

## Mountain aphid and parasitoid guilds on *Aconitum* spp. in Europe

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### Abstract

Research on *Aconitum*-associated aphids and their aphidiid parasitoids yielded *Aphidius sussi* Pennacchio et Tremblay and *Monoctonus leclanti* Tomanovic et Stary, newly reared from *Delphiniobium junackianum* (Karsch) in the Czech Republic. This parasitoid guild was also determined in Serbia and partially also in Italy and Slovenia. It is classified as a representative of endemic mountain plant-aphid-parasitoid associations in Europe. Also, specific predators are recorded. Keys for identification of aphid parasitoids and mummies on *Aconitum*-associated aphids were done as well.

**Key words:** aphids, Aphididae, parasitoids, Aphidiinae, *Aconitum*, mountains, Europe.

### Introduction

*Aconitum* species are known to be associated with a somewhat specific aphid fauna (Blackman and Eastop, 2006). Holman (2009) reports only two host-specific aphids genera - *Delphiniobium* (3 species) and *Brachycaudus* (2 species) feeding on *Aconitum* in Europe. Except for some initial and scattered information which has attributed them to the mountain ecosystems and boreal area in Europe no special interest was paid to the respective aphid-parasitoid associations (Starý, 1973; Pennacchio, 1989; Pennacchio and Tremblay, 1988; Tomanović *et al.*, 2002; 2003). Many *Aconitum* plants are endemic montane-alpine and subalpine species (Gajić and Niketić, 1992).

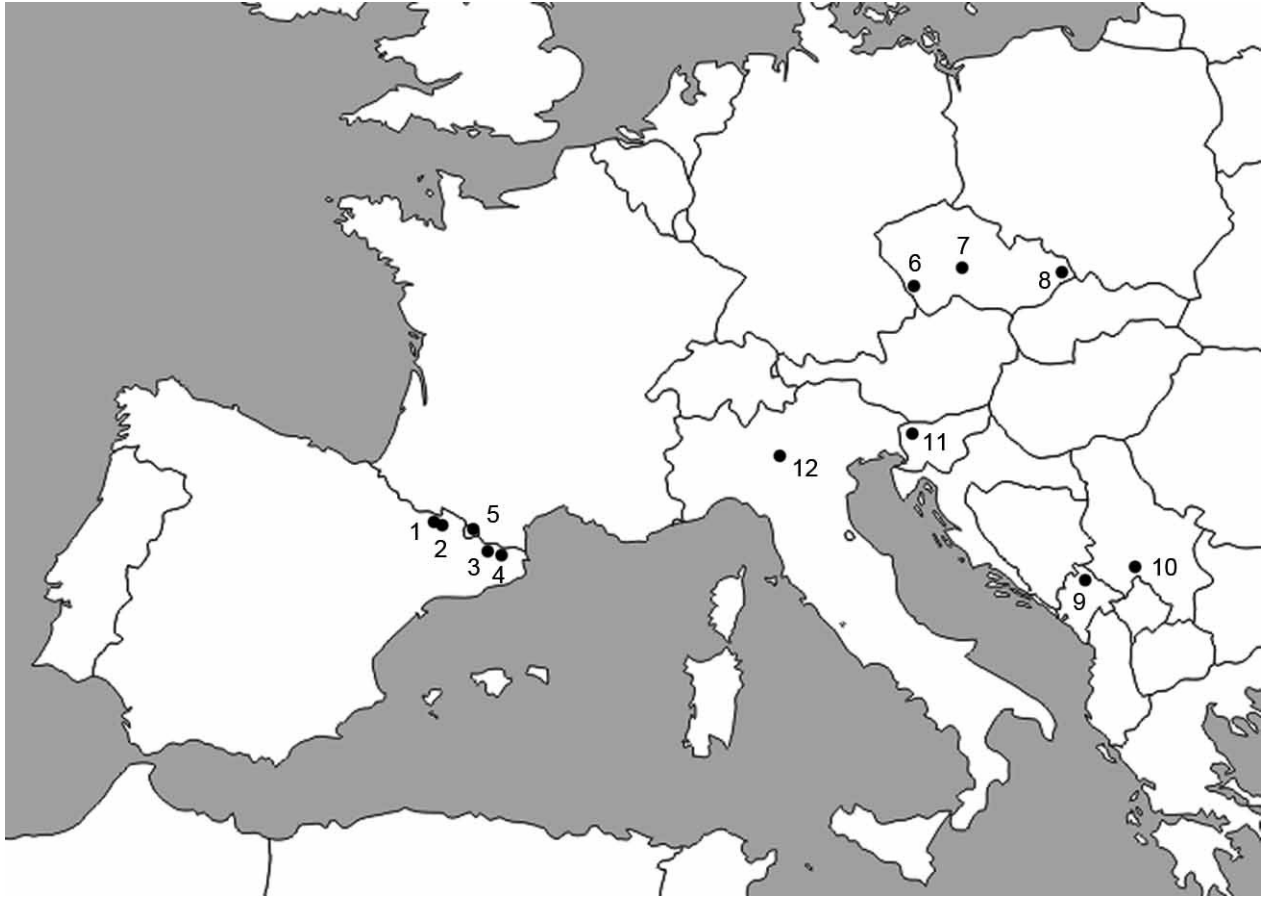
Our study focuses on some *Aconitum*-aphid-parasitoid associations in six geographically different mountain and/or boreal ecosystems: 1) the middle and eastern Pyrenées - Spain and Andorra; 2) Šumava range, Czech Republic; 3) the western Carpathians, Czech Republic; 4) Italian Alps, Lombardy, Italy; 5) Slovenian Alps, Slovenia; 6) the Balkans - Mt. Durmitor, Montenegro and Kopaonik, Serbia.

### Materials and methods

Most of the presented detailed research was done in the Czech Republic, with previous background information and experience obtained in Italy (Pennacchio, 1989; Pennacchio and Tremblay, 1988), in Serbia (Kavallieratos and Tomanović, 2001; Kavallieratos *et al.*, 2004; Tomanović *et al.*, 2002; 2003), and in Slovenia (Kos *et al.*, 2012). Preliminary information on the occurrence of aphid incidence on *Aconitum fir-*

*mum* ssp. *moravicum* Skalicky was obtained during 2006-2007 and extended to the whole Radhostske Beskydy mountain range in 2008-2012. The two selected main *Aconitum* sites were visited throughout the season, from early June to mid September. A smaller amount of aphids was sampled in ethanol 70% (for collection) or 96% (for DNA analysis). Some leaves were cut off and the aphids were shaken down onto a plastic plate and then transferred in a plastic rearing cage (500 ml) which was covered with nylon mesh. In accordance with the Nature Conservation Protection Rules, to avoid any mechanical injury the aphid-attacked flowers were gently shaken down onto a plastic plate. The same procedure was followed for the leaves, but a few of them were by necessity cut off and added to the sampled aphids for their survival in the rearing. When in the field the cages were kept and transported in portable plastic coolers until they reached the laboratory where they were maintained at 18-20 °C. The emerged parasitoids were sampled in ethanol 70 or 96%.

The following localities were sampled in Czech Republic: 1) River valley near Čeladná, Beskydy, NE Moravia, in the Nature Protected area - a mountain herb-rich beech forest, with spruce mixture, a spring wetland area. It is the main area of endemic *A. firmum* ssp. *moravicum* in the Czech Republic (Mackovčín and Jatiová, 2002; Weissmannová *et al.*, 2004); 2) Modrava and Kremelna River valley, Šumava National Park, SW Bohemia, on *Aconitum plicatum* Reichenbach; 3) A garden in Talenberk, near to Pacov, the highlands (500 m a.s.l.), southern Bohemia. There was *A. plicatum* in culture - was introduced there from the Savoian Alps with a population of *Delphiniobium junackianum* (Karsch) in 1988. To extend the chance



**Figure 1.** Map of sampling localities of *Aconitum* - Aphids - Aphidiinae: 1) Spain, Lleida Prov., Boí; 2) Spain, Huesca Prov., Hospital de Benasque; 3) Spain, Girona prov., Núria; 4) Spain, Girona prov., Vallter; 5) Andorra, Sorteny; 6) Czech Republic, SW Bohemia, Šumava Mts., Modrava; 7) Czech Republic, S Bohemia, Pacov, Talenberk; 8) Czech Republic, NE Moravia, Beskydy Mts.; 9) Montenegro, Mt. Durmitor, Crno jezero, Sušica; 10) Serbia, Mt. Kopaonik-Metode; 11) Slovenia, Slovenian Alps, Bohinj Lake; 12) Italy, Italian Alps, Lombardy.

of aphidiine parasitoids to find their hosts we transferred potted *Aconitum* plants infested with *Delphiniobium* in a mixed forest with the rich herbal undergrowth, near the garden.

Samples of *Aconitum* species in the mountains of Serbia, Montenegro, Slovenia and Spain were realised in the framework of the detailed research on plant-aphid-parasitoid associations in these countries in 2011-2012. General map of sampling localities for the study of *Aconitum*-aphids-aphidiine parasitoids associations is presented in figure 1 (the locality in the neighbourhood of Moscow, Russia, was omitted for technical reasons).

The aphid and parasitoid material from the Czech Republic is deposited in the Laboratory of Aphidology (Institute of Entomology, Academy of Science of Czech Republic) and in collections of P. Starý (České Budějovice). Material collected in Serbia and Montenegro is deposited in the Institute of Zoology, Faculty of Biology, University of Belgrade, whereas material from Slovenia is deposited in the Department of Agronomy, Biotechnical Faculty, University of Ljubljana.

## Results

### Czech Republic

Aphids *D. junackianum* were sampled from about mid June to late August. They form dense colonies on the lowerside of the leaves; later on they moved to the terminal, along the stem and formed colonies on the peduncles of the individual flowers and on follicles. They were determined of both host-plants species - on *A. firmum moravicum*, and to a lesser degree on *Aconitum variegatum* L. in the site area (Havelka *et al.*, 2011).

Parasitoids: *Aphidius sussi* Pennacchio et Tremblay: Čeladenka River valley, near Čeladná, Radhostske Beskydy Mt. Range, NE Moravia, Czech Republic 2007, 1 male (leg. J. Janeček). Ditto, 1<sup>st</sup> August 2012, 1 female, sample 2012 / 26 (leg. P. Starý and J. Havelka). *Monoctonus leclanti* Tomanović et Starý 2002: Čeladenka River Valley, near Čeladná, Radhostske Beskydy Mt. range, NE Moravia, Czech Republic, 6 July 2012, on *A. firmum moravicum*, 2 females, sample 2012/ 26 (leg. P. Starý). The first determination of parasitoids of *Delphiniobium* was drawn from a single adult *Aphidius* sp. male which was found in the aphid

### Key to parasitoid species (females) associated with *Aconitum* spp.

- 1 - Ovipositor sheath ploughshare-shaped, gradually widened (figure 2C); stigma about 5.5 times as long as wide (figure 1F); body of prevalently yellow coloration . . . . . *Monoctonus leclanti*  
 -- - Ovipositor sheath short, gradually narrowed at the apex (figures 2A, 2B); stigma about 3.4-4.5 times as long as wide (figures 2D, 2E); body of prevalently dark coloration . . . . . 2  
 2 - Anterolateral area of petiole rugose (figure 2G); petiole about 3.5 times as long as wide at spiracles level; antennae (17)18-19(20) - segmented . . . . . *Aphidius ervi*  
 -- - Anterolateral area of petiole costulate (figure 1H); petiole 2.5-3.0 times as long as wide at spiracles level; antennae (16)17(18) -segmented. . . . . *Aphidius sussi*

In the key *A. medvedevi* described from western Siberia (Davidian and Gavryljuk, 2010) reared from *B. aconiti* on *A. vulparia* was not included. On the basis of the description this species runs to *A. sussi* and needs additional checking. A key to *Monoctonus* species distinguishing *M. leclanti* from its related congeners was published by Tomanović *et al.* (2002). The presented key covers all three species guild members determined on *Delphiniobium* spp.

### Key to emerged aphid mummies from *Aconitum* spp.

- 1 - Emergence hole with regular margins, mostly with emergence lid (it may be broken) . . . . . 2  
 -- - Emergence hole with irregular margins . . . . . Hyperparasitoids  
 2(1) - Emergence hole situated in whatever part of the mummy. . . . . *Aphidius* spp.  
 -- - Emergence hole situated at the whole distal part of the metasoma, the emergence lid bears often the aphid siphuncles. . . . . *Monoctonus leclanti*

and plant garbage in a rearing cage. But despite intensive sampling and rearing throughout the season (June to August), no mummies were found in the subsequent years. In early July 2012, however, in spite of a rather low aphid population density, evidently dispersed and rare mummies were found on the lower side of older leaves and, exceptionally, also on the plant terminal, but with a rather low aphid population. Because of the weather, we supposed the absence of aphids was due to heavy rains. Rearing of aphids in July and early August yielded some mummies and possibly parasitized aphids, but merely a single female specimen of *A. sussi* and two specimens of *M. leclanti* emerged, besides a *Dendrocerus* sp. hyperparasitoid.

It also ought to be noted that almost no other aphid-plant associations were detected as potential alternative hosts in the sites. Only *Aphis fabae* Scopoli on *Cirsium palustre* (L.) Scop., on *Impatiens noli-tangere* L., on *Impatiens parviflora* DC. and rarely on *Impatiens balsamina* L.; *Impatiens balsamines* (Kaltenbach) on *I. noli-tangere*; *Impatiens asiaticum* Nevsky on *I. parviflora* were detected.

Exposure trials of aphids in the garden as well as in the forest yielded neither parasitoids nor their mummies.

It seems noteworthy that apparently the only effective natural enemy was the predatory gall-midge *Aphidoletes aphidimyza* (Rondani). Mummies were generally rare and isolated in aphid colonies. Surprisingly neither coccinellid beetles nor their larvae were ever observed, including the exotic, rather oligophagous and expanding *Harmonia axyridis* Pallas. Also, merely a single case of the presence of syrphid flies, *Platycheirus* sp. was determined in August 2012, and one sample also included Chamaemyiid pupae (*Leucopis* sp.).

*Brachycaudus napelli* (Schrank) sampled on *A. plicatum* in the Šumava mountain range (2011) yielded merely a few brownish mummies, but no parasitoids emerged in the laboratory.

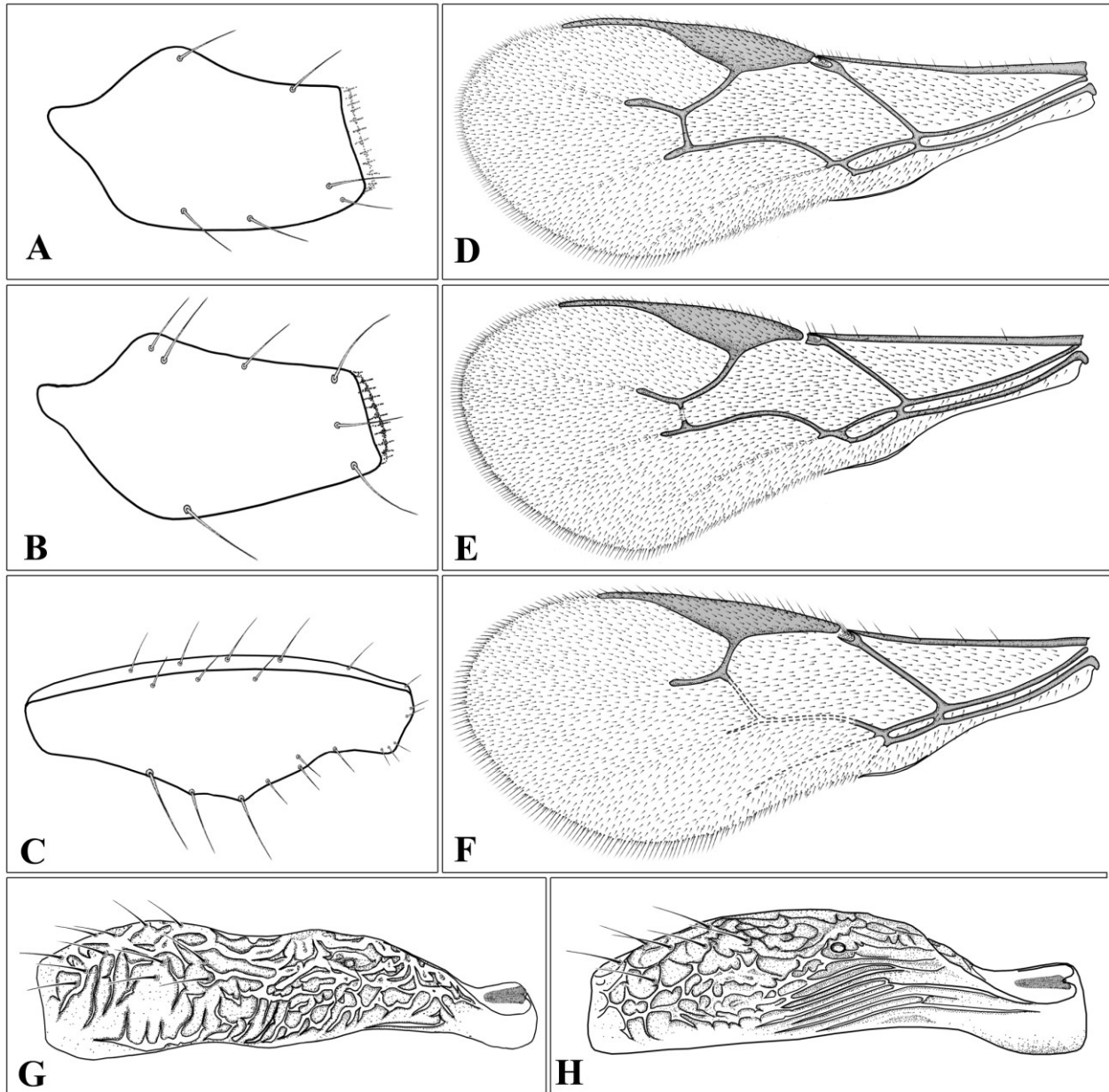
### Spain

Sampling efforts were realised in the middle and eastern Pyrenées in the provinces of Huesca, Lleida, Girona and in Andorra in 2011-2012. Aphids were found on *Aconitum napellus* L. everywhere and on *Aconitum pyrenaicum* L. in Andorra. These aphids were identified as *Brachycaudus aconiti* (Mordvilko) in all the samples. Mummies were not observed in the field inspection of the plants, and even rearing of sampled aphid colonies in cages did not produce any parasitoids. Also, the following predators were found: *Orius* sp. (Anthocoridae), *Coccinella septempunctata* L. (Coccinellidae), *Aphidoletes* sp. (Cecidomyiidae), *Episyrphus balteatus* (De Geer) and *Paragus* sp. (Syrphidae).

### Discussion

The first parasitization of *Delphiniobium carpaticeae* Mamontova from *Aconitum* sp. comes from European Russia (Starý, 1973). The information on the parasitization of *Delphiniobium* sp. by *Aphidius ervi* Haliday together with the description of a new species, *A. sussi* (Pennacchio and Tremblay, 1988; Pennacchio, 1989) from *D. junackianum* on *A. napellus*, close to the western Alps in Italy (Lombardy area).

In the last 12 years, aphids and parasitoids have been frequently sampled from *Aconitum toxicum* Reichenb. subsp. *bosniacum* (Beck) Niketić and *Aconitum pentheri* Hayek in Serbia mountain areas and Montenegro. Both plant species are endemic in the Balkan Peninsula. Aphids *D. junackianum* was found in all samples from June till the end of August, but *Delphiniobium lycotoni* Börner was sampled only once in Montenegro on *Aconitum vulparia* Reichenb. (Biogradsko jezero, 26 July, 2001). Incidence of parasitoids started in the middle of July (*A. sussi*) and during August were in greater abundance with the appearance of *M. leclanti*. All



**Figure 2.** A) *A. sussi*, ovipositor sheath, lateral side; B) *A. ervi*, ovipositor sheath, lateral side; C) *M. leclanti*, ovipositor sheath, lateral side; D) *A. sussi*, forewing; E) *A. ervi*, forewing; F) *M. leclanti*, forewing; G) *A. ervi*, anterolateral area of petiole; H) *A. sussi*, anterolateral area of petiole.

samples were taken from a few localities in Serbia (Mt. Kopaonik-Metode) and Montenegro (Mt. Durmitor - Crno jezero, Sušica). Five species of secondary parasitoids are collected, as follows: *Alloxysta fulviceps* (Curtis), *Alloxysta victrix* (Westwood), *Alloxysta macrophadna* (Hartig), *Coruna clavata* Walker and *Pachyneuron aphidis* (Bouche). The complete list of collected associations was published in Tomanović *et al.* (2002) and Kavallieratos *et al.* (2004).

From 2008, only a few sites in the Slovenian Alps were visited to collect aphid parasitoids. Most samples were taken on Velika planina (the Kamnik-Savinje Alps), but no aphids on *Aconitum* sp. were found. Only *Delphiniobium* sp. colony was found in sample of *Aconitum angustifolium* Bernh. ex Reichenb. from

Bohinj, by Bohinj Lake (The Julian Alps) on July 14<sup>th</sup> 2009. From the mummies 1 male and 1 female of *A. sussi* emerged in the laboratory (Kos *et al.*, 2012).

Lastly, Davidian and Gavryljuk (2010) described *Aphidius medvedevi* reared from *B. aconiti* on *Aconitum lycoctonum* L., Upper Altai mountain range, Western Siberia, Russia.

A synthesis of the new information from the Czech Republic and the earlier evidence from the Balkans shows that the same, apparently endemic parasitoid guild composed of *A. sussi* and *M. leclanti* is distributed in the sub-mountain and mountain areas in Central Europe and the Balkans, associated with *D. junackianum* but on a number of different species, often endemic in the area. No other interactions with the other

trophic webs have been determined. Also, the parasitoid guild is presumed to manifest a disjunctive distribution. The occurrence of *A. ervi* in *Delphinobium carpathicae* Mamontova (on *A. variegatum* in neighbourhood of Moscow, Russia) (Starý, 1973) and in *D. junackianum* (on *Aconitum napellus* L. in Lombardy, Italy) (Pennacchio, 1989; Pennacchio and Tremblay, 1988) is supposed to be due to the generally common presence of this parasitoid species in quite a range of habitats together with its host range features.

Finally, both *A. sussi* and *M. leclanti* have been newly determined for the Czech Republic. The strict specificity of the *Aconitum*-associated aphid and natural enemy guild seems to be due to the chemical composition of *Aconitum* plants - namely content of alkaloids (Heie, 1996) in a manner similar, for example, to *Aphis sambuci* L. (on *Sambucus nigra* L.) and *Macrosiphum albifrons* Essig (on *Lupinus polyphyllus* Lindl.) vs. coccinellids (Hodek 1966; Starý and Havelka, 1991).

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