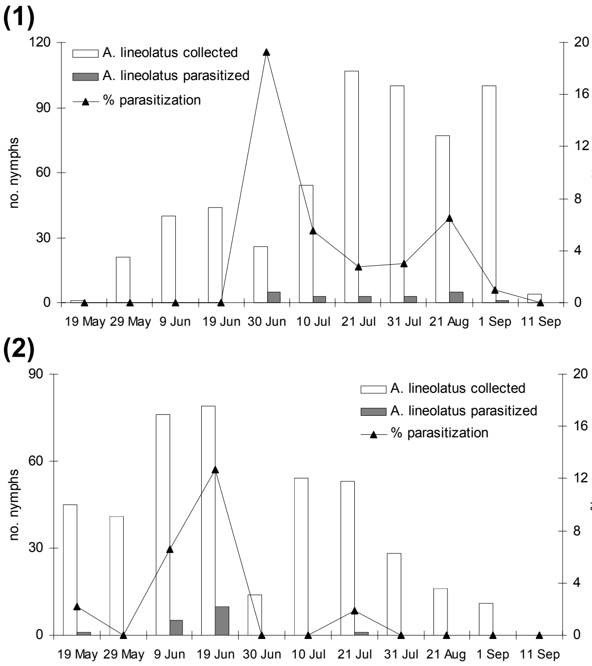

Figure 3. Parasitization by *Peristenus* spp. of *A. lineolatus* nymphs collected on alfalfa (1) and on meadow (2) in northwestern Italy in 2003.

Table 3. Number and species of the parasitoids emerged from *L. rugulipennis* and *A. lineolatus* nymphs in 2001-2003.

Plant bug species	Year	No. of parasitoids		Parasitoid species		
		Pupated	Emerged	*Peristenus digoneutis*	*Peristenus relictus*	Others
L. rugulipennis	2001	132	84	73 (44♀, 29♂)	6 (2♀, 4♂)	5 *Mesochorus* spp.
	2002	85	63	56 (25♀, 31♂)	7 (1♀, 6♂)	
	2003	132	49	40 (20♀, 20♂)	6 (3♀, 3♂)	1 *Leiophron* sp. 2 undetermined
A. lineolatus	2002	21	17	15 (8♀, 7♂)	1 (1 ♂)	1 *Peristenus picipes* (1 ♂)
	2003	43	9	7 (5♀, 2♂)	2 (1♀, 1♂)	

Biology of *P. digoneutis*

The mature larva of *P. digoneutis* egressed from the host abdomen through a tear on the side of the plant bug nymph of the fifth-instar; the exit required only a few minutes. After the larva came out, the host nymph lived up to 24 hours at the most, with a tear in the ventral part visible in its empty abdomen. Once egressed, the parasitoid larva moved around very rapidly, seeking a pupation site. In the glass dish it buried itself at a depth of 1-2 cm into the substrate, and started rapidly to spin a cocoon. The cocoon was spun within the following 7-8 hours. The period spent inside the cocoon varied depending on the season: 8-15 days for individuals that pupated between mid-May and late August; 180-200 days for the individuals that pupated in September and entered diapause. In outdoor insectary conditions, *P. digoneutis* emerged in spring, during the 2nd and 3rd week of March. In captivity, the adults generally lived from two to three weeks, or less at temperatures higher than 25 °C, and they were not very mobile in the absence of light.

In the surveyed agroecosystems, *P. digoneutis* completed three generations per year. The adults of the overwintering generation emerged from the cocoon in late March-early April. In spring, they attacked plant bug nymphs mainly on winter cereals. Adults of the new generation emerged in late May-early June, and migrated to other plants searching for the hosts. Adults of the second generation emerged in early August, even if over the summer adult emergences generally overlapped. Females preferred to oviposit in third-instar nymphs; in fact, in the three-year surveys the parasitism levels were higher in the field-collected nymphs of third-instar than those of second-instar (data not shown).

Discussion and conclusions

The parasitism of *L. rugulipennis* and *A. lineolatus* nymphs was variable in the surveyed agroecosystems of Piedmont. Only on alfalfa the proportion of parasitized nymphs was positively correlated with *L. rugulipennis* nymph density, suggesting a density-dependent relationship between *L. rugulipennis* and *Peristenus* spp. populations as observed for other *Lygus* species in California (Pickett *et al.*, 2007). Generally, for both *L. rugulipennis* and *A. lineolatus* in all the other crops, the parasitism was not associated with the mirid population density. Indeed, very few parasitized nymphs were collected on sunflower, which was one of the favourite host plants for *L. rugulipennis*, as the high infestation levels showed. Unlike what was observed for *L. hesperus* in USA (Barman *et al.*, 2010), in Italy *L. rugulipennis* proved to feed and reproduce on sunflower (Colazza and Bin, 1990).

The host plant plays an important role in attracting parasitoids, as already widely reported for many natural enemies including other Braconidae species (Dudareva *et al.*, 2006; Erb *et al.*, 2010); plant structure and/or emitted volatiles can be crucial to attract or repel the ovipositing females when searching for the host insect. Moreover, the presence and abundance of the parasitoids are influenced by chemical treatments. In northwestern Italy, no pesticides are used on alfalfa and meadow habitat while at the most one insecticidal treatment is applied on wheat. Indeed, the parasitism levels of plant bug nymphs were generally higher on these crops. By contrast, the relatively low level of parasitized nymphs collected on strawberries and groundcover in peach orchards could be actually due to the frequent application of pesticides. In fact, the insecticide regime of a farm is an important factor influencing the parasitism because the application of pesticides can have a negative impact on development of *Peristenus* spp. (Tilmon and Hoffmann, 2003; Crampton *et al.*, 2010). Climatic conditions, especially temperature, can affect the activity of *Peristenus* spp., too. The lowest parasitism level as well as the highly reduced adult emergence of parasitoids in 2003 may be due to the high temperatures recorded during the summer, one of the hottest in Europe in the recent years (Luterbacher *et al.*, 2004). The negative effect of the high temperatures was also confirmed by the reduced longevity of adults when temperatures exceeded 25 °C (data not shown), as observed in another study (Whistlecraft *et al.*, 2010).

In Piedmont crops, the parasitism of *Peristenus* species varied between 10 and 30%, values similar to those observed for *P. digoneutis* and *P. relictus* in Poland (Loan and Bilewicz-Pawińska, 1973) and for *P. varisae* and *P. relictus* in Finland (Varis and van Achterberg, 2001), but lower than that observed in North America where *P. digoneutis* was introduced for the biological control of the nearctic *L. lineolaris* (Day, 1996; 2005). In the surveyed agroecosystems, *P. digoneutis* was the main parasitoid of both *L. rugulipennis* and *A. lineolatus* nymphs, while *P. relictus* was found regularly on different crops but in lesser quantities. The male-biased *sex ratio* observed in *P. relictus* could negatively affect its abundance on the crops and consequently its parasitism efficiency. The other parasitoid species were found very rarely. Only one adult of *Leiophron* sp. was obtained, whereas on the North American continent some species of *Leiophron* are important for the control of *Lygus* populations (Norton *et al.*, 1992; Williams *et al.*, 2003b).

The present study confirmed that in Piedmont *P. digoneutis* completed three generations per year, just as its host *L. rugulipennis* (Rancati *et al.*, 1996), while in North Europe and North America the parasitoid is known to be bivoltine (Loan and Bilewicz-Pawińska, 1973; Day, 2005). Also in accord with our results, in Finland the life cycle of *P. varisae* was synchronized with that of its *Lygus* host (Varis and van Achterberg, 2001). The relationship between *P. digoneutis* and *L. rugulipennis* in Piedmont is an example of adaptation of a beneficial parasitoid to the life cycle of its primary phytophagous host. In fact, *P. digoneutis* can parasitize other mirids but it proved to prefer *L. rugulipennis* (Haye *et al.*, 2005).

The hyperparasitism was very low, and only 2.3% of emerged wasps were identified as *Mesochorus* sp. This rate was similar to what has been reported in the United States (1-11%) (Day, 2002), but much lower than that observed in Canada (25-28%) (Ashfaq *et al.*, 2005). Thus, in northwestern Italy, *Mesochorus* sp. does not seem to have a strong negative effect on the primary parasitoids.

In conclusion, the parasitism of plant bug nymphs by *Peristenus* species in northwestern Italy was too low to provide effective biological control of plant bug infestations, contrary to what was observed for the nearctic *Lygus* spp., populations of which were decreased more than 50% in a short time after the introduction of palaearctic *P. digoneutis* and *P. relictus* (Day, 2005). Nevertheless, the presence of these parasitoids in the agroecosystems is indicative of an environmentally friendly crop management, and it should be conserved to contribute positively to the establishment of a natural balance. Further studies are needed to improve the knowledge of these parasitoids in order to increase their presence and abundance in our regions and to implement conservation biological control of plant bugs.

Acknowledgements

We thank C. van Achterberg of National Museum of Natural History (Leiden, the Netherlands) for identification of the parasitoids. Research was supported by a grant from Regione Piemonte.

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Received March 24, 2011. Accepted January 31, 2012.