

***Brachycaudus* Species on Herbaceous Plants along Highways in Hungary**

ZS. BASKY*

Plant Protection Institute, Centre for Agricultural Research, Hungarian Academy of Sciences,
P.O.B. 102, H-1525 Budapest, Hungary

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Survey of aphids on dicotyledonous herbaceous plants along the Hungarian highways on 33 sampling points revealed the presence of four holocyclic *Brachycaudus* species. The monoecious *B. lychnidis* L. 1758 was the most frequently collected species. It colonised the perennial *Silene alba* (Mill.) E. H. L. Krause 1893 on the youngest highway section around Budapest (5 locations). The frequency of this species is due to frequent occurrence of its host plant on this section compared to other host species. New record for the Hungarian fauna is the occurrence of monoecious *B. setosus* Hille Ris Lambers 1948 on the biennial or perennial *Tragopogon orientalis* L. 1753 on two locations on the southern part of the country. The heteroecious *B. cardui* L. 1758 was found on biennial or perennial *Senecio jacobaea* L. 1753 in one location on north-western part of Hungary. On the north-eastern part of the country the perennial *Symphytum officinale* subsp. *bohemicum* (F. W. Schmidt) Čelak 1891 occurred on a damp area. The monoecious *B. mordvilkoii* Hille Ris Lambers 1931 colonised this Boraginaceae species.

Keywords: Hungarian highway, *Brachycaudus lychnidis*, *B. setosus*, *B. cardui*, *B. mordvilkoii*.

Detailed faunistic investigations of scale insects in Hungary were started in relation to climate change in the 1980s cf. (Kozár, 1984, 1989, 1997, 1998; Kozár and Viktorin, 1978; Kozár and Dávid, 1986). Later on Ferenc Kozár extended his regular scale insect surveys to the plants of the extending highway network of Hungary (Kozár, 2009; Kozár et al., 2009). His idea was to survey scale insects along the highways from Athens to Brussels, from Rome to Kiev. Actually he has started to monitor the abundance and phenological investigations on *Pseudaulcaspis pentagona* (Targioni-Tozzetti 1886) scale insect along Athens–Amsterdam highway. His unexpected decease terminated his valuable activity. However, he encouraged us to extend surveys of different insect groups on the highway network of Hungary. Based on his idea the Zoological Department of our institute submitted an OTKA proposal for surveying invasive arthropod pest species and their natural enemies along the Hungarian highway network. This study reports preliminary results of aphid survey; the occurrence of *Brachycaudus* species on their herbaceous host plants on the stopping places of Hungarian highways.

Dedicated to the memory of Dr. Ferenc Kozár.

* E-mail: basky.zsuzsa@agr.ar.mta.hu

Materials and Methods

Along the 2655.9 km long highway network 33 evenly distributed sampling places were marked on rest areas or petrol stations. Aphids were surveyed on host plants from middle of May till the beginning of July in 2011 and 2012. The sampling places are published in Kiss et al. (2013). Aphid colonies were collected with fine camel hair brush and placed into Eppendorf tubes containing 70% ethanol. Location, sampling date and host plant name were recorded on the labels placed into the tubes. Apterous individuals were slide mounted using the method of Szalay-Marzsó (1969). The last step of slide mounting was to dye the cleared individuals according to Kosztarab and Kozár (1978).

Aphids were identified based on the identification keys of Blackman and Eastop (2006a, b), Baizongia Rondani – Aphids on the World's Plants, Burger (1975); Hayder et al. (2012); Heie (1992) and Darwish (1982).

The characters of slide mounted individuals were measured under microscope at 40, 100 and 200* magnification depending the size of the measured item. The structure of antesiphuncular sclerites was examined at 400* magnification. The above listed keys had to be used for identification of the collected four *Brachycaudus* species. Different keys required different morphometric characters for identification of a given species. All characters were measured and the ratios necessary for identification of a given species were calculated at each individual. The following characters were recorded: body length (BL), length of antenna (Antenna), length of ultimate rostral segment (RIV+V), length of second segment of hind tarsus (HTII), length of siphunculi (SIPH), length of process terminalis (PT), length of base of VI antennal segment (BaseVI), length of ANTIII (ANTIII), basal diameter of ANTIII (ANTIII base), longest hair on ANTIII, longest hair on ABDtergIII (HairABDtergIII), longest hair on ABDtergVIII, longest hair on frons (HairFRONS) were measured. The ratios Antenna/BL, PT/BaseVI, SIPH/Cauda, SIPH/HTII, SIPH/BL, ANTIII/SIPH, RIV+V/HTII, HairABDtergIII/ANTIIIbase, HairFRONS/ANTIIIbase were calculated.

Brachycaudus species occurred on their herbaceous host plants: *Silene alba* (Mill.) E. H. L. Krausse 1893, *Tragopogon orientalis* L. 1753, *Senecio jacobaea* L. 1753 and *Symphytum officinale* subsp. *bohemicum* (F. W. Schmidt) Čelak 1891.

Results

The morphometric parameters are summarised in Table 1. The column key includes the interval values of a morphometric parameter given in keys of Blackman and Eastop (2006a, b), Baizongia Rondani – Aphids on the World's Plants, Burger (1975); Hayder et al. (2012); Heie (1992) and Darwish (1982). The column measured contains the measured lowest and highest morphometric parameter values of the individuals studied.

Brachycaudus lychnidis L. 1758 were collected from perennial *Silene alba*. Aphids colonised flowers of *S. alba*. Small colonies were present on synsepalous calyx-leaves and below the calyx on the upper part of the flower stalks. Some individuals were found on the petals and on styles. However, no colonies occurred on the lower part of the stems

Table 1

Morphometric characters mm (hairs in μm) and comparisons of apterous adult individuals of *Brachycaudus lychnidis*, *B. setosus*, *B. cardui*, *B. mordvilkoii* collected from *Silene alba*, *Tragopogon orientalis*, *Senecio jacobaea*, *Symphytum officinale* subsp. *bohemicum*, respectively. Localities: Turul, Zsámbék, Annahegy, Ferihegy, Dunakeszi 2012, Röske, Kecskemét 2012, Moson 2011, Reketyés 2011, respectively

Characters	<i>B. lychnidis</i>			<i>B. setosus</i>			<i>B. cardui</i>			<i>B. mordvilkoii</i>		
	Key	Measured	Key	Key	Measured	Key	Key	Measured	Key	Measured	Key	Measured
Body length (BL)	1.8–2.9	1.94–2.27	2.2–2.6		1.94–2.22	1.6–2.8		2.27–2.59	1.7–2.3	2.09–2.38		
RIV+V	0.183–0.218	0.173–0.183			0.127–0.147	0.180–0.225		0.173–0.178	0.165–0.195	0.163–0.193		
HTII		0.096–0.129			0.127–0.153			0.132–0.137		0.086–0.117		
Sphunculi length		0.193–0.220			0.122–0.153			0.168–0.265		0.239–0.306		
Longest hair ANTIII μm	32–53	25.50–40.80			7.65–10.20			25.50–30.60	7	7.65–10.20		
Longest hair ABDtergIII μm		40.80–81.60		8–40 μm^*	20.40–40.80	< 23		25.50–30.60		7.65–15.30		
Longest hair ABDtergVIII μm	80–120	40.80–61.20			35.70–51.00			30.60–45.90	6–18	7.65–10.20		
Antenna/BL	0.6–0.8	0.5–0.85			0.45–0.60	0.6–0.8		0.65–0.80	0.6–0.8	0.55–0.68		
PT/Base VI	4.1–6.6	4.33–5.59		2.00–2.60	2.38–4.38	3.2–5.1		4.10–5.00	4.8–6.0	3.31–4.45		
SIPH/Cauda	1.9–2.3	1.90–2.83	1.2–1.7		1.35–2.00	2.1–3.4		1.56–2.73	2.8–3.2	2.14–3.13		
SIPH/HTII		1.10–1.90			0.85–1.20			1.22–1.52		2.60–2.90		
SIPH/BL	0.07–0.1	0.07–0.09	0.04–0.08		0.05–0.07	0.10–0.16		0.05–0.08	0.11–0.13	0.10–0.13		
ANTIII/SIPH	2.05–2.42	2.08–2.36			2.04–3.18	1.5–2.0		1.58–3.08		0.60–0.75		
RIV+V/HTII	1.50–1.60	1.22–1.79	0.7–0.9		0.86–1.04	1.3–2.0		1.30–1.36	1.3–2.0	1.61–2.12		
Hair ABDtergIII/ANTIII base	1.7–3.6	1.58–2.67			1.00–2.00			0.91–1.20		0.31–0.60		
Hair FRONS/ANTIII base		1.00–2.00			1.09–2.25	0.4–2.8		1.40–1.64	0.2–0.3	0.15–0.40		

* Longest hair on ABDterg III
Brachycaudus tragopogonis 8–15 μm
Brachycaudus tragopogonis ssp. *setosus* 16–40 μm
Blackman and Eastop (2006a)

and on the lower leaves. The species is monoecious, holocyclic in Europe, West Siberia, Turkey and Caucasus (Heie, 1992). Szépligeti (1883) gave the first account of the presence of the species in Hungary on *Lychnis dioica* L. 1753.

Apterous viviparous females of *B. lychnidis* have dark sclerotic dorsal shield extending from abdominal tergites I to VI. The dark shield reaches the stigmal plates (Fig. 1 a). Head, thorax, cornicles, cauda and genital plate are dark brown or black. Conspicuous transverse rows of imbrications on abdominal tergites are situated anterior to siphunculi. The surface of the imbrications is sunken in the cuticle; therefore the cuticle is creased around the imbrications (Fig. 1 a) Siphunculi truncated conical; the base is 1.7–2.2 times wider than distal end above flange. Morphometric parameters of the species are included in Table 1. From the collected species, *B. lychnidis* has the longest hairs on ANTH, ABDtergIII and ABDtergVIII.

Brachycaudus setosus Hille Ris Lambers, 1948 individuals were collected from the upper parts of stems and from the flower stalks of diurnal or perennial *Tragopogon orientalis*. The monoecious, holocyclic species has not been recorded from the Hungarian fauna yet (Ripka, 2008).

Brachycaudus tragopogonis Kaltenbach 1843 is recorded on *Tragopogon* species in Europe from Sweden, Denmark, Britain, Germany, Spain, Hungary, Russia, Transcaucasia, West Siberia, Central Asia, Turkey, Israel, and it was introduced to South America (Heie, 1992). The species is monoecious, holocyclic. *Brachycaudus tragopogonis* was first recorded in Hungary from *Tragopogon orientalis* by Pintera and Szalay-Marzsó (1962).

Hille Ris Lambers (1948) described a subspecies with long dorsal hairs in Israel as *Brachycaudus tragopogonis* ssp. *setosus* Hille Ris Lambers (1948), (Blackman and Eastop, 2006a). The subspecies is present in Central Asia and Pakistan (Mostafawy, 1967). The valid name of the species is *Brachycaudus setosus* Hille Ris Lambers 1948 (Nieto Nafria, 2004). Recently the species was recorded from Iran (Starý et al., 2000; Hayder et al., 2012; Barahoei et al., 2012, 2014). In the most recent check list of Hungarian aphids the species is not recorded either as *B. tragopogonis* ssp. *setosus* or as *B. setosus* (Ripka, 2008).

Apterous viviparous females of *B. setosus* are dark brown. Abdominal dorsum has extensive dark sclerotisation. Dorsal cross bars on mesonotum, metanotum and on abdominal tergite I are broken in the middle. Crossbars on abdominal tergites II–VI are separated from each other, but not broken. Crossbars of abdominal tergites do not reach stigmal pores (Fig. 1 b). Anterior siphuncular sclerites consisting of transverse rows of reticulation of dorsal cuticle situated on none sclerotized pleuromarginal or marginal area. The reticulations are flat group of cells on the surface of cuticle (Fig. 1 b). Cauda is black, helmet shaped. Siphunculi black, short, truncated; the base is 1.67–2.67 times wider than distal end above flange. The siphunculi of *B. setosus* are the shortest among the studied species. Hind tarsus II is long, therefore the SIPH/HTII ratio is the lowest among the species examined 0.85–1.20 (Table 1). The key data in Table 1 are the data of *B. tragopogonis*, the only key information related to *B. setosus* are published in Blackman and Eastop (2006a) are given in Table 1 foot note.

Brachycaudus cardui L. 1758 individuals were collected from perennial or biennial *Senecio jacobaea*. Aphids colonised flower stalks, but not the lower parts of the plants. The species is heteroecious and holocyclic in continental climates with a sexual phase

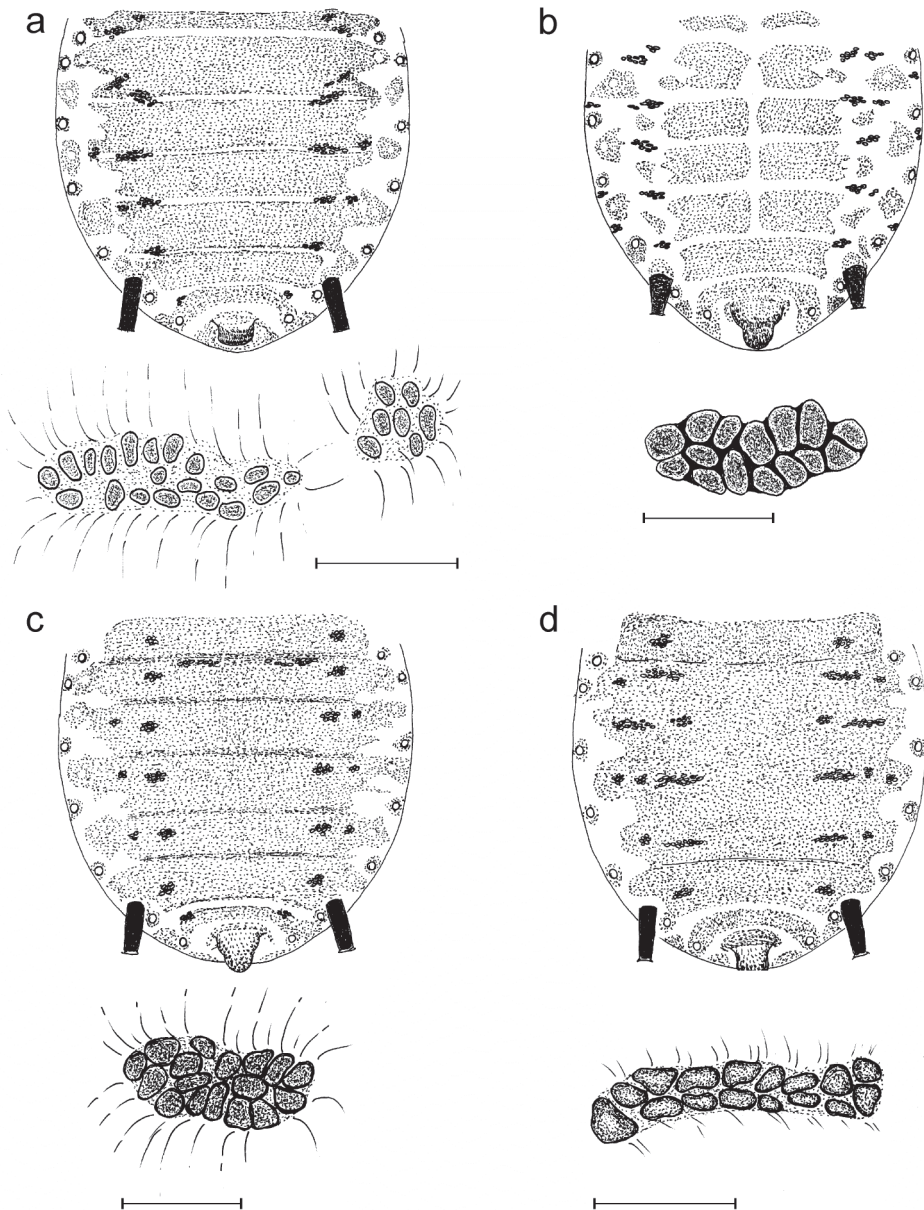


Fig. 1. Abdominal dorsal pigmentation of *Brachycaudus* species and the structure of antesiphuncular sclerites (scale bar 50 μ m). (a) *Brachycaudus lychnidis*, (b) *Brachycaudus setosus*, (c) *Brachycaudus cardui*, (d) *Brachycaudus mordvilko*

on *Prunus domestica* L. 1753 and *Prunus spinosa* L. 1753. From the primary woody hosts it migrates many species of Asteraceae (e.g. *Arctium*, *Carduus*, *Cirsium*, *Cynara*, *Chrysanthemum*, *Matricaria*, *Artemisia*, *Tanacetum*, *Senecio*) or Boraginaceae (*Echium*, *Anchusa*). *Brachycaudus cardui* is widespread all over Europe, Asia, North America, Gran Canaria, Azores and Africa (Heie, 1992). Szépligeti (1883) was the first to report the presence of *B. cardui* in Hungary. The host plant was *Onopordum acanthium* L. 1753. Szalay-Marzsó (1969) reported the species from *Senecio* sp.

Apterous viviparous females of *B. cardui* on herbaceous summer hosts are light green. Metanotum fused with abdominal tergites I–VI forming an extensive dark dorsal shield over the whole dorsum. The edge of the dark shield reaches stigmal plates (Fig. 1 c). Antesisiphuncular sclerites consisting of conspicuous transverse rows of imbrications are situated on abdominal tergites. The cuticle is creased around the imbrications (Fig. 1 c). The conspicuous, semi-globular mesosternal processes are dark. Siphunculi dark, sometimes slightly constructed at the base, but mainly truncated, conical; the base is 1.87–2.14 times wider than distal end above flange. Morphometric parameters of the species are included in Table 1.

Brachycaudus mordvilkoii Hille Ris Lambers 1931 individuals were collected from the flower stalks of perennial *Symphytum officinale* subsp. *bohemicum*. *Brachycaudus mordvilkoii* is monoecious, holocyclic on certain Boraginaceae (*Anchusa*, *Echium*, *Solenanthus* and *Symphytum*) species. It is widespread in Europe: Britain, Germany, Poland, Russia, Ukraine, Czech Republic and Slovakia, Hungary and Italy (Heie, 1992). Szelegiewicz (1966), (1968 a cit: Ripka, 2008) reported the occurrence of the species in Hungary from *Echium* sp.

Apterous viviparous females of *B. mordvilkoii* are green with shiny black dorsum. The dark, sclerotic dorsal shield extending from abdominal tergites I to VI; it covers the whole abdomen, reaching the stigmal plates (Fig. 1 d). Head, thorax, cornicles, cauda and genital plates are black. Mesosternal process is present, but less conspicuous than in *B. cardui*. Although transverse rows of imbrications are situated on the dark shield they are less conspicuous than those of *B. cardui* and *B. lychnidis*. The imbrications are hardly sunken, therefore the cuticle is seldom creased around the imbrications (Fig. 1 d).

Hairs are short. From the collected species, *B. mordvilkoii* is the shortest haired aphid (Table 1). The siphunculi are long, truncated and conical; the base is 1.83–2.14 times wider than distal end above flange. Siphunculi of *B. mordvilkoii* are the longest, hind tarsus II is the shortest from the examined species. Therefore SIPH/HTII ratio is the highest among the species examined: 2.6–2.9 (Table 1).

Altogether six keys were used for identification of these species. The presence of transverse rows of imbrications was mentioned only by Burger (1975) and Darwish (1982). Both of them mention presence of indistinct imbrications or almost absent (Burger, 1975) at *B. cardui*.

The imbrications consist of group of cells similar to those of wax glands. There is no obvious wax production of these species; this is the reason why these antesisiphuncular sclerites are called transverse rows of imbrications on the abdominal tergites (Burger, 1975).

Discussion

The total length of highways in Hungary is 2655.9 km. The highway margin area together with the petrol stations and rest areas is above 2000 ha (Kozár, 2009).

The aim of insect survey on rest areas or petrol stations was to find out whether highway margins serve as a corridor for migration of insects along highways. The survey revealed the presence of one *Brachycaudus* species on its Caryophyllaceae and two species on their Asteraceae and one species on its Boraginaceae herbaceous host plants. The host species are native in the Hungarian flora (Simon, 2004; Király, 2009; Király et al., 2011).

The highway margins and rest areas are created together with road constructions with changing characters of terrains. Grass mixture is sown and bushes or trees are planted on the created highway margins and rest areas. Actually a 2000 ha large artificial green stripe is formed along highways (Kozár, 2009). In this area the occurrence of native plants is rather sporadic.

Silene alba is common in the meadows and road banks all over the country. This species occurred more often on the youngest highway section around Budapest. The monoecious *B. lychnidis* colonised the flowers of this Caryophyllaceae plant (on 5 locations). It indicates that propagation materials of the species (seeds or root fragments) were present more often in the upper soil layer than those of other species.

T. orientalis is common in Hungary; its occurrence was sporadic in the area of study. The monoecious, holocyclic *B. setosus* colonised the flower stalks of this asteraceous species. If we consider the southern origin of the species: it was described from Palestine (Hille Ris Lambers, 1948). It has been reported recently from Iran by Starý et al. (2000); Hayder et al. (2012) and Barahoei et al. (2012, 2014). Based on the occurrence of *B. setosus* on the southern border crossing-place at M5 and 90 km northwest on Kecskemét a northward expansion of the species can be supposed. However, the area of distribution of the species does not support the corridor role of highway margins. Although on the map of Fauna Europea (Nieto Nafria, 2004) indicated the absence of *B. setosus* in Romania and Bulgaria. However, the species recorded to be present in Serbia, Kosovo, Montenegro, Turkey and also in Hungary and Slovakia. It has not been recorded from Hungary yet; Ripka (2008) and Ripka (Budapest, pers. com. 2014). There is no record about the presence of *B. setosus* in Serbia; Petrovic-Obradovic (Belgrade, pers. com. 2014). The species has not been recorded from Turkey; Özdemir (Ankara, pers. com. 2014). It is also not present in Slovakia; Stary and Havelka (Ceske Budejovice pers. com. 2014).

Brachycaudus setosus is monoecious, its host is *T. orientalis*; a wild plant species, therefore presence or absence of the species does not have any economic importance. However the aphid species form its black conspicuous colonies on the flower stalks therefore it is hard to imagine that the presence of the species in all of these countries has been overlooked.

Senecio jacobaea is common in Hungary, mainly in arable land and abandoned area. It was seldom found on the area of study. The heteroecious, holocyclic *B. cardui* colonized the flower stalks of this asteraceous species on one location, on north-western part of Hungary. The overwintering hosts of *B. cardui* are *Prunus* species. There were neither aphid colonies nor symptoms of *Brachycaudus* infestation found on *Prunus* species during the survey.

The Boraginaceae species: *Symphytum officinale* subsp. *bohemicum* was present on a damp area near the fence on one north-eastern rest area. On the location it was obvious that terrain changes did not disturb the habitat of this plant species. The monoecious, holocyclic *B. mordvilkoii* colonized this species.

Based on the results of this study it can be concluded that the occurrence of aphid species is subjected to the presence of host plants. The highway construction technology is not favourable to botanical diversity. In spite of all, the systematic survey resulted in recording the presence of *B. setosus* a southern aphid species new for the Hungarian fauna.

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