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Seasonal Abundance of the Nearctic Gall Midge *Obolodiplosis robiniae* in Italy and the Impact of Its Antagonist *Platygaster robiniae* on Pest Populations

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Seasonal Abundance of the Nearctic Gall Midge *Obolodiplosis robiniae* in Italy and the Impact of Its Antagonist *Platygaster robiniae* on Pest Populations

C. DUSO,[1,2] A. BOARIA,[1] L. SURIAN,[1] AND P. N. BUHL[3]

ABSTRACT The Nearctic gall midge *Obolodiplosis robiniae* (Haldeman, 1847) (Diptera Cecidomyiidae) infesting black locusts, *Robinia pseudoacacia* L. (Fabaceae), was detected in Asia in 2002 and in Europe (first in Italy) in 2003. Its distribution in Europe has expanded dramatically, probably favored by extensive distribution of its host plant along the main routes. The results of a 3-yr study on the seasonal abundance of *O. robiniae* in northern Italy are reported here. *O. robiniae* can develop three to four generations per year by exploiting plants of different ages and vigor. Overwintering takes place as diapausing larvae and adults emerge in spring. Two generations are completed on mature plants where populations decline in summer. Two additional generations can develop on root suckers from midsummer onward. Pest population densities reach their highest levels in late spring. Gall midge larvae were attacked by various predators, but parasitism by the platygastrid *Platygaster robiniae* Buhl & Duso was particularly significant. The impact of parasitism by *P. robiniae* is indicated as a key factor in reducing *O. robiniae* population densities.

KEY WORDS Cecidomyiidae, *Robinia pseudoacacia*, Platygastridae, seasonal abundance, biological control

The black locust, *Robinia pseudoacacia* L. (Fabaceae), was introduced into Europe in the 17th century from North America as an ornamental. *Robinia* species, in particular *R. pseudoacacia,* are ornamentally attractive, drought-tolerant, and fast-growing. They also fix nitrogen, have durable wood, and are adaptable to various climates and soils (De Gomez and Wagner 2001). *R. pseudoacacia* therefore spread rapidly in Europe as well in South America, Asia, Africa, and Australia (Weber 2003). The role of black locust in Europe is controversial: it provides a large amount of nectar (fundamental for apiculture) and firewood, but it also is considered a stand-deteriorating contributor (Pignatti 1982).

Many Nearctic arthropods, mainly homopterans [e.g., *Appendiseta robiniae* (Gillette) and *Metcalfa pruinosa* (Say)] and lepidopterans [e.g., *Parectopa robiniella* Clemens and *Phyllonorycter robiniella* (Clemens)] associated with black locusts were introduced to Europe accidentally, first in Italy (Vidano 1970, Miceli De Biase and Calambuca 1979, Zangheri and Donadini 1980, Bolchi Serini and Trematerra 1989). The leafminers *Pa. robiniella* and *Ph. robiniella* were rapidly controlled by native hymenopterans, mainly Chalcidoidea (Bolchi Serini 1990, Gibogini et al.

1996). The impact of the polyphagous *M. pruinosa* was reduced after the release of the Nearctic dryinid *Neodryinus typhlocybae* (Ashmead) (Girolami and Mazzon 1999).

Obolodiplosis robiniae (Haldeman, 1847) (Diptera Cecidomyiidae) is a Nearctic pest of black locust introduced into Europe. It was detected at the beginning of this century in South Korea and Japan (Kodoi et al. 2003, Woo et al. 2003) and then in Italy (Duso and Skuhravá 2004). The dramatic spread of *O. robiniae* in Europe and Asia has attracted the interest of various researchers (e.g., Navone and Tavella 2004, Yukawa and Usuba 2005, Yang et al. 2006, Skuhravá et al. 2007, Mihajlovic et al. 2008, Roskam et al. 2008, Skrzypczynska 2008, Jørgensen 2009, Molnar et al. 2009, Toth et al. 2009), most of them concerned about the possible economic impact of *O. robiniae* on black locusts.

The biology of *O. robiniae* in North America has been poorly studied (Barnes 1951), although the species is considered to be multivoltine (Gagné 1989). Studies in Japan and Europe indicate that *O. robiniae* develops two to four generations per year (Kodoi et al. 2003, Duso et al. 2005, Uechi et al. 2005, Skuhravá et al. 2007, Mihajlovic et al. 2008). Females lay eggs on black locust tips and larval feeding produces rolling of leaflet margins (galls). At high larval densities, the leaflet blades are rolled along the midrib, they change in color (from light green to dark red) and the leaflets fall precociously (Duso and Skuhravá 2004). *O. robiniae* can colonize trees of different ages and sizes in

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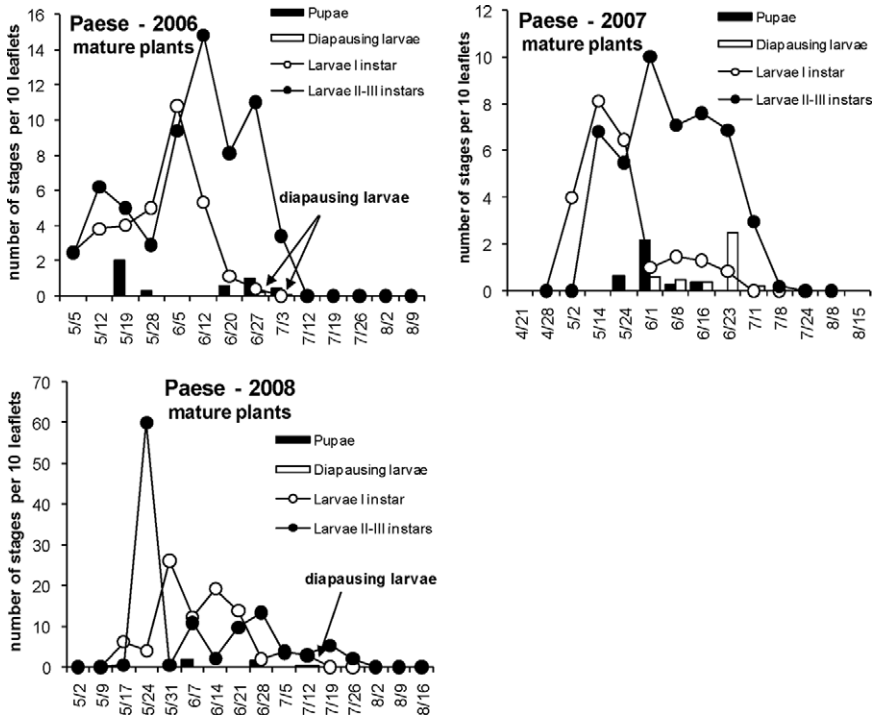[3] Troldhøjvej 3, DK-3310 Olsted, Denmark.

Fig. 1. *O. robiniae* seasonal abundance on mature plants in Paese, 2006–2008.

natural stands, hedges, agroecosystems, gardens, and along roads. In Italy, *O. robiniae* has been found throughout the areas of black locust distribution, from the Alps to Sicily, even at altitudes exceeding 800 m above sea level (a.s.l.) (Duso and Skuhrava 2004, Duso et al. 2005, Skuhrava et al. 2007, Bella 2007).

In 2004, 1 yr after the detection of *O. robiniae* in Italy, we observed several larvae parasitized by Platy-gastridae (Hymenoptera: Proctotrupoidea). The spe-cies associated with parasitism, *Platygaster robiniae* Buhl & Duso, has been described previously (Buhl and Duso 2008). The Platygastrinae (particularly the genus *Platygaster*) are well-known to parasitize only Cecidomyiidae (Austin et al. 2005), and the impact of this parasitoid did seem to be noticeable in subsequent investigations. Observations on the seasonal abun-dance of *O. robiniae* populations and the incidence of parasitism by *P. robiniae* were carried out in four sites in northeastern Italy. The results of these studies are reported here.

Materials and Methods

Observations were carried out from April to Octo-ber 2006–2009 in three sites (Paese, Bassano, and Cos-talunga H) in the Veneto region, northeastern Italy. An additional site (Costalunga L) was examined in 2007 and 2008. Paese and Bassano are located in the plain (Paese: altitude, 32 m a.s.l.; 45° 40′36″ 48 N, 12° 9′43″20 E; Bassano: altitude, 129 m a.s.l.; latitude, 45° 46′6″ 60 N, 11° 44′12″12 E). The other sites belong to the same locality as Monte Grappa (Costalunga: 45°

49′34″ 68 N, 11° 50′4″ 92 E) but at different altitudes (620 m a.s.l. in Costalunga L and 830 m a.s.l. in Cos-talunga H).

Ten black locust trees (6–10 m high) selected from hedges growing within agroecosystems (Paese and Bassano) or mixed broadleaf stands (Costalunga H and L) were surveyed. Mowing was regularly applied in Paese and Bassano. Twenty compound leaves per plant, selected from the apex of two shoots, were sampled approximately every week from April to Oc-tober 2006–2009 to evaluate the extent of *O. robiniae* infestation. In each site, three yellow sticky traps were placed on the plant canopy at 1.5 m above ground level to detect *O. robiniae* adults. Traps were inspected approximately every week from April to October 2006–2008. On each sampling date, 100 leaflets with galls (10 leaflets per plant) were removed from addi-tional compound leaves of the selected plants and inspected in the laboratory to estimate the number of larvae, pupae, and pupal exuviae of *O. robiniae* as well of *O. robiniae* larvae showing symptoms of parasitism. The latter are called "parasitized larvae" in the figures. On some sampling dates, the number of infested leaf-lets was <100, and data in the figures are thus ex-pressed as the number of *O. robiniae* stages per 10 leaflets.

The above-mentioned sampling methods were not effective in assessing *O. robiniae* oviposition, which is concentrated on fresh tips. Additional sampling pro-cedures were therefore applied during 2007 and 2008. In each site, 10 tips in total were removed weekly from plants (one tip per plant), different from those se-
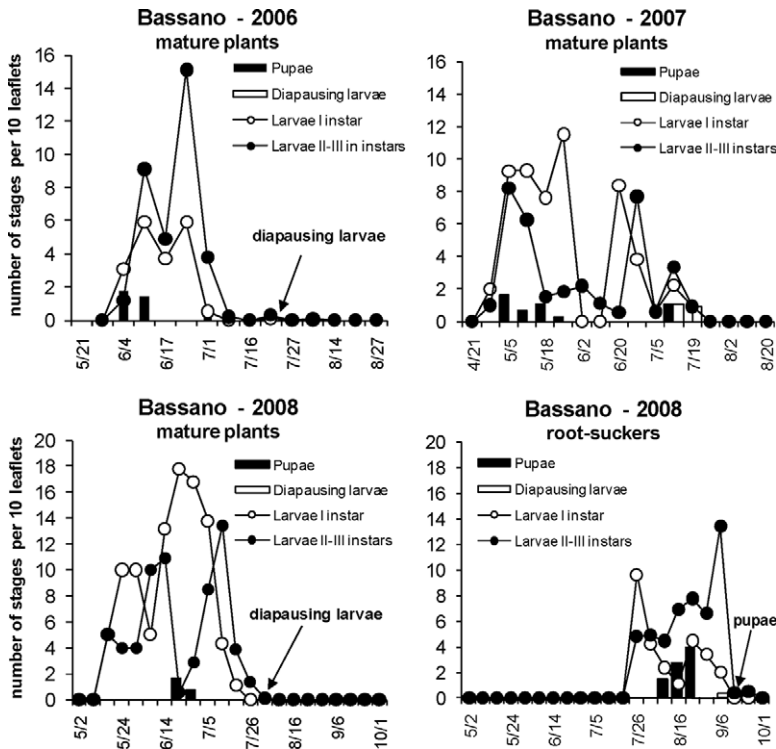
Fig. 2. *O. robiniae* seasonal abundance in Bassano, 2006–2008.

lected previously. The tips were transported to the laboratory, where eggs were counted by using a dissecting microscope. Additional samples were taken from root suckers where present. In this case, 10 shoots, each bearing four to five compound leaves, were sampled with the methods described above.

In late winter 2006, litter material was taken from a soil layer 5 cm in depth around the black locust trees and analyzed to detect *O. robiniae* diapausing larvae. Twenty samples were taken from each site. This material was put in pots and inspected under a dissecting microscope.

The occurrence of predators of *O. robiniae* larvae also was noted. The incidence of parasitism was expressed by the ratio between the number of parasitized larvae over the number of total larvae and pupae found in galls. Parasitized larvae with evidence of imminent adult parasitoid emergence were placed in petri dishes. Parasitoid specimens were preserved in ethanol and then identified.

Temperature, relative humidity, and rainfall of three stations (Paese, Bassano, and Pove, close to Costalunga L) were provided by Agenzia Regionale per la Prevenzione e protezione Ambientale del Veneto (ARPAV) (Regione Veneto) from 2000 to 2009.

Results

Phenology of *O. robiniae* and Incidence of *P. robiniae* in Plain Sites. In 2006, black locust sprouting started in April, when *O. robiniae* adults were occa-

sionally found on the yellow sticky traps. At Paese, the first larvae were detected in early May and the first pupae 2 wk later (Fig. 1). Adults emerged in a few days, and a large number of first-instar larvae were recorded in early June. Pupae were detected from late June to early July, and adults emerged soon after, but no larvae were found from mid-July onward on mature plants. In contrast, larvae were detected on a root sucker growing near the selected trees in September. Several *O. robiniae* larvae, collected from late June to early July, seemed to be flattened and immobile unless stimulated. These larvae did not pupate, and once placed on the surface of petri dishes containing sandy soil, they survived until winter. In February 2007, some diapausing larvae were observed in the litter and soil material removed from this site.

At Bassano, leaf sampling started in early June 2006, when all *O. robiniae* stages were taking place. First-instar larvae were abundant in the second and third weeks of June, and pupae were found again in early July. Larval numbers dramatically declined in July, when diapausing larvae were detected (Fig. 2). As observed in Paese, larvae were recorded on a single root sucker in September.

In both sites, infestation of compound leaves increased from early May to late June, with a higher incidence in Paese (Fig. 3). Predation of *O. robiniae* larvae by mirids, anthocorids, and nabids was seldom observed. The first symptoms of parasitism in *O. robiniae* larvae were noted in late spring, and the proportion of parasitized larvae over the total larval pop-
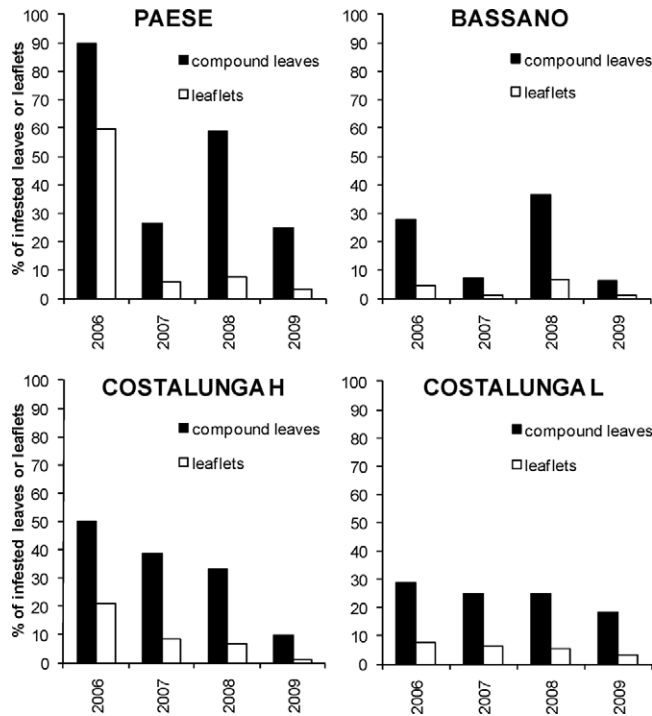
Fig. 3. Maximum *O. robiniae* infestation levels in four sites, 2006–2009.

ulation increased from June to July (Figs. 4 and 5). Signs of the presence of platygastrids were visible in the *O. robiniae* third-instar larvae, which became white, opaque, and flattened. Later, larval integuments were translucent, showing parasitoid cocoons. The parasitoid pupal and adult stages developed in individual cocoons formed by the larvae in the *O. robiniae* carcass, and the number of *P. robiniae* cocoons per larva varied from four to 28. Usually, adult parasitoids soon emerged from the cocoons. However, in July, several adult parasitoids remained inside the *O. robiniae* larval integument. They were stored outside during the winter and transferred to the laboratory in February. Some of these adults emerged from mid-March to May.

In 2007, black locust started to sprout in March, due to unusually high spring temperatures (Table 1). The first *O. robiniae* adults were observed in April. At Paese, oviposition was detected from early May to mid-June. Larvae were recorded from early May and the first pupae at the end of May (Fig. 1). Adults emerged continuously from late May to mid-June. Larval populations declined dramatically in late June to early July, corresponding to high temperatures and drought conditions. No pupae were detected from mid-June onward, in contrast to diapausing larvae. At Bassano, oviposition was detected from late April to mid-May, from early to late June, and in the second half of July. However, only the first two phases were followed by larval populations (Fig. 2). The occurrence of diapausing larvae was observed in July. Several larvae were detected on an isolated root sucker in September. In both sites, infestation peaked in July (Fig. 3). The incidence of parasitism by *P. robiniae* was higher in Paese than in Bassano (Figs. 4 and 5). In spring 2008, temperatures were close to those for 2000–2009. At Paese, oviposition was detected from mid-May until the first half of July. First-instar larvae densities peaked in late May and mid-June (Fig. 1). Pupae were recorded on various dates of June and July. A few diapausing larvae were detected on 12 July. No *O. robiniae* individuals were detected from August onward. At Bassano, *O. robiniae* oviposition on mature plants was continuously detected from early May to late July. Three oviposition peaks were observed, but larval densities peaked significantly in late May and late June only (Fig. 2). Pupae were detected in May and July and diapausing larvae in early August. Many root suckers developed in this area, because mowing was not applied in this season. Oviposition on root suckers was observed from late July to early September. Larvae were detected from late July and pupae in August (Fig. 2). A new peak of larvae was observed from late August to early September. Diapausing larvae were collected in September and rare pupae late in that month. Final infestation levels were higher in Paese (Fig. 3). Observations carried out in 2009 showed a decline in *O. robiniae* infestation levels compared with the previous year (Fig. 3). In both sites, the proportion of parasitized larvae was significant from July onward (Figs. 4 and 5). Regarding Bassano, the incidence of parasitism
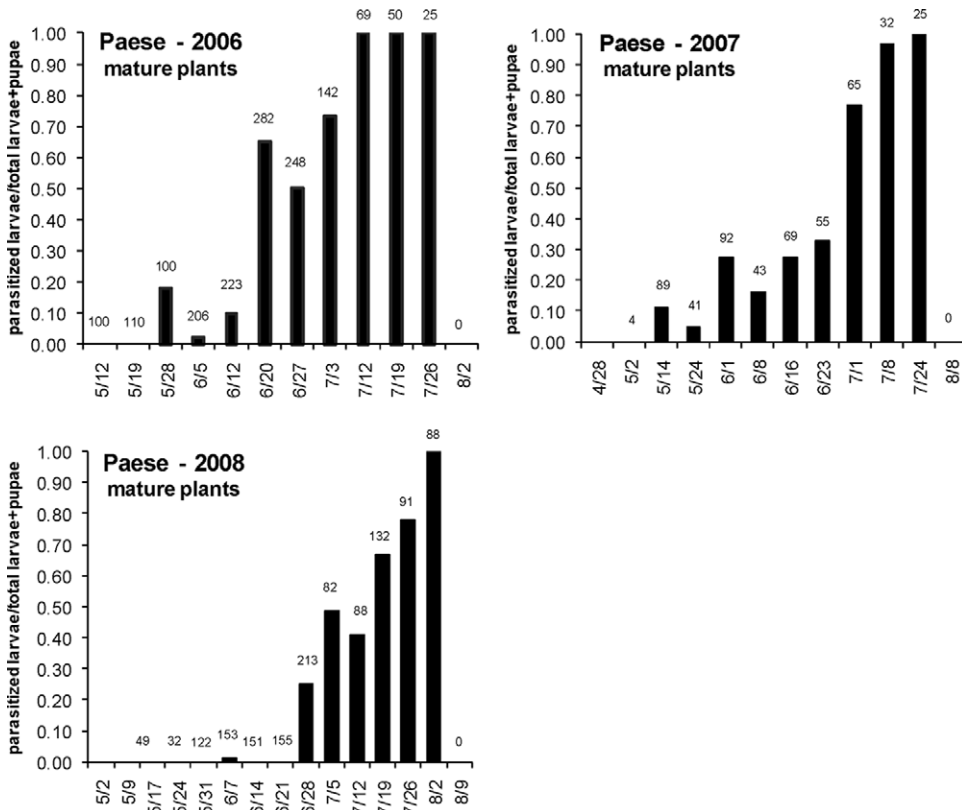
Fig. 4. Incidence of parasitism by *P. robiniae* in Paese, 2006–2008. Numbers reported above bars: total number of *O. robiniae* larvae found in samples on different dates.

seemed to be higher on mature plants than on root suckers.

Phenology of *O. robiniae* and Incidence of *P. robiniae* in Mountain Sites. In Costalunga sites, black locust sprouting was delayed with respect to the previous sites, probably because of lower spring temperatures (Table 1). In 2006, the first symptoms of larval activity at Costalunga H were observed in late May, and considerable numbers of pupae were detected in the first half of June (Fig. 6). The densities of first instar larvae peaked in late June. No pupae were detected from early July onward, but many diapausing larvae were observed in July. *O. robiniae* developmental stages were no longer detected from late July onward, but a few larvae were found on root suckers in September. Infestation peaked in early July (Fig. 3). On mature plants, the incidence of parasitism by *P. robiniae* was significant in late July–early August (Fig. 7).

In 2007, oviposition on leaf tips of mature plants at Costalunga H was detected in early May when the larval population was abundant (Fig. 6). Egg densities peaked in early June, but larval densities were not consistent with this trend. Oviposition on root suckers was detected from late June to early August, and larval symptoms were observed first in late June. The densities of first-instar larvae peaked in late July (Fig. 6), and most of the larvae entered into diapause in August.

At Costalunga L, oviposition and larval trends in 2007 were similar to those for Costalunga H (Fig. 8). Oviposition on root suckers was observed from June to August, but in Costalunga L, larval populations peaked in July, August, and September (Fig. 8).

Infestation of mature plants attained its highest levels in July (Fig. 3). On root suckers, this was in late August (39.2% of compound leaves and 18.4% of leaflets) or September (17.8% of compound leaves, 4.9% of leaflets) at Costalunga H and L, respectively. In both sites, the incidence of parasitism in 2007 was lower than in other sites and years (Figs. 7 and 9). A greater impact of parasitism was observed more frequently on root suckers than on mature plants at Costalunga L (Fig. 9).

In 2008, oviposition started in May and peaked in July in both sites. At Costalunga H, densities of first-instar larvae peaked in late May and early July and pupae were detected in the second half of June and July (Fig. 6). Pest populations reached negligible levels in August. The presence of *O. robiniae* on root suckers was only observed in midsummer. At Costalunga L, oviposition lasted from May to September and larval populations were detected continuously over the season (Fig. 8). Pupae were noted in three different phases, whereas diapausing larvae were detected in August and September. Pest symptoms on root suckers were observed from late July onward.
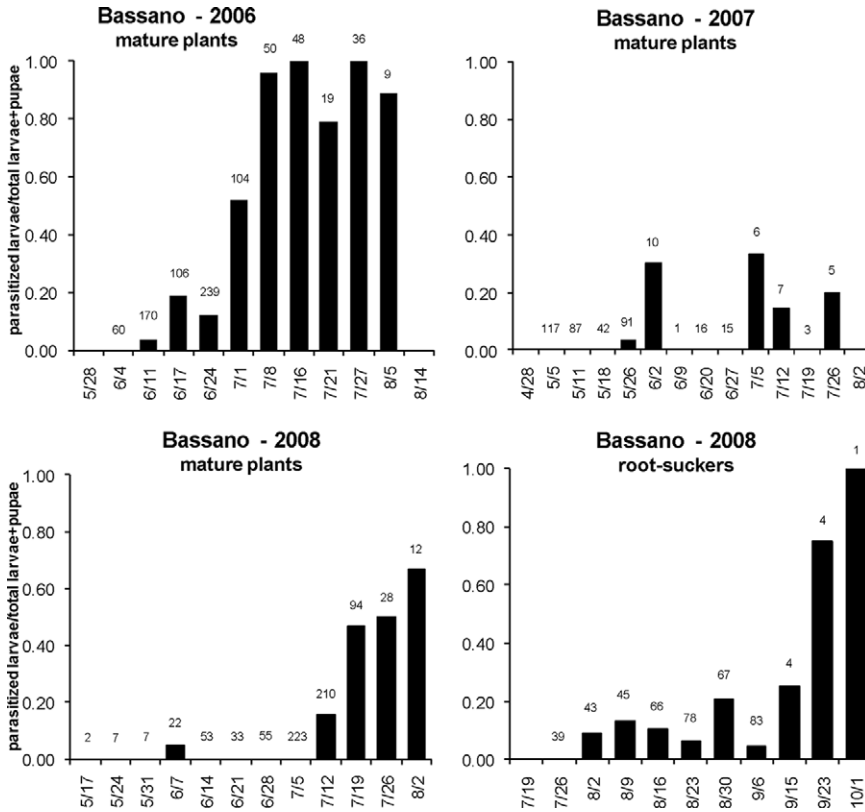
Fig. 5. Incidence of parasitism by *P. robiniae* in Bassano, 2006–2008. Numbers reported above bars: total number of *O. robiniae* larvae found in samples on different dates.

Oviposition was detected continuously from August to September, and larval populations were consistent with this trend. Pupae were found in mid-August and in the second half of September (Fig. 8).

Infestation of mature plants attained maximum values in late July. On root suckers, infestation peaked in August (53.3% of compound leaves and 8.9% of leaflets at Costalunga H; 30.4% of compound leaves and 5.7% of leaflets at Costalunga L). Infestation levels in 2009 declined, especially in Costalunga H (Fig. 3). In both sites, signs of parasitism were detected from July onward but were higher in Costalunga L, where larval populations persisted longer on mature plants as well on root suckers (Figs. 7 and 9).

Discussion

In North America, *O. robiniae* is a minor pest of black locusts, in contrast with earlier records (Haldeman 1847, Fitch 1859). Because the occurrence of *O. robiniae* in Asia and Europe has been associated with local outbreaks, this pest has stimulated several investigations. The first observations on *O. robiniae* biology came from Japan, where the species can develop two to three generations per year (Kodoi et al. 2003). The development of three generations also was indicated in northern Italy (Duso and Skuhrava 2004, Duso et al. 2005) and the Czech Republic (Skuhrava et al. 2007),

Table 1. Mean monthly temperatures in Paese, Bassano, and Pove (near Costalunga) from March to November 2006–2008

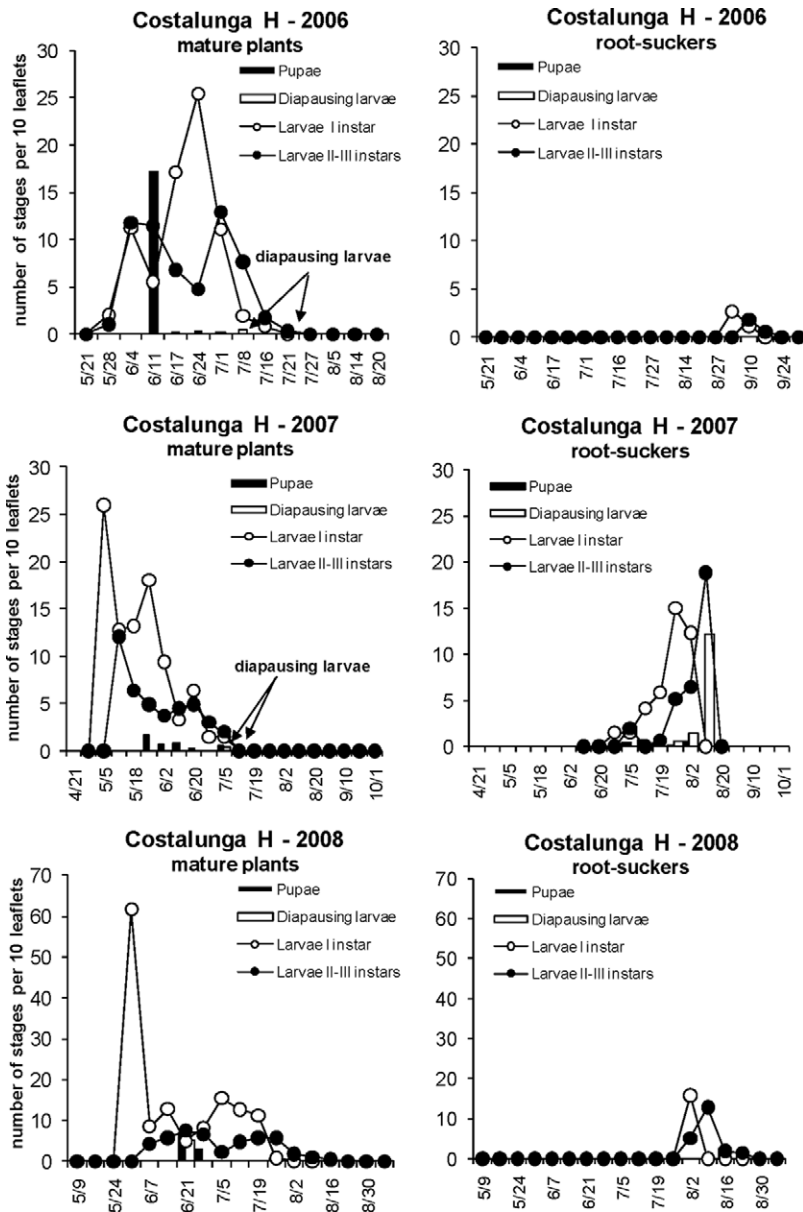| Mo	Site	2006	2007	2008
March	Paese	7.7	10.4	8.5
	Bassano	7.4	12	8.5
	Pove	4	8.3	5.8
April	Paese	12	16.1	12.5
	Bassano	14	14.7	12
	Pove	11	15	9.6
May	Paese	18.2	19.1	18.4
	Bassano	17	20	17
	Pove	14	16	15
June	Paese	22.4	22.3	22.2
	Bassano	22	22	21
	Pove	19	19	19
July	Paese	23.9	24.3	24.1
	Bassano	26	25	23
	Pove	24	22	21
Aug.	Paese	21.1	22.5	23.8
	Bassano	20	22	22
	Pove	17	20	21
Sept.	Paese	19.3	17.4	17.9
	Bassano	20	17	18
	Pove	18	15	15
Oct.	Paese	13.6	12.9	14.6
	Bassano	16	13	15
	Pove	14	11	13
Nov.	Paese	7.4	7.4	8.8
	Bassano	9.9	7.4	8.4
	Pove	8	5.9	6.7

Fig. 6. *O. robiniae* seasonal abundance in Costalunga H, 2006–2008.

whereas Mihajlovic et al. (2008) mentioned completion of three to four generations in Serbia. Most of these conclusions originate from descriptive observations. The present study adds new findings to the knowledge of *O. robiniae* life cycle in the area involved in the first records in Europe. Overwintering is carried out by larvae developing from midsummer onward. We found overwintering larvae in litter and soil material in late winter but failed to detect pupae. We assume that overwintered larvae pupate in early spring, because adults were recorded in March–April. Females laid eggs on tips of mature plants from May to July. An exception was recorded at Costalunga L,

during 2008, where oviposition persisted until late September. In sites in the plain (Paese and Bassano), the first larvae inside galls were found in early May. A new larval generation developed from June to early July. In most cases, two overlapping generations developed from spring to early summer, and population densities declined dramatically in July. Second generation pupae and diapausing larvae were detected from the second half of June onward. The phenology of both black locust and *O. robiniae* was clearly early in 2007, due to the unusual spring temperatures. In the two mountain sites (Costalunga H and L), *O. robiniae* phenology was delayed because of the colder spring
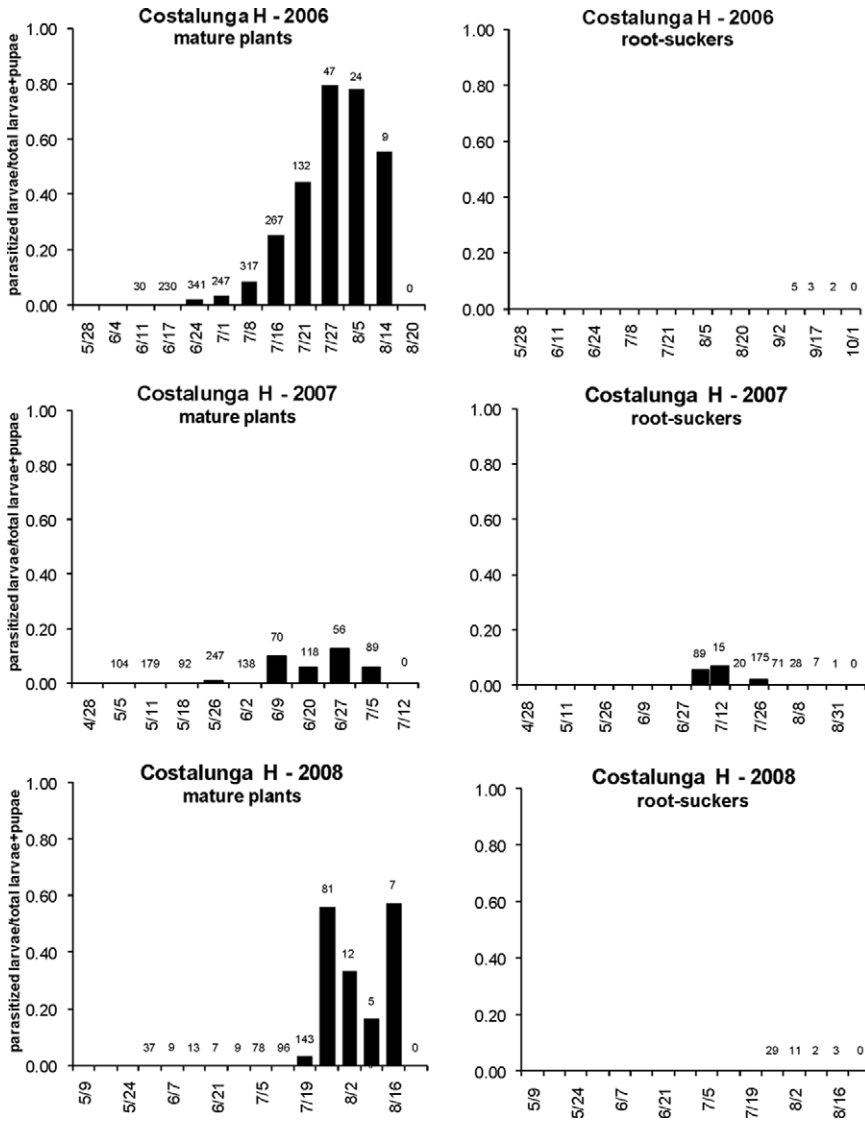
Fig. 7. Incidence of parasitism by *P. robiniae* in Costalunga H, 2006–2008. Numbers reported above bars: total number of *O. robiniae* larvae found in samples on different dates.

temperatures, retarding black locust sprouting. The first larvae on mature plants were detected in late May, and an additional overlapping generation usually developed from June to July. Then, larval populations declined, apart from 2008, when rainfall reached unusual high levels, promoting prolonged black locust growth. Some differences were seen during 2007 because of the unusual climatic conditions.

Generally, black locust growth slowed in summer, corresponding to high temperatures and drought. These factors were associated to a dramatic decline in larval populations on mature plants, although oviposition had been detected at significant levels in July. Therefore, adult females continue to lay eggs on suitable tips until July, but the fate of this population is probably affected by climate and plant conditions. To our knowledge, there are no data on temperatures critical for the survival of eggs and larvae and the development of *O. robiniae*. Plant features are clearly crucial for population persistence, as oviposition and the subsequent larval populations involved root suckers (when available) from midsummer onward. In addition, plant and climatic conditions probably induced the development of diapausing larvae. They generally appeared from July onward, but in 2007 (high temperatures in spring and dry conditions in summer) they also were detected in early June (see Paese). Mihajlovich et al. (2008) associated the development of overwintering larvae with the third generation, but in our study this phenomenon occurred from the second generation onward.
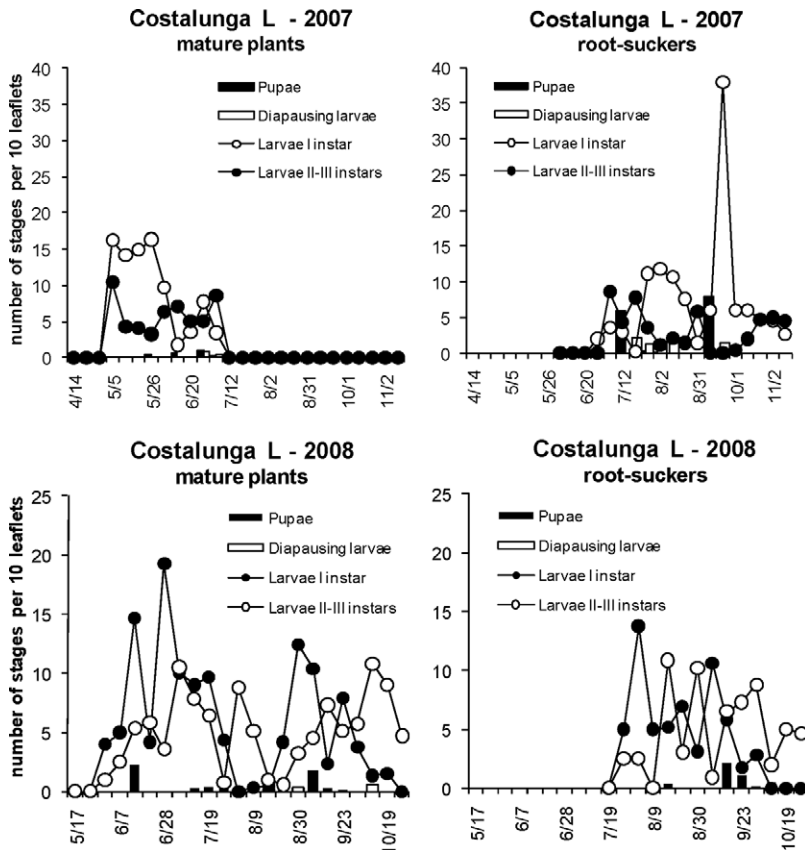
Fig. 8. *O. robiniae* seasonal abundance in Costalunga L, 2007–2008.

The simultaneous presence of both diapausing larvae and pupae at various sampling dates indicates that *O. robiniae* follows two strategies according to environmental conditions: 1) diapausing larvae develop during different periods in summer; and 2) adults that can exploit habitat resources or explore new areas are produced in late summer. In most of our observations, adults were attracted locally by root suckers with suitable oviposition sites. Therefore, pest phenology was strongly affected by the availability of root suckers.

The synchronization of gall midges with host plant phenology determines the quality and quantity of food resources and affects the performance of gall midges and other herbivores (Yukawa 2000). This is crucial for insects such as gall midges, with short-lived adults and among them for univoltine species. At emergence, the multivoltine *O. robiniae* does not seem to be closely synchronized with the phenology of *R. pseudoacacia*, probably because this host can offer suitable oviposition sites for at least 2 mo. Nevertheless, the availability of root suckers is another possibility for *O. robiniae* to exploit plant resources. In experimental plain sites root suckers were removed continuously by growers, but they may easily grow in mountain sites, being fundamental for pest population growth. In 2008, mowing was not carried out at Bassano and *O. robiniae* populations exploited root suckers, confirming the tendency seen in

the other sites. Oviposition on root sucker tips was detected from late June to September, reaching relatively high levels in August, leading to significant numbers of larval populations in August and September. The number of generations developing on root suckers depended on availability of the latter, as well on environmental conditions. The most significant cases were seen at Bassano in 2008, Costalunga H in 2007, and Costalunga L in 2007 and 2008. In these situations, two to three generations developed on root suckers over the season.

From the overall data collected from mature plants and root suckers in the same site, we can conclude that, in northeastern Italy, *O. robiniae* can complete three to four generations. Differing climatic conditions in the Czech Republic and Serbia may explain differences in pest phenology with respect to northern Italy conditions (Skuhrava et al. 2007, Mihajlovich et al. 2008).

The ample distribution of black locust in Europe and the pest strategy may explain why a delicate insect such as *O. robiniae* has moved so rapidly throughout Europe and elsewhere. Because the adults are weak fliers, wind may play an important role. However, passive dispersal (e.g., by road vehicles, trains) is likely to be the simplest dispersion means for such a species. The role of nurseries in the pest spread has been
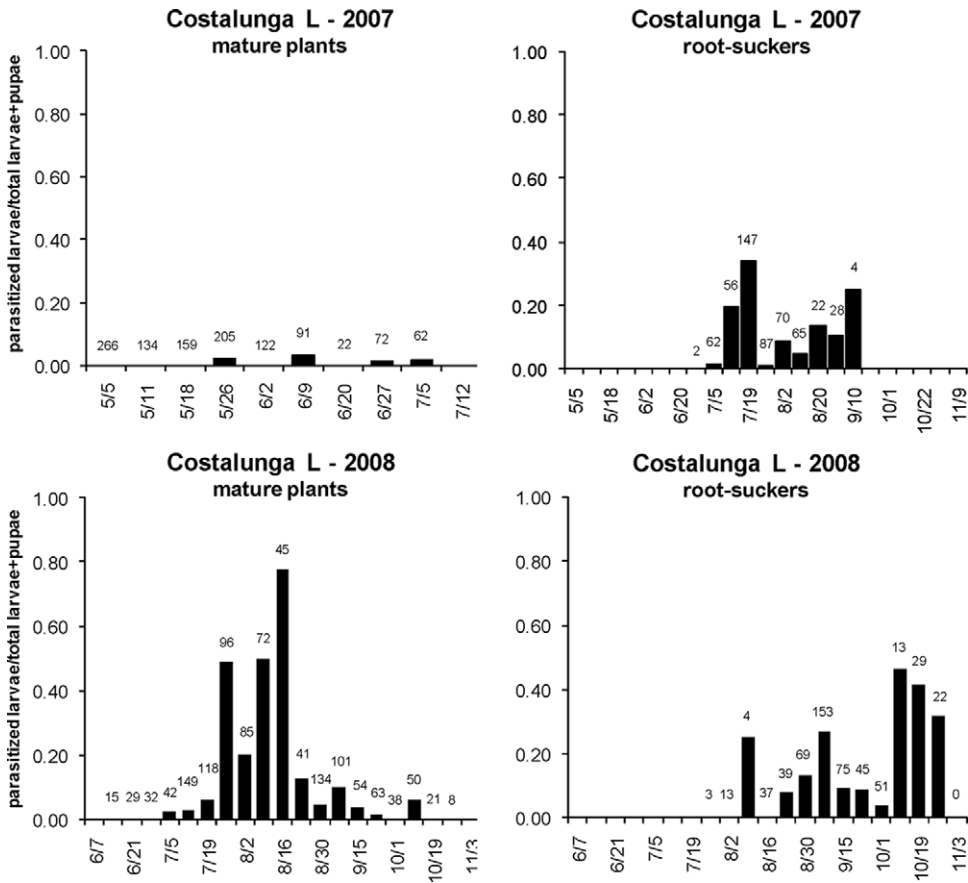
Fig. 9. Incidence of parasitism by *P. robiniae* in Costalunga L, 2007–2008. Numbers reported above bars: total number of *O. robiniae* larvae found in samples on different dates.

mentioned previously (Skuhrava et al. 2007, Mihajlovich et al. 2008, Toth et al. 2009).

In this study, the predators and pathogens of *O. robiniae* seemed to play a limited role in its control, in contrast with the platygastrid *P. robiniae.* The impact of parasitoids seemed to be significant at Paese (in 2006 and 2007) and Bassano (in 2006). In Paese, high parasitism rates in 2006 and 2007 resulted in a dramatic decline in *O. robiniae* infestation in 2007 and 2008. A similar situation was observed in Bassano and Costalunga H during 2006. Instead, the low parasitism rate in 2007 in Bassano was followed by an increase in infestation levels during 2008.

A precise relation between *O. robiniae* infestation rate and parasitism rate by *P. robiniae* over the seasons is difficult to ascertain, because multiple factors affect interactions among plants, herbivores, and their parasitoids. Little is known about black locust–*O. robiniae* interactions or the foraging behavior and dispersal capacity of *P. robiniae.* Seasonal or spatial variation in host–parasitoid interactions and interference by other parasitoid competitors require detailed experiments. Studies on a host–parasitoid system comprising the gall midge *Rhopalomyia californica* Felt (Diptera: Cecidomyiidae) and its parasitoid *Platygaster californica*

Ashmead (Hymenoptera: Platygastridae) are an excellent example of the complexity of these interactions. The midge forms galls on *Baccharis pilularis* De Candolle (Asteraceae), a native shrub in California. Midges can breed rapidly and kill *B. pilularis* plants if parasitoids are experimentally excluded (see Briggs [1993] in Darrouzet-Nardi et al. 2006). However, in natural conditions, midge outbreaks are rare because of the impact by parasitoids (Ehler and Kinsey 1991). Parasitoids can move substantially farther than their hosts and carefully search for host eggs among plants (Darrouzet-Nardi et al. 2006). Hosts can partially avoid parasitism through their oviposition behavior. The results of this study showed how this host–parasitoid system may persist, due to spatially variable incomplete parasitism.

The almost simultaneous detection of *O. robiniae* and *P. robiniae* in several areas in Europe and Asia strongly suggests that the parasitoid was introduced together with the pest (Buhl and Duso 2008, Jørgensen 2009, Sviridov and Bazhenova 2009). In many other situations, gall midges invaded new areas without associated natural enemies. Recent invasions also involved Europe and North America. Two gall midge species, *Dasineura oxycoccana* (Johnson) and *Pro-*

diplosis vaccinii (Felt), have colonized European blueberry (*Vaccinium* spp.) plantings from North America, but associated native parasitoids have not been found in European cultivations (Sampson et al. 2006). A reverse situation is represented by the occurrence of the Swedish midge *Contarinia nasturtii* (Kieffer), a pest of cruciferous crops recently introduced into North America from Europe (Hallett and Heal 2001). These pests may need to be controlled through insecticides, but they can only provide short-term control; biological control may be an option (Sampson et al. 2006).

Although the implications of *O. robiniae* damage for apiculture and nurseries have been claimed as significant, the use of insecticides against *O. robiniae* should be excluded. When *O. robiniae* was first detected in Europe, infestations caused the precocious fall of infested leaves. Black locusts also were observed to produce suckers which replaced fallen leaves (Duso et al. 2005). Later, no severe damage was observed, probably because of the response by natural enemies, mainly platygastrids. Therefore, conservation biological control is a crucial strategy for maintaining *O. robiniae* populations at acceptable levels in systems where black locust plays a significant role. *O. robiniae* populations exploit mature plants and root suckers, and the parasitism rate on the latter seems to be lower than on mature plants. Therefore, root suckers represent a significant possibility for *O. robiniae* population biology but also an exterminating reservoir of victims for *P. robiniae.* Experimental manipulation of root suckers within a definite ecosystem may provide information on interactions between these two species.

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