

## Aphid-parasitoid Associations on the *Impatiens* Plants in Central Europe (Hemiptera, Aphididae; Hymenoptera, Braconidae, Aphidiinae)

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### ABSTRACT

Three *Impatiens* species are recorded in Czech Republic, one native, *I. noli-tangere* and two neophytes, *I. parviflora* and *I. glandulifera* of different origin. Neophytes have expanded all over Czech Republic. A long-term research on aphids and their parasitoids yielded in four aphid species, *Aphis fabae*, *A. nasturtii*, *Impatientinum asiaticum* and *I. balsamines* which are parasitized with 14 parasitoid species forming 29 tritrophic associations. The key point is that the local *I. noli-tangere* is primarily separated from both the neophytes by its association with *I. balsamines*, and also by the lack of *I. asiaticum*. *A. fabae* is broadly specific, adapted both to the local *Impatiens* species as well as to the neophytes. Also, parasitoid complexes are rather different, in spite of the presence of *P. volucre* on all three species. The aphid-parasitoid associations on *I. glandulifera* may be an example of adaptation of local fauna to a new invasive plant and aphid immigrants. A key for the identification of aphid parasitoids associated with *Impatiens* aphids in Central Europe is provided.

**Key words:** Invasions, *Impatiens*, *Aphis fabae*, *Impatientinum asiaticum*, parasitoids.

### INTRODUCTION

The genus *Impatiens* in the Czech Republic includes a combination of a single local species, *I. noli-tangere* L. and the two neophytes of different origin, *I. parviflora* DC and *I. glandulifera* Royle (Slavík, 1996, 1997). The Himalayan balsam, *I. glandulifera*, is globally an important non-native plant species that invades the natural habitats (Cronk and Fuller, 1995; Weber, 2003). In the Czech Republic it was determined for

the first time from a castle garden near Jirkov, Northern Bohemia in 1846. The first out-of-garden expansion was detected in 1897, but namely later on the sides of Jizera River near Turnov in 1903, and since that time *I. glandulifera* has occurred as one of the most common synanthropic plants over the state (Slavík, 1996). It has been targeted in a similar way as another neophyte species, *I. parviflora* (introduced to the Czech Republic in 1844 and 1870 (Slavík, 1996)) since the very early beginning of their determination in the Czech Republic. The extensive botanical information covers a set of papers from taxonomy, ecology, community classification to management (Hejda and Pyšek, 2006; Kopecký, 1989, 1991; Mandák, 2006; Pyšek and Prach, 1995a,b; Sádlo and Pyšek, 2004; Slavík, 1996, 1997). However, the research on the adaptation of the local fauna to these new neophytes has remained almost omitted in the Czech Republic, although extensive studies were carried out in nearby Germany (Schmitz, 1990, 1991, 1992a,b, 1994, 1995, 1997, 1998; Chittka and Schürkens, 2001), as well as in Switzerland (Burkhart and Nentwig, 2008) and in Spain (Bartomeus *et al.*, 2010). It was notified that the neophyte stands appeared to be characterized by only a few insect species and reduced proportions of natural enemies (Klipfel and Tscharnkte, 1997). In the Czech Republic, Holman (1971, 2006) reported the accidentally introduced aphid *Impatiensium asiaticum* Nevsky feeding on *I. parviflora*. A partial interest to the associates of *I. glandulifera* included the flower-visiting bumble-bees (Starý and Tkalců, 1998) and the predatory syrphid fly complex on aphids *Aphis fabae* Scopoli and *I. asiaticum* (Starý and Láška, 1999; Růžička, 2006). Also, the parasitoid species on *A. fabae* and *I. asiaticum* were listed (Starý, 1966, 1970, 2006; Starý and Havelka, 2008) and discussed in relation to the local ecosystems (Starý, 2001).

The present account brings results of a long-term research on the adaptation of local phytophages (aphids) and associated food web of their parasitoids on *Impatiens*. Additionally, a key for the identification of aphidiines that attack aphids on *Impatiens* in Central Europe is provided.

## MATERIAL AND METHODS

Samples of *Impatiens* plants and their aphid - parasitoid associations were sampled all over Czech Republic since 1973, as a part of an over-all research on the parasitoid-aphid-plant associations. Special attention on the *Impatiens* associations was paid in the period of 1995-2011. In that time the material was intensively sampled in the following faunistic grids according to Pruner and Mika (1996): 3537, 5450, 5550, 5952, 6051, 6254, 6268, 6368, 6455, 6571, 6654, 6750, 6755, 6759, 6771, 6849, 6952, 6953, 6954, 6955, 7350, 7352.

Aphid-infested parts of plants were cut with scissors and transferred into 250 ccm plastic tubes with nylon mesh as the ceiling. The tubes were transported in an air-conditioned plastic field cool boxes up to the laboratory, where they were maintained under +18-22°C temperature, 18 hours photoperiod (fluorescent light) and about 70% relative humidity, slightly sprinkled with water twice a day. Emerged parasitoid adults were identified to the species level by P. Starý. Voucher material is deposited in the collection of P. Starý (České Budějovice, Czech Republic).

The external structures of the emerged parasitoids were studied using ZEISS Discovery V8 stereomicroscope. Morphological terminology follows the key Sharkey and Wharton (1997). The number of antennal segments in parentheses indicate the character states which are not common. The measurements in the key were taken using a micrometer eyepiece.

## RESULTS

Only four aphid species were identified infesting *Impatiens* plants in the Czech Republic: *Aphis fabae* Scopoli, *A. nasturtii* (Kaltenbach), *Impatientinum asiaticum* and *I. balsamines* Kaltenbach. The analysis of *A. fabae* material manifested an obvious prevalence of *A. fabae cirsiacanthoidis* over occasionally occurring *A. fabae fabae* subspecies. Fourteen Aphidiinae parasitoids are associated with these aphids forming 29 tritrophic associations.

### *Impatiens* - Aphid - Parasitoid Associations

*Impatiens noli-tangere* - *Aphis fabae* Scopoli: *Aphidius colemani* Viereck (Figs. 1, 15, 28), *Binodoxys aculephae* (Marshall) (Figs. 4, 18, 31), *Ephedrus plagiator* (Nees) (Figs. 7, 21, 34), *Praon volucre* (Haliday) (Figs. 14, 27, 41).

*Impatientinum balsamines* (Kaltenbach): *Ephedrus lacertosus* (Haliday) (Figs. 6, 20, 33), *E. plagiator*, *Monoctonus nervosus* (Haliday) (Figs. 12, 25, 39), *Praon longicorne* Marshall (Figs. 13, 26, 40), *P. volucre*.

*Impatiens parviflora* - *Aphis fabae*: *Lysiphlebus fabarum* (Marshall) (Figs. 11, 24, 38).

*Impatientinum asiaticum* Nevsky: *Aphidius colemani*, *A. urticae* Haliday (Figs. 3, 17, 30), *Ephedrus plagiator*, *Praon longicorne*, *P. volucre*.

*Impatiens glandulifera* - *Aphis fabae*: *Aphidius colemani*, *A. matricariae* Haliday (Figs. 2, 16, 29), *Binodoxys aculephae*, *B. angelicae* (Haliday) (Figs. 5, 19, 32), *Ephedrus plagiator*, *Lipolexis gracilis* Förster (Figs. 8, 22, 35), *Lysiphlebus cardui* (Marshall) (9, 36), *L. confusus* Tremblay et Eady (10, 23, 37), *L. fabarum*, *Praon volucre*. *Aphis nasturtii* (Kaltenbach): *Lysiphlebus cardui*. *Impatientinum asiaticum*: *Ephedrus plagiator*, *Praon longicorne*, *P. volucre*.

A prevailing association on *I. glandulifera* over the state included *Aphis fabae*/*Lysiphlebus cardui* and *L. confusus*, and that on *I. asiaticum* - *Praon volucre*. The seasonal occurrence of *A. fabae* and the associated dominant *Lysiphlebus* parasitoid species on *I. glandulifera* has been broadly demonstrated in another contribution (Starý *et al.* in press). Other data like localities, distribution, host plant associations and the sampling data, can be found in Starý (2006).

### Key to the Aphidiinae parasitoids (females) of aphids on *Impatiens* species in Europe

1. Forewing venation complete with eight cells. 3RSb vein reaching the margin of the wing (Figs. 6, 7) .....2
- Forewing venation incomplete with less than eight cells. 3RSb vein (Figs. 1-3, 9-12) or randRS vein (Figs. 4-5, 8, 13-14) not reaching the wing margin.....3

2. Flagellomere I 1.5-1.6 times as long as flagellomere II. Forewing r vein equal or slightly longer than stigma width (Fig. 6). Length of ovipositor sheath 3.50–3.80 times as long as its maximum width at base (Fig. 33) ..... *Ephedrus lacertosus*  
 - Flagellomere I 1.1-1.2 times as long as flagellomere II. Forewing r vein distinctly shorter than stigma width (Fig. 7). Length of ovipositor sheath 2.90–3.30 times as long as its maximum width at base (Fig. 34)..... *Ephedrus plagiator*
3. RS+M vein present in forewing (Figs. 13, 14). Notaulices present and complete on mesoscutum .....4  
 - RS+M vein absent (Figs. 1-5, 8-12). Notaulices incomplete or absent .....5
4. Petiole 1.6-1.8 times as long as wide at spiracles (Fig. 26). Ovipositor sheath with almost straight dorsal outline (Fig. 40). Antennae with (20) 21-23 segments.....  
 ..... *Praon longicorne*  
 - Petiole 1.2 to 1.5 times as long as wide at spiracles (Fig. 27). Ovipositor sheath with clearly concave dorsal outline (Fig. 41). Antennae with 17-18 (19) segments  
 ..... *Praon volucre*
5. Forewing Mandm-cu vein present, complete (Figs. 1-3, 12) or reduced in anterior part (Figs. 9-11).....6  
 - Forewing Mandm-cu vein absent (Figs. 4, 5, 8).....12
6. Forewing Mandm-cu vein complete (Figs. 1-3, 12). Ovipositor sheaths with almost parallel sides and truncated at tip (Figs. 28-30) or plough-share shaped (Fig. 39). Propodeum carinated and areolated at dorsal surface .....7  
 - Forewing Mandm-cu vein reduced in anterior part (Figs. 9-11). Ovipositor sheaths pointed at tip (Fig. 36-38). Propodeum smooth with two divergent carinae at lower part .....10
7. Ovipositor sheaths plough-share shaped (Fig. 39). Forewing stigma extremely elongated, more than 4.0 times as long as R1 (Fig. 12) ..... *Monoctonus nervosus*  
 - Ovipositor sheaths with almost parallel sides and truncated at tip (Figs. 28-30). Forewing stigma normally elongated, equal or slightly shorter than R1 (Figs. 1-3).....8
8. Anterolateral area of petiole costate (Fig. 15) ..... *Aphidius colemani*  
 - Anterolateral area of petiole costulate (Figs. 16-17) .....9
9. Antennae 18-19-segmented ..... *Aphidius urticae*  
 - Antennae 14-15-segmented ..... *Aphidius matricariae*
10. Forewing marginal setae distinctly longer than to those on surface (Fig. 10)  
 ..... *Lysiphlebus confusus*  
 - Forewing marginal setae similar to those on surface or shorter (Figs. 9, 11) .....11
11. Hind femur covered mostly with adpressed setae ..... *Lysiphlebus fabarum*  
 - Hind femur covered with erected and semi-erected setae ..... *Lysiphlebus cardui*

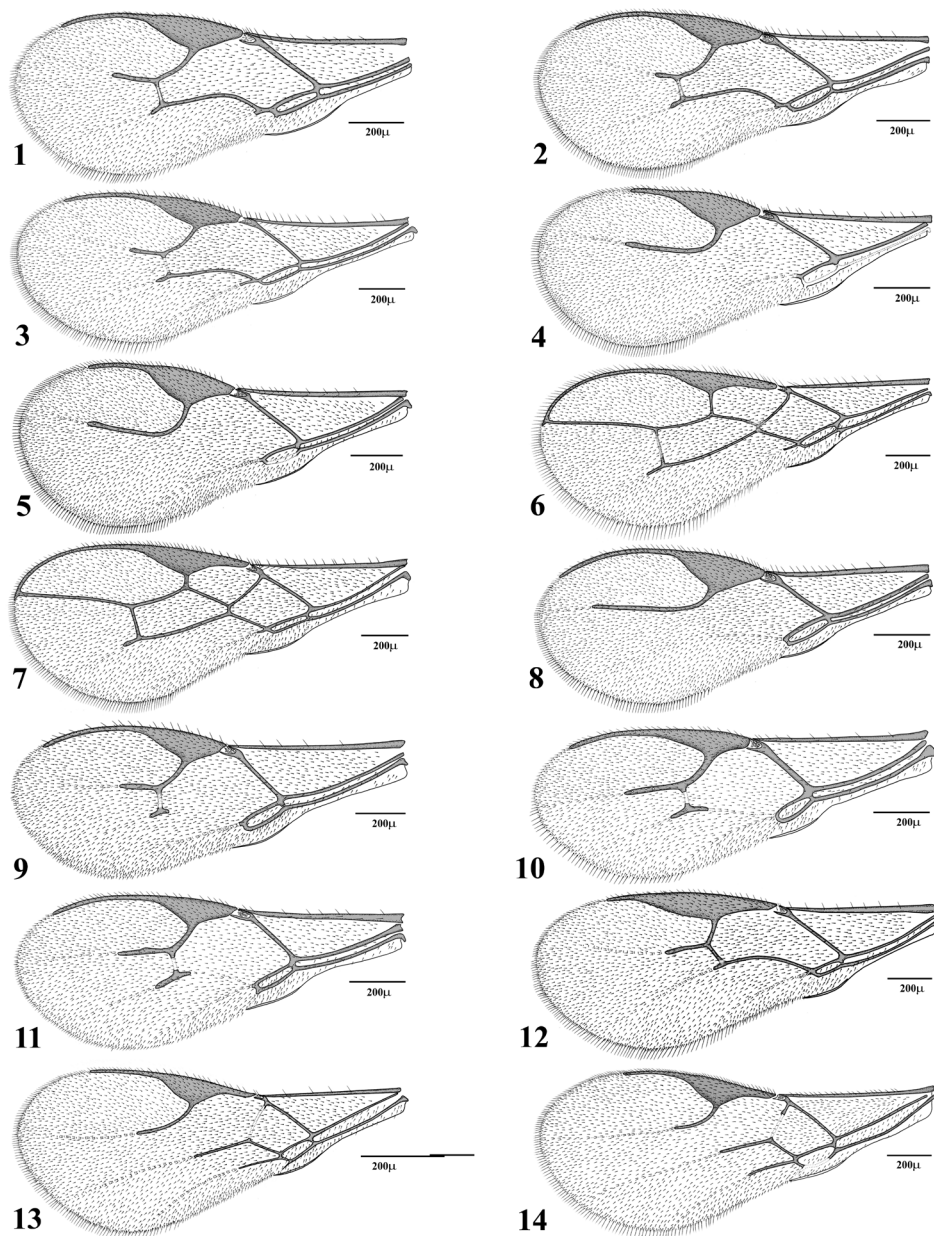


Fig. 1-14. Forewings (females). 1. *Aphidius colemani* Viereck; 2. *Aphidius matricariae* Haliday; 3. *Aphidius urticae* Haliday; 4. *Binodoxys acalephae* (Marshall); 5. *Binodoxys angelicae* (Haliday); 6. *Ephedrus lacertosus* (Haliday); 7. *Ephedrus plagiator* (Nees); 8. *Lipolexis gracilis* Foerster; 9. *Lysiphlebus cardui* (Marshall); 10. *Lysiphlebus confusus* Tremblay and Eady; 11. *Lysiphlebus fabarum* (Marshall); 12. *Monoctonus nervosus* (Haliday); 13. *Praon longicorne* Marshall; 14. *Praon volucre* (Haliday).



12. Hypopygium without prongs. Ovipositor sheath strongly curved downwardly (Fig. 35). Forewing r and Rs extending over tip of distal abscissa of R1, reaching near the outer border of forewing (Fig. 8). Petiole with two dorsal prominent carinae diverging toward base (Fig. 22) ..... *Lipolexis gracilis*

- Hypopygium with prongs. Ovipositor sheaths slightly curved downwardly (Figs. 31, 32) Forewing r and Rs vein reaching the end of distal abscissa of R1, in maximum length (Figs 4, 5). Petiole smooth dorsally (Figs. 18, 19) ..... 13

13. Distance between primary and secondary tubercles less than width at petiole spiracles (Fig. 18) ..... *Binodoxys acalephae*

- Distance between primary and secondary tubercles longer than the width at petiole spiracles (Fig. 19) ..... *Binodoxys angelicae*

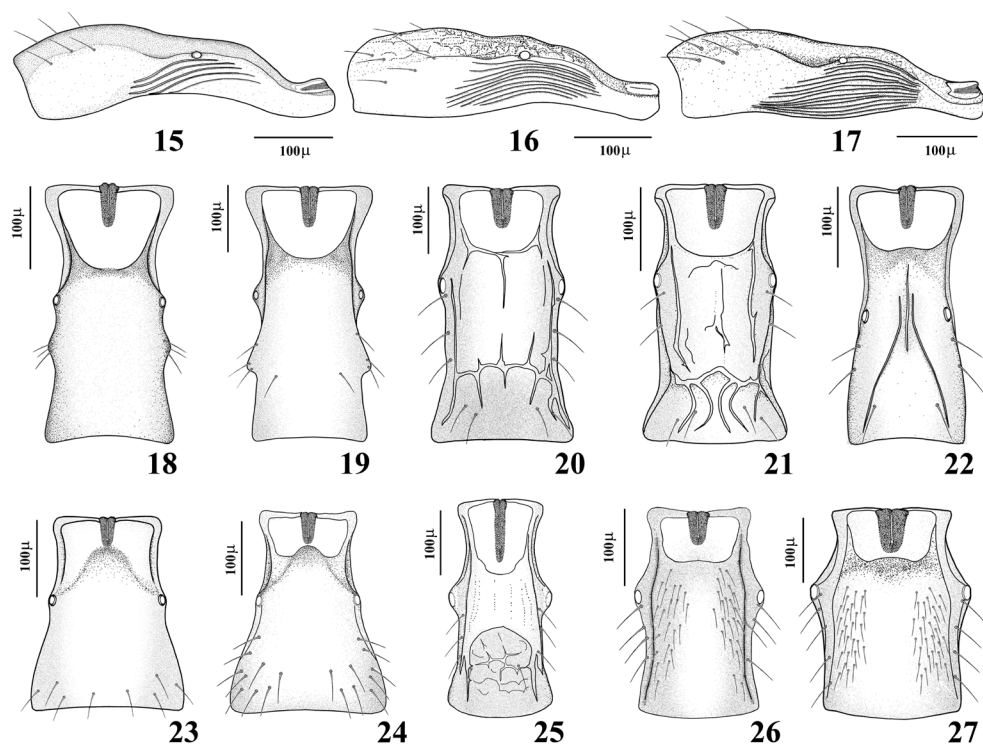
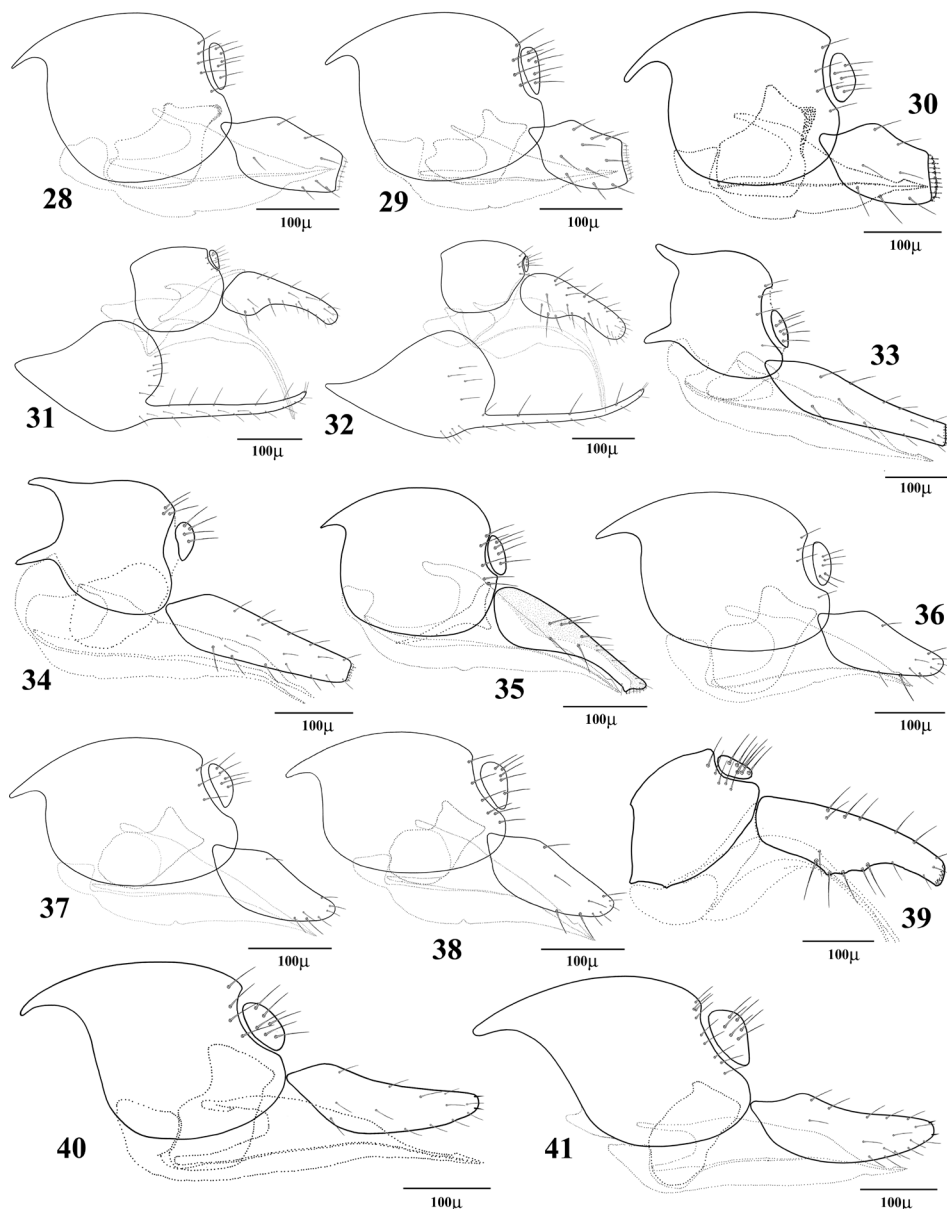


Fig. 15-27. Lateral and dorsal aspect of petiole (females). 15. *Aphidius colemani* Viereck; 16. *Aphidius matricariae* Haliday; 17. *Aphidius urticae* Haliday; 18. *Binodoxys acalephae* (Marshall); 19. *Binodoxys angelicae* (Haliday); 20. *Ephedrus lacertosus* (Haliday); 21. *Ephedrus plagiador* (Nees); 22. *Lipolexis gracilis* Foerster; 23. *Lysiphlebus confusus* Tremblay and Eady; 24. *Lysiphlebus fabarum* (Marshall); 25. *Monoctonus nervosus* (Haliday); 26. *Praon longicorne* Marshall; 27. *Praon volucre* (Haliday).

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Figs. 28-41. Lateral aspect of genitalia (females). 28. *Aphidius colemani* Viereck; 29. *Aphidius matricariae* Haliday; 30. *Aphidius urticae* Haliday; 31. *Binodoxys acalephae* (Marshall); 32. *Binodoxys angelicae* (Haliday); 33. *Ephedrus lacertosus* (Haliday); 34. *Ephedrus plagiator* (Nees); 35. *Lipolexis gracilis* Foerster; 36. *Lysiphlebus cardui* (Marshall); 37. *Lysiphlebus confusus* Tremblay and Eady; 38. *Lysiphlebus fabarum* (Marshall); 39. *Monoctonus nervosus* (Haliday); 40. *Praon longicorne* Marshall; 41. *Praon volucre* (Haliday).

## DISCUSSION AND CONCLUSION

A structural analysis of an ecosystem includes also the determination of the individual food webs as well as of their interrelationships and the same approach is required in case of invasive exotic species. This approach has been commonly undertaken in the research of the aphidiine parasitoids where the determination of the tritrophic associations has been attributed in most of the contributions since the 50ties of the last century. One of the key phenomena is relatively easy determination of the respective food web members as the parasitoids can be obtained combining the field collecting and the laboratory rearing material. Also, the aphidiines are the only group of primary parasitoids (with exception of few species from the genus *Aphelinus* Dalman) of aphids; hence the participation of other parasitoids is avoided. Within such framework, the research on a new exotic plant and/or aphid immigrant such as the plant *I. glandulifera* and the aphid *I. asiaticum* can be relatively easily situated and determined in local ecosystems, together with the determination of the interrelationships.

The adaptation of *Aphis fabae cirsiacanthoidis* on *Impatiens* neophytes may be presumed/ derived from introduction/ expansion data to be of older date on *I. parviflora* and somewhat later on *I. glandulifera* because of its extensive known host range and the occurrence on *I. noli-tangere*. However, the date of adaptation of *I. asiaticum* to *I. parviflora* is well known, in 1968 (Holman, 1971), and it was sometimes later followed by that on *I. glandulifera*.

The key point is that the local *I. noli-tangere* is primarily separated from both the neophytes by its association with *I. balsamines*, and also by the lack of *I. asiaticum*. *Aphis fabae* is broadly specific, adapted both to the local *Impatiens* species as well as to the neophytes. Also, parasitoid complexes are rather different, in spite of the presence of *P. volucre* on all three species. In spite of its exotic origin, *I. glandulifera* has become widespread, reaching the status of a neophyte or an "as-native species" in the Czech Republic (Slavík, 1996, 1997). The exotic Himalayas-derived phenology preserved also in the new area by *I. glandulifera* has apparently been significant in contributing to the new association of *I. glandulifera* and the native *A. fabae* in the area. This association has become widespread over the state and increasingly playing the role of an important seasonal refugium of the aphid. For all dominant associated parasitoid species (*Lysiphlebus cardui*, *L. confusus*, *L. fabarum*) the new association *A. fabae*/*I. glandulifera* in wetland habitats is important as a refugium for overwintering and even hibernation.

It should be notified that every refugium of *I. glandulifera* manifests the variation per a site and in individual years per a site. Apparently, the presence of respective plants as sources of aphids and parasitoids within or in a nearby ecosystem is important. In general terms, *I. glandulifera* may be classified as one of a model situations which falls in the grouping of landscape diversification owing to human activities; due to its phenology, respective associations with the aphids, their parasitoids and predators, the ants, and bumble bees *I. glandulifera* may be classified as a member of riverside



biocorridors (cf. Michal, 1994). Also, phytocenological classification evaluated put *I. glandulifera* as non-major problem for the preservation of native biodiversity (Hejda and Pyšek, 2006).

The results achieved in the Czech Republic are believed as contributing to the information on the responses of local ecosystems when they interacting with a new exotic invasive plant and/ or animal immigrants.

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