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ORIGINAL ARTICLE

P. Starý · B. Lumbierres · X. Pons

Opportunistic changes in the host range of *Lysiphlebus testaceipes* (Cr.), an exotic aphid parasitoid expanding in the Iberian Peninsula

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Abstract *Lysiphlebus testaceipes* (Cr.), an exotic aphid parasitoid, but widespread along the West Mediterranean and Atlantic coastal areas, was regularly found in the northeastern part of the Iberian Peninsula parasitizing several aphid hosts, inland and in the Pyrenees. It was found that the environmentally induced restriction of available host species together with the opportunistic response and host alternation of the parasitoid contributed to the successful and on-going expansion and establishment of *L. testaceipes* from the coast to the inland montane areas of the Iberian Peninsula. Also, a comparison of the overall host range of *L. testaceipes* in several areas of the West Mediterranean/Atlantic (southern France, Spain, Portugal) demonstrated a rapid increase in the host range in these areas.

Keywords *Lysiphlebus testaceipes* · Aphid · Host range · Iberian Peninsula

Introduction

The Aphidiinae represent a group of parasitic Hymenoptera for which information on the host range of the individual species can be relatively easily obtained because they parasitize aphids as a single host group. Composition and changes in the host range depending on the area and the biocontrol agents introduced are also of interest.

Lysiphlebus testaceipes (Cr.), a species originally introduced from the West Indies (Cuba) to southern France in 1973–1974 (Starý et al. 1988a, 1988b) has gradually become widespread both to the west and east along coastal areas of the Mediterranean and the western Atlantic. Its host range and regional and temporal changes have been extensively studied in coastal areas of France, Spain and Portugal. However, *L. testaceipes* was not found in the inland and montane areas of the Iberian Peninsula. Its expansion was, however, presumed to be possible because of the distribution of potential aphid hosts from the coast up to these regions (biocorridors). On the other hand, the geographic gradient was suggested to restrict the expansion of the parasitoid inland (France) (Völkl 1989).

The present account presents original evidence of the expansion of *L. testaceipes* to the inland and montane areas of the Iberian Peninsula. The host range of the parasitoid in the West Mediterranean/Atlantic coastal areas was used as the basis to understand *L. testaceipes* host alternation in the course of its expansion from the coast to some inland montane areas of the Iberian Peninsula. The determination of the tritrophic associations (parasitoid-aphid-plant) derived from samples taken in the field and then reared in the laboratory was aimed at confirming or rejecting the hypothesis of this expansion.

Material and methods

Three areas differing in their geographical characteristics and altitudes were selected in the northeastern Iberian Peninsula:

1. coastal area (Tarragonès, Tarragona province). Localities: Tarragona town and surroundings
2. inland coastal area (Segrià, Lleida province). Localities: Lleida town and surroundings
3. inland-montane area (the Pyrenees):
   a) La Vall de Boí (Alta Ribagorça, Lleida province). Localities: El Pont de Suert, Caldes de Boí, Boí, Barruera
   b) Basins of the North Segre and Valira Rivers (Alt Urgell, Lleida province). Localities: Montferrer, Adrall, Farga de Moles, Anserall, Arcavell
   c) The Aragon Pyrenees (Jacetania, Huesca province). Localities: Jaca, Biescas, Broto, Boltaña

P. Starý (✉)
Institute of Entomology,
Academy of Sciences of the Czech Republic,
Branišovská 31, 37005 České Budějovice, Czech Republic
E-mail: stary@entu.cas.cz

B. Lumbierres · X. Pons
Centre UdL-IRTA, University of Lleida, Lleida, Spain

The geographic coordinates and altitudes of the different localities sampled are shown in Table 1.

There was an aphid-host selection in the sampling because of the known preference of the target parasitoid for aphids from the Aphidine and Myzine groups (genera *Aphis, Brachycaudus, Myzus, Rhopalosiphum, Toxoptera*, and some others). The sampling of habitat suffered a similar restriction, being made preferably in roadsides, gardens and waste places in urban agglomerations and field verges, where the key associations might be best found. Among the numerous associations in the area, several aphid-plant associations (namely for *Aphis hederae, A. ruborum, A. urticata*) were selected as monitors for targeting *L. testaceipes*.

Aphid-infested pieces of plants were gently cut with scissors and transferred into 250-cc translucent plastic cages covered with nylon. Each sample was numbered together with the details of the location name, date, plant and habitat. Part of the aphid material was preserved in 70% ethanol, and the aphid species was identified under the microscope to confirm the initial species determination. The plants were identified in situ, and—if necessary—the identification was confirmed by specialists at the University of Lleida. The field samples were transported to the laboratory and preserved at 20–24 °C and 70% RH. The individual cages were checked almost daily for the emergence of the parasitoid adults, which were collected and preserved in 70% ethanol for later identification.

The majority of the research was carried out in 2001–2003, based on earlier studies in the Costa Brava and Valencia (P.Starý, unpublished data) and extensive information published on the targets in the determined areas (e.g. González and Michelena 1987; Suay and Michelena 1997; Sanchís et al. 1995).

In order to confirm host alternation by *L. testaceipes,* transfer tests of parasitoid populations were made between some aphid–plant associations in the laboratory at 20–24 °C, 70% RH and 18-h photoperiod under fluorescent light.

The *L. testaceipes* host range in the West Mediterranean/Atlantic (France, Spain and Portugal) coastal areas recorded in the literature was added to the results obtained in the present study in order to examine the expansion and increase in host range of the parasitoid since its introduction to southern France in 1973.

All the collected material is deposited in the University of Lleida and in the collection of P. Starý (České Budějovice).

Results

Distribution and host range composition of *L. testaceipes* in the coastal (Tarragona), inland coastal (Lleida) and inland montane areas in the provinces of Lleida and Huesca are presented in Table 2.

The transzonal role of the selected aphid monitor species (*Aphis craccivora, A. fabae, A. hederae, A. ruborum, A. urticata, Brachycaudus cardui)* in relation to the environmentally restricted host range of *L. testaceipes* is apparent.

The abundance of the individual native parasitoid species and of the recently expanding *L. testaceipes* drawn from samples collected in the montane areas of the Pyrenees is presented in Table 3. It varied in all the sites, and indicates the process of expansion and penetration of *L. testaceipes* in the native parasitoid guilds in the montane zone.

Earlier evidence on host alternation by *L. testaceipes* (Starý et al. 1988b) was supplemented by successful laboratory transfers of parasitoid populations from *Aphis urticata*/*Urtica* sp. and *Aphis ruborum*/*Rubus fruticosus* to *Aphis fabae*/*Faba vulgaris*, and vice versa.

A summary of the field records on the host range of *L. testaceipes* in West Mediterranean/West Atlantic coastal areas is given in Table 4, indicating the number of aphid-hosts that *L. testaceipes* has acquired since its introduction to Europe.

Table 1 Geographic coordinates and altitudes of the localities where the study was done

Locality	Latitude	Longitude	Altitude (m)
1. Tarragona	41°07′N	1°16′E	67
2. Lleida	41°36′N	0°38′E	155
3. Pyrenees			
3.1 Vall de Boí (Lleida)			
Pont de Suert	42°25′N	0°45′E	838
Caldes de Boí	42°34′N	0°51′E	1,470
Boí	42°32′N	0°50′E	1,282
Barruera	42°31′N	0°48′E	1,096
3.2 Basins of the North Segre and Valira Rivers (Lleida)			
Montferrer	42°19′N	1°26′E	732
Adrall	42°20′N	1°24′E	639
Farga de Moles	42°27′N	1°28′E	1,100
Anserall	42°23′N	1°27′E	740
Arcavell	42°27′N	1°29′E	1,142
3.3. The Aragon Pyrenees			
Jaca	42°34′N	0°33′W	818
Broto	42°36′N	0°08′W	905
Biescas	42°38′N	0°09′W	870
Boltaña	42°27′	0°04′W	643

Discussion

Inland expansion and distribution

It is generally agreed that *L. testaceipes* is associated with coastal areas, where it has become expansive and established and that it does not expand inland in the Mediterranean/Atlantic regions (González and Michelena 1987; Starý et al. 1988a, 1988b; Völkl 1989; Cecilio 1994; Sanchís et al. 1995; Suay and Michelena 1997).

Several papers have targeted the detection of *L. testaceipes* in areas others than the coast, i.e. southern France and the Iberian Peninsula. Starý et al. (1988a,

Table 2 Host range of*Lysiphlebus testaceipes* in the coastal (*1* Tarragona), inland coastal (*2* Lleida) and inland montane (*3.1* La Vall de Boí (Lleida province), *3.2* basins of the North Segre and Valira rivers (Lleida province), *3.3* the Aragon Pyrenees (Huesca province) areas

Aphid	1	2	3.1	3.2	3.3
Aphis craccivora Koch	X	X			X
Aphis fabae Scop.	X	X			X
Aphis gossypii Glov.	X	X			
Aphis hederae Kalt.		X			X
Aphis nerii B.d.F.	X	X			
Aphis ruborum Börn.	X	X	X	X	X
Aphis spiraecola Patch	X				X
Aphis umbrella Börn.		X			
Aphis urticata Gmel.		X	X	X	X
Brachycaudus cardui L.		X			X
Cavariella aegopodii Scop.		X			
Coloradoa bournieri Rem. et Lecl.		*X*			
Melanaphis bambusae Full.		X			
Rhopalosiphum padi L.		X			

Table 3 Numbers of parasitoid specimens reared from the individual samples taken in the montane areas: La Vall de Boí (Lleida province), basins of the North Segre and Valira rivers (Lleida province), the Aragon Pyrenees (Huesca province)in 2002 and 2003. *Am, Aphidius matricariae* Hal.; *Ba, Binodoxys acalephae* (Hal.); *Ep, Ephedrus plagiator* (Nees); *Lg, Lipolexis gracilis* Förster; *Lc, Lysiphlebus confusus* Tremblay and Eady group; *Lf, Lysiphlebus fabarum* (Marshall) group; *Lt, Lysiphlebus testaceipes* (Cr.)

Area/location	Aphid	Plant	Date	Am	Ba	Ep	Lg	Lc	Lf	Lt
La Vall de Boi 2002										
Pont de Suert	*A. ruborum*	*Rubus fruticosus*	9.VI.							5
Boí	*B. helichrysi*	*Aster sp.*	9.VI.	45						
Boí	*A. ruborum*	*Rubus fruticosus*	9.VI.		6					2
Boí	*A. urticata*	*Urtica dioica*	9.VI.							22
Barruera	*A. urticata*	*Urtica dioica*	9.VI.							3
Basins of the North Segre and Valira Rivers 2002										
Arcavell	*A. urticata*	*Urtica dioica*	25.VI.	5	234					
Montferrer	*A. ruborum*	*Rubus fruticosus*	25.VI.		6			32		1
Anserall	*A. craccivora*	*Medicago sativa*	25.VI.						8	
Anserall	*A. urticata*	*Urtica dioica*	25.VI.				1			1
Adrall	*A. urticata*	*Urtica dioica*	25.VI.		9			1		57
Montferrer	*A. ruborum*	*Rubus fruticosus*	25.VI.		8			57		1
Anserall	*A. fabae*	*Galium aparine*	25.VI.			18				
Farga de Moles	*A. ruborum*	*Rubus fruticosus*	25.VI.		1	1		1		1
Aragon Pyrenees 2002										
Jaca	*B. cardui*	*Carduus* sp.	3.VII.						46	
Jaca	*A. ruborum*	*Rubus fruticosus*	3.VII.					14		7
Biescas	*A. fabae*	*Cirsium vulgare*	3.VII.						76	3
Biescas	*A. fabae*	*Arctium minus*	3.VII.						18	
Biescas	*A. ruborum*	*Rubus fruticosus*	3.VII.					56		
Biescas	*A. urticata*	*Urtica dioica*	3.VII.		4				78	32
Broto	*A. urticata*	*Urtica dioica*	3.VII.		18					1
Broto	*A. ruborum*	*Rubus fruticosus*	3.VII.		2			44		2
Boltaña	*B. cardui*	*Onopordon acanthium*	3.VII.						146	
Boltaña	*A. fabae*	*Arctium minus*	3.VII.							21
Boltaña	*A. fabae*	*Chenopodium* sp.	3.VII.							44
Boltaña	*B. cardui*	*Arctium minus*	3.VII.						45	
Boltaña	*A.ruborum*	*Rubus fruticosus*	3.VII.					16		
Boltaña	*B. cardui*	*Carduus* sp.	3.VII.							4
Boltaña	*A. verbasci*	*Verbascum* sp.	3.VII.						1	
Boltaña	*Brachycaudus sp.*	*Carthamus* sp.	3.VII.				1	1		
Jaca	*B. cardui*	*Carduus* sp.	3.VII.						40	
Jaca	*A. ruborum*	*Rubus fruticosus*	3.VII.							4
The Aragon Pyrenees 2003										
Jaca	*A. craccivora*	*Gleditchia triacanthos*	8.VII.		13					38
Jaca	*A. hederae*	*Hedera helix*	8.VII.		5					
Jaca	*A. hederae*	*Hedera helix*	9-VII.						79	1
Biescas	*A. hederae*	*Hedera helix*	8.VII.					6		3
Broto	*A. craccivora*	*Robinia pseudoacacia*	8.VII.		2					2
Broto	*A. spiraecola*	*Tecomaria* sp.	8.VII.							9

1988b) did not find any evidence of *L. testaceipes* beside the coastal belt of the French Riviera between Monaco and Montpellier. Völkl (1989) determined the gradient 44°17′ to be the northern distribution limit of *L. testaceipes* associated with *Aphis fabae cirsiiacanthoidis* Scop./*Cirsium arvense* along the Rhone River valley from the Mediterranean coast. In Spain, Suay and Michelena (1997) analysed the distribution of *L. testaceipes* in areas of different bioclimatic levels and altitudes in the province of Valencia, which is generally of the Mediterranean type. Although *L. testaceipes* was detected in all the areas, it favoured 150 m altitude, which indicates a preference for coastal areas, and its abundance decreased at 700 m altitude. Sanchís et al. (1995) took samples with Malaise traps in the centre of the Iberian Peninsula (La Sierra de Guadarrama, about 60 km north of Madrid, at 1,450 m altitude), but *L. testaceipes* was not determined in the numerous samples. The absence of *L. testaceipes* in the area was also suggested to corroborate other hypotheses (references cited) proposing that the target species has difficulties in adapting to the continental climate. Michelena et al. (1998) studied the aphid–parasitoid associations in the Spanish Pyrenees (provinces Huesca and Lleida) and in Andorra, but they did not succeed in detecting *L. testaceipes* in the area. Sampling aphidiine parasitoids in valleys and mountains in Andorra (1,050 m altitude) with Malaise traps in 1992–1993, Sanchis et al. (1997, 1999) did not report the presence of *L. testaceipes*.

L. testaceipes has been reported to expand to the north along the Atlantic coast in Portugal (Cecilio 1994). In this connection, it should be emphasized that *L. testaceipes* was not reported in a relatively complex study on aphid–parasitoid relationships in the province of León (northwestern Spain) (Tizado and Núñez 1991, 1992). But soon thereafter, *L. testaceipes* was determined

Table 4 A summarized host range of *Lysiphlebus testaceipes* in the West Mediterranean and Atlantic areas: southern France (Starý and al. 1988a, 1988b), Spain (Gonzalez and Michelena 1987; Suay and Michelena 1997; Pons and Lumbierres 2003**;** and data from the present study), Portugal (Cecilio 1994)

Aphid	France	Spain	Portugal
Aphis affinis Del Gu.		X	
Aphis arbuti Ferr.	X		
Aphis balloticola Szel.		X	
Aphis chloris Koch	X	X	
Aphis cisticola Lecl. and Rem.		X	
Aphis clematidis Koch		X	
Aphis confusa Walk.	X	X	
Aphis craccae L.	X		
Aphis craccivora Koch	X	X	X
Aphis eryngii-glomeratus Bozh.	X		
Aphis fabae Scop.	X	X	
Aphis frangulae Koch		X	
Aphis gossypii Glover	X	X	X
Aphis hederae Kalt.	X	X	X
Aphis helianthemi Ferr.		X	
Aphis intybi Koch	X		
Aphis nasturtii Kalt.		X	
Aphis nerii B.d.F.	X	X	X
Aphis parietariae Lich.	X		
Aphis picridophila H.R.L.	X		
Aphis polygonata Nevs.	X		
Aphis psammophila Szel.		X	
Aphis punicae Pass.	X	X	X
Aphis ruborum Börn.	X	X	X
Aphis rumicis L.	X	X	
Aphis sambuci L.	X	X	
Aphis sedi Kalt.		X	
Aphis solanella Theo.	X		
Aphis spiraecola Patch	X	X	
Aphis teucrii Börn.		X	
Aphis umbrella Börn.		X	
Aphis urticata Börn.	X	X	
Brachycaudus amygdalinus Sch.			X
Brachycaudus cardui L.	X	X	
Brachycaudus helichrysi Kalt			X
Brachycaudus prunicola Kalt.			X
Brachyunguis harmalae Das		X	
Cavariella aegopodii Scop.		X	
Cavariella theobaldi G. and B.		X	
Coloradoa bournieri Remaudière et Leclant		X	
Dysaphis apiifolii petroselini Börn.		X	
Dysaphis plantaginea Pass.		X	X
Dysaphis pyri B.d.F.		X	
Hyalopterus pruni Geoffr.		X	
Hyperomyzus lactucae L.		X	
Melanaphis bambusae Full.		X	
Myzus cerasi F.		X	
Myzus ornatus Laing		X	
Myzus persicae Sulz.	X		
Paraschizaphis rosazevedoi Ilh.			X
*Rhopalosiphum maidis*Fitch	X	X	
Rhopalosiphum padi L.	X	X	X
Schizaphis scirpi Pass.		X	
Schizaphis rotundiventris Sign.		X	
Toxoptera aurantii B.d.F.	X	X	X

as a rare species in the area, which was considered evidence of its expansion along the coast (Tizado et al. 1992). This information can also be classified as a record of expansion of *L. testaceipes* from the Atlantic coastal areas to the inland regions (province León) of the Iberian Peninsula.

We also detected an obvious expansion of *L. testaceipes* inland and even in the Pyrenees. A comparison of all three model areas, i.e. coastal, inland coastal and inland montane, indicates that the expansion of *L. testaceipes* followed this general direction from the coast up to the mountains in the Lleida and Huesca provinces. Apparently, the oligophagous host range, the ability to alternate between available host aphid species and even to restrict significantly its host range to a few available host species contributed to the successful expansion of *L. testaceipes* into the relatively cooler inland/montane areas.

Völkl (1989) hypothesized that unsuccessful overwintering in a temperate climate may be one possible explanation for the restricted distribution of *L. testaceipes*. However, an analysis of the overall distribution range and climatic types in, for example, Washington State (Pike et al. 2000), North America in general and in the northern Korean Peninsula (Starý et al., 2002) casts doubt on the aforementioned hypothesis.

Biocorridors

Roadsides represent a common type of biocorridor. They are transzonal, and many common plant-aphid–parasitoid associations may be detected there. The individual associations are affected by the local climatic conditions to different degrees.

Several aphid–plant associations were selected as monitors targeting *L. testaceipes* from often very numerous associations in the area.

Nerium oleander –Aphis nerii is common in coastal areas. Besides its widespread use as an ornamental shrub in urban agglomerations, oleander is also extensively planted as a central hedge on highways. Its potential positive role in the fast expansion of *L. testaceipes* was hypothetized by Starý et al. (1988a). However, oleander is clearly attributed to warmer coastal areas; it disappears gradually from the coast inland, and is absent in the pre-montane and montane zones.

Other monitor associations are actually transzonal from the coast up to the mountains where they may even represent the majority of the few aphid species occurring in the area. Some examples are *Aphis urticata*/*Urtica* spp., *Aphis ruborum*/*Rubus fruticosus, Brachycaudus cardui*/*Carduus* spp., *Aphis hederae*/*Hedera* spp. Our results document that just these associations, within the frame of restricted host species availability, represented the key hosts of *L. testaceipes* during its expansion up to the mountains (Table 2).

In a similar manner, Cecilio (1994) analysed the individual host species of *L. testaceipes,* their occurrence and relationships in different habitats and refugia in Portugal. Furthermore, the role of the *Aphis ruborum*/*Rubus* association as a reservoir of aphid parasitoids was determined in Greece (Kavallieratos et al. 2002).

Interspecific relations

Research on the distribution and host range of *L. testaceipes* has also included relationships of the target species to local parasitoid guilds associated with more or less different aphid species or groups. *L. testaceipes* has been reported to reach the dominant position in the parasitoid guilds on many aphid species in the coastal areas of France (Starý et al. 1988b; Völkl 1989), Spain (Suay et al. 1992; Melia 1993; Michelena et al. 1994; Michelena and Sanchís 1997; Suay and Michelena 1997; Pons and Lumbierres 2003) and Portugal (Cecilio 1994).

Furthermore, intra-guild relationships were also determined to be dependent on the bioclimatic levels and altitude, coastal areas favouring *L. testaceipes* whose role gradually decreases, up to its complete absence at higher altitudes (Völkl 1989; Sanchís et al. 1995; Suay and Michelena 1997). Our evidence on the species composition and relative abundance of its members in the parasitoid guilds, however, indicated cases of low to dominant interaction of *L. testaceipes* when expanding and even at higher altitudes (Table 3). This variation is typical for the interaction of an expanding species with the local guilds on conspecific aphids.

Temporal and spatial increase in the overall host range

A comparison of the initial host range with its further development in all three coastal Mediterranean/Atlantic areas (France, Spain, Portugal) clearly documented that the initially poor host range had significantly increased in subsequent years.

L. testaceipes was introduced in the south of France in 1973 with hosts such as *Aphis nerii* and *Toxoptera aurantii*. Soon after, it was determined on *Aphis fabae* and *A. rumicis,* and some years later (1986), on a long list of species (compare Starý 1976 with Starý et al. 1988a, 1988b).

L. testaceipes was first detected in Spain in 1982–1984, due to expansion from its release sites in France and colonization trials in 1976 in Castellón (no recovery until 1982). Also, very few hosts were recorded at the initial detection period (Baixeras and Michelena 1983; Starý et al. 1985), but research in subsequent years yielded evidence of a very extensive host range (González and Michelena 1987; Suay et al. 1992; Melia 1993; Suay and Michelena 1997; Lumbierres et al. 2003).

Initially (1984), *L. testaceipes* was reported to be absent in Portugal, it was then detected on *Aphis nerii* (1985) and, in 1986, the parasitoid was determined on different host aphid species in several provinces in the south and southern coastal areas (Costa and Starý 1988). Further extensive information on the host range increase in *L. testaceipes* was summarized by Cecilio (1994).

Miller et al. (2002) reported the successful development of *L. testaceipes* in the insular environment of Guam, where—moreover—the released parasitoid population originated from an aphid species (*Schizaphis graminum* Rond.) not occurring on the island.

The presumed host alternation/switching of host species by *L. testaceipes* in the field in France was also verified under laboratory conditions by Starý et al. (1988b). The results from Spain presented in this contribution supplement this evidence.

Opportunistic features in the host range

The fate of aphid parasitoid biocontrol agents except for their interactions with the target pest aphid species has been widely neglected, and information on the adaptation (host range) of parasitoids to a broader environment is rare in biological control programmes. However, even these rare examples (Starý et al. 1988a, 1988b; Starý 1993, 2002; Cecilio 1994; Suay and Michelena 1997; Pike et al. 2000) document how useful such information may be in both fundamental and applied research.

Three independent studies on the host range of initially released or expanded populations in the Mediterranean/Atlantic coastal areas (southern France, Spain, Portugal) and established/adapted expanding populations of *L. testaceipes* have the following similar features:

1. *L. testaceipes* has become an ''as-native'' species, participating and commonly reaching even the dominant position in the native parasitoid guilds
2. its host range has become very aggressive, the parasitized species falling into three groups:
   a) conspecific species as in Cuba, the native home of the target *L. testaceipes* population (Starý 1968; Starý et al. 1988b)
   b) conspecific species as in the distribution range of *L. testaceipes* species, namely North, Central and South America (North America: Pike et al. 2000; Chile: Starý 1995)
   c) new hosts, not formerly found parasitized in the distribution range of *L. testaceipes*.

The aforementioned information from the coastal regions of the West Mediterranean/Atlantic area agrees that the host range patterns are opportunistic and, moreover, broadly expansive within the generally defined host range patterns of *L. testaceipes* (some genera of the Aphidine and Myzine aphids): the positive role of a combination of favourable climate together with a broad availability of various aphid-plant associations is obvious.

However, we have clearly documented a significantly different situation where the host range becomes restricted due to the less favourable inland-montane environment: Only a small proportion of the aphid species which are available in the coastal areas can be found in the mountains, but *L. testaceipes* opportunis-

tically restricted its host range to a few available species (like *Aphis ruborum, A. urticata, A. hederae, Brachycaudus cardui)* to favour its on-going expansion in the inland/montane areas. Its extensive host alternation capability (Starý et al. 1988a, 1988b, and our results) is an additional supporting phenomenon.

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References

Baixeras AJ, Michelena JM (1983) Aparición del *Lysiphlebus (Phlebus) testaceipes* (Cresson, 1880) (Hym.: Aphidiidae) en España. Actas I Congr Ibér de Entomol, León, pp 69–73

Cecilio A (1994) Faunistic evolution after the introduction of *Lysiphlebus testaceipes* (Cresson) (Hymenoptera: Aphidiidae) in Portugal, and its importance for the control of aphids. Bol San Veg Plagas 20:471–476

Costa A, Starý P (1988) *Lysiphlebus testaceipes* , an introduced aphid parasitoid in Portugal (Hym.: Aphidiidae). Entomophaga 33:403–412

González P, Michelena JM (1987) Relaciones parasitoide-pulgón (Hymenoptera: Aphidiidae; Homoptera: Aphididae) en la provincia de Alicante. Boln Asoc Esp Entomol 11:249–258

Kavallieratos NG, Stathas GJ, Athanassiou CG, Papadoulis GT (2002) *Dittrichia viscosa* and *Rubus ulmifolius* as reservoirs of aphid parasitoids (Hymenoptera: Braconidae: Aphidiinae) and the role of certain coccinellid species. Phytoparasitica 30:231–242

Lumbierres B, Starý P, Pons X (2003) Plant–aphid–natural enemy associations in urban green areas of Lleida (Spain). Mitt Biol Bundesanst Land-Forstwirtsch 394:257

Melia A (1993) Evolución poblacional de *Toxoptera aurantii* (Boyer de Fonscolombe) (Homoptera: Aphididae) en los últimos quince aňos y su relación a la aparición de *Lysiphlebus testaceipes* (Cresson) Hymenoptera: Aphidiidae). Bol San Veg Plagas 19:609–617

Michelena JM, Sanchis A (1997) Evolución del parasitismo y fauna útil sobre pulgones en una parcela de cítricos. Bol San Veg Plagas 23:241–255

Michelena JM, González P, Sanchis A (1998) Aphids (Homoptera, Aphididae) and parasitoids (Hymenoptera, Braconidae, Aphidiinae) from the Pyrenees. Nouvelle RevEntomol 15:125–129

Michelena JM, Sanchís A, González P (1994) Afidiinos sobre pulgones de frutales en la Comunidad Valenciana. Bol San Veg Plagas 20:465–470

Miller R, Pike KS, Starý P (2002): Aphid parasitoids (Hymenoptera: Aphidiidae) on Guam. Micronesica 34:87–103

Pike KS, Starý P, Millert T, Graf G, Allison D, Boydston L, Miller R (2000) Aphid parasitoids (Hymenoptera: Braconidae: Aphidiinae) of northwest USA. Proc Entomol Soc Wash 102:688–740

Pons X, Lumbierres B (2003) Aphids on ornamental shrubs and trees in an urban area of the Catalan coast: bases for an IPM program. In: Simon JC, Dedryver CA, Rispe C, Hullé M (eds) Aphids in a new millenium. Editions INRA (in press)

Sanchís A, Michelena JM, Nieves JL, Rey del Castillo C (1995) Afidiinos (Hymenoptera: Braconidae, Aphidiinae) del centro peninsular. Boln Asoc Esp Entomol 19:219–228

Sanchís A, Michelena JM, Pujade J (1997) Aphidiines (Hymenoptera, Braconidae) from Andorra. Boln Asoc Esp Entomol (Suppl) 21:145–146

Sanchís A, Michelena JM, Pujade J (1999) Afidiinos (Hymenoptera, Braconidae) del Pirineo Andorrano. Boln Asoc Esp Entomol 23:239–247

Starý P (1968) Biological control of aphid pests (Homoptera, Aphidoidea) by parasites (Hym., Aphidiidae) in the West Indies. Ann Soc Entomol Fr NS 4:27–43

Starý P (1976) Aphid parasitoids (Hym.: Aphidiidae) of the Mediterranean area. Dr W Junk , The Hague. Trans Czechosl Acad Sci, Ser Math Nat Sci 86(2):1–95

Starý P (1993) The fate of released parasitoids (Hymenoptera: Braconidae: Aphidiinae) for biological control of aphids in Chile. Bull Entomol Res 83:633–639

Starý P (1995) The Aphidiidae of Chile (Hymenoptera, Ichneumonoidea, Aphidiidae). Dtsch Entomol Z NF 42:113–118

Starý P (2002) Field establishment of *Aphidius colemani* Vier. (Hym., Braconidae, Aphidiinae) in the Czech Republic. J Appl Entomol 126:405–408

Starý P, Leclant F, Lyon JP (1988a) Biocontrol of aphids by the introduced *Lysiphlebus testaceipes* (Cress.) (Hym., Aphidiidae) in mediterranean France. Z Angew Entomol 105:74–87

Starý P, Lyon JP, Leclant F (1988b) Post-colonization host range of *Lysiphlebus testaceipes* (Cresson) in the mediterranean area (Hymenoptera, Aphidiidae). Acta Entomol Bohemoslov 85:11

Starý P, Michelena JM, Meliá A (1985) *Lysiphlebus testaceipes* (Cresson, 1880) un parásito exótico de áfidos y agente de control biológico en Espaňa (Hym., Braconidae). Graellsia 41:131–135

Starý P, Havelka J, Choi JY (2002) New species and populations of *Lysiphlebus* Foerster—aphid parasitoids (Hymenoptera: Braconidae: Aphidiinae) in Korea. Ins Koreana 19:205–211

Suay V, Michelena JM, Sanchís A (1992) Pulgones sobre plantas ornamentales en Valencia. Invest Agr: Prod Prot Veg 7:429–441

Suay V, Michelena JM (1997) Dispersión of *Lysiphlebus testaceipes* (Cresson,1880) (Hymenoptera, Braconidae, Aphidiinae) and host range in Valencia. Zool Baetica 8:111–121

Tizado EJ, Núňez E (1991) Aportación al conocimiento en Espaňa de los parasitoides de pulgones de la subfamilia Aphidiinae (Hym. Braconidae). Bol San Veg Plagas 17:545–554

Tizado EJ, Núňez E (1992) Relaciones parasitoide-pulgón (Hym., Braconidae: Aphidiinae) en la Provincia de León (Espaňa). Actas V. Congr Ibér Entomol, Lisboa, Bol Soc Port Entomol, Suppl 2, pp 401–410

Tizado EJ, Núňez E , Nieto JM (1992) Reservoirs silvestres de parasitoides de pulgones del género *Aphis* con interées agrícola en la Provincia de León (Hym., Braconidae: Aphidiinae); Hom., Aphididae). Bol San Veget Plagas 18:309–313

Völkl W (1989) The parasitoid complex of *Aphis fabae cirsiiacanthoidis* Scop. (Homoptera: Aphididae) and its changes along a geographical gradient in the Rhone valley. Acta Oecol, Oecol Appl10:167–176