



**APOSERIS FOETIDA (L.) CASS. EX LESS., CONFIRMED AS A HOST-PLANT OF TRIOZA FOERSTERI MEYER-DÜR, 1871 (HEMIPTERA: PSYLLOIDEA: TRIOZIDAE)**

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**Abstract** – In the past, pit-galls on leaves of *Aposeris foetida* (L.) Cass. ex Less. (Asteraceae) have been attributed to *Trioza dispar* Löw, 1876 (Homoptera: Psylloidea: Triozidae), although there were some hesitations regarding this host association. Rearing of immatures to the adult stage in controlled conditions showed unambiguously that *Trioza foersteri* Meyer-Dür, 1871 causes these pit-galls and *A. foetida* is its true host-plant. Hence, all earlier records of *T. dispar* referring to *A. foetida* should be re-associated with *T. foersteri*. In Slovenia, this species is widely distributed but uncommon and *A. foetida* has been the only recorded host-plant so far, since there have been no records on the occurrence of pit-galls and immatures on its other known host-plants, *Lactuca muralis* and *Prenanthes purpurea*. During the rearing assay a considerable number of specimens of the parasitoid wasp *Tamarixia upis* (Walker, 1839) (Hymenoptera: Chalcidoidea: Eulophidae) emerged from parasitized immatures. *Trioza foersteri* is reported as a new host of this parasitoid wasp here. A complementary description of the fifth instar nymph of *T. foersteri* is provided. Several stages are documented with a series of photographs.

**KEY WORDS:** Psyllids, jumping plant-lice, immature morphology, biology, host-plant, Asteraceae, galls, parasitoid, Slovenia

**Izveček** – *APOSERIS FOETIDA* (L.) CASS. EX LESS. JE GOSTITELJSKA RASTLINA BOLŠICE *TRIOZA FOERSTERI* MEYER-DÜR, 1871 (HEMIPTERA: PSYLLOIDEA: TRIOZIDAE)

Oblikovanje mehurjastih šišek na listih navadne smrdljivke (*Aposeris foetida* (L.) Cass. ex Less. [Asteraceae]) so v preteklosti pripisovali bolšici *Trioza dispar* Löw, 1876 (Homoptera: Psylloidea: Triozidae), čeprav so bili glede tega tudi nekateri pomi-

sleki. Gojenje mladostnih razvojnih oblik v nadzorovanih razmerah do razvojne stopnje odraslih pa je nedvoumno pokazalo, da te šiške povzročata bolšica *Trioza foersteri* Meyer-Dür, 1871 in da je *A. foetida* njen pravi gostitelj. Zato je treba vse starejše navedbe, ki se nanašajo na vrsto *T. dispar* na gostiteljski rastlini *A. foetida* prenesti na vrsto *T. foersteri*. V Sloveniji je ta vrsta bolšice precej razširjena, a ne prav pogosta. Navadna smrdljivka je za zdaj tudi edini gostitelj te vrste pri nas, saj ni nobenih podatkov o pojavljanju šišk in mladostnih razvojnih stopenj te vrste na sicer znanih gostiteljih navadnem zajčjem lapuhu (*Lactuca* (= *Mycelis*) *muralis*) in škrlatnordeči zajčici (*Prenanthes purpurea*). Med gojenjem se je iz parazitiranih nimf izleglo tudi veliko število parazitoidnih osic vrste *Tamarixia upis* (Walker, 1839) (Hymenoptera: Chalcidoidea: Eulophidae). Bolšica *T. foersteri* doslej ni bila znana kot gostitelj tega parazitoida in je zato to nov podatek. Na novo in bolj podrobno je opisana peta razvojna stopnja nimfe bolšice *T. foersteri*. Različne stopnje so tudi fotografsko dokumentirane.

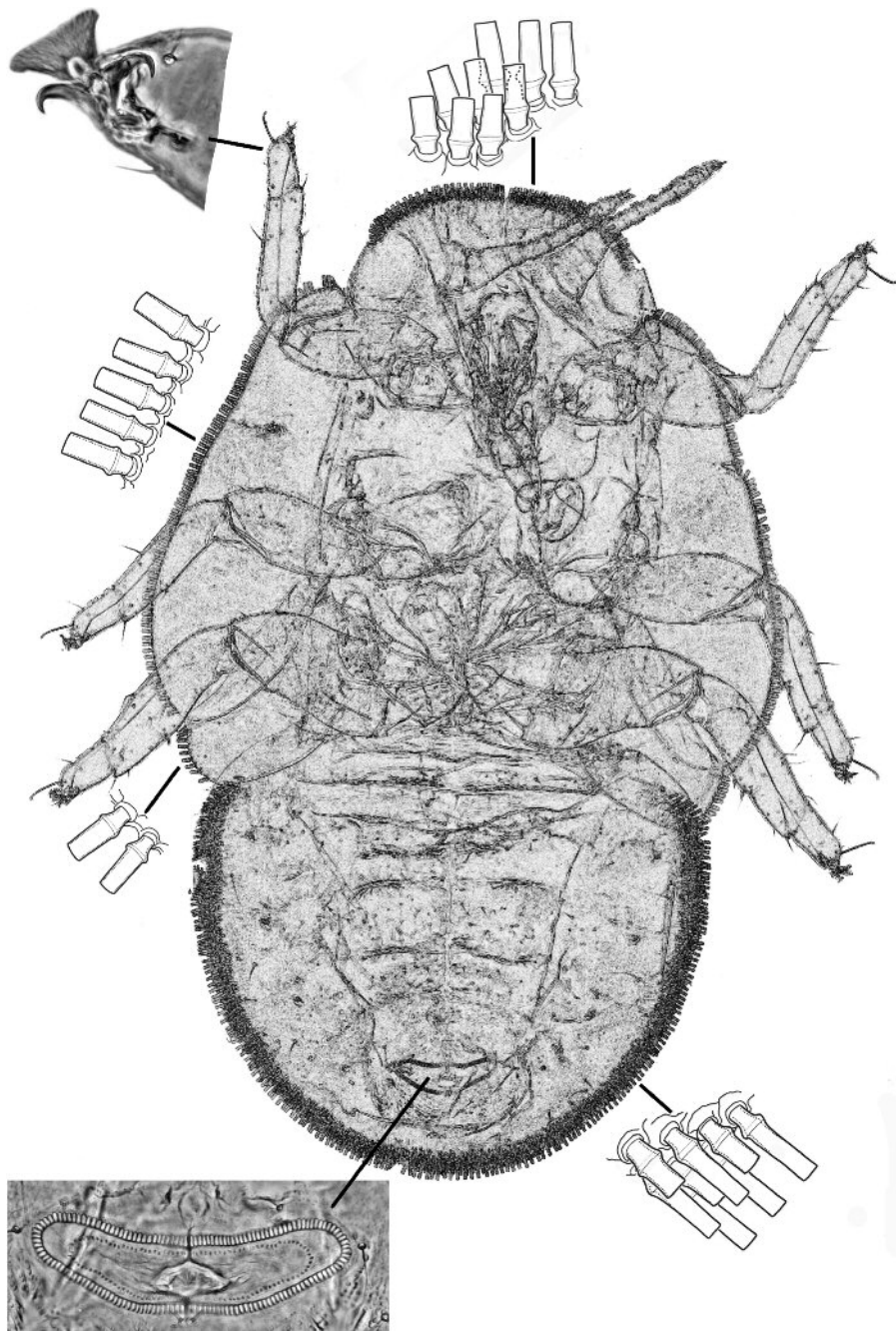
KLJUČNE BESEDE: Psylloidea, bolšice, morfologija mladostnih stopenj, biologija, gostiteljska rastlina, Asteraceae, šiške, prazitoid, Slovenija

## Introduction

The main distribution area of *Aposeris foetida* (L.) Cass. ex Less. (Asteraceae: Cichorieae) (Figure 2) is the eastern Alpine region, with radiations towards east up to Romania and Ukraine and isolated occurrences in Switzerland, France and Spain (EURO+MED, 2018). In Slovenia, this plant species is widely distributed and common, except in the easternmost (Prekmurje) and south-western (sub-Mediterranean) parts of the territory (JOGAN & al., 2001). It populates fresh shady forests and bushy habitats.

The occurrence of a gall inducing jumping plant-louse species from the Triozidae family on the leaves of *A. foetida* (Figure 2) has been well-documented in the literature dealing with zoocidia. Most authors or perhaps even all of them have associated these galls with the species *Trioza dispar* Löw, 1878 (e.g. HOUARD, 1909; BUHR, 1965; JANEŽIČ, 1989; ELLIS, 2018). Also the majority of previous taxonomic works on Triozidae listed *A. foetida* as a host-plant of *T. dispar* (Löw, 1888; VONDRÁČEK, 1957; DOBREANU & MANOLACHE, 1962; KLIMASZEWSKI, 1975; SELJAK, 2006). Some experts, however, expressed their doubts in referring to this association and pointed out to a need for its verification (LAUTERER & MALENOVSKÝ, 2002; OUVARD, 2018).

In Slovenia, *T. dispar* was recorded as widespread by JANEŽIČ (1989). In a comprehensive account on the plant-galls of Slovenia, he recorded this species from at least 30 localities across the territory. All these records referred to *A. foetida* exclusively. In the same work, there are no records of any psyllid species that would be associated with *Taraxacum officinale* L. or *Lactuca muralis* (L.) Fresen. and *Prenanthes purpurea* L., known as confirmed host-plants of *T. dispar* and *T. foersteri*, respectively. These data as such were summarized by the present author in an earlier overview on the psyllids of Slovenia (SELJAK, 2006). Finding of a large population of *Aposeris foetida* plants heavily infested by immatures of Triozidae in 2016 enabled the present author to rear the immatures to adults and subsequently to identify the species causing the galls on this plant.



**Fig. 1:** Fifth instar immature of *Trioza foersteri* Meyer-Dür, 1871 with details of setasetae, the circumanal pore ring and tarsal arolium.



**Fig. 2:** *Aposeris foetida*, a flowering plant

### Materials and methods

On July 27 2016, a large population of *Aposeris foetida* plants heavily infested by immatures of Trioziidae was encountered in a mountainous beech forest below Soriška planina (coord. 46°13'48" N, 14°01'24" E) at the altitude of about 1100 m. Several plants of *A. foetida* with typical pit-galls and living immatures on the lower sides of the leaves were dug out and taken to the author's home. These plants were planted in pots of an appropriate size and put in an insect cage. The cage was kept outdoors but protected from rain and direct sunshine. The presence of adults was checked once or twice a day. Freshly moulted adult specimens were left on plants for about a day in order to enable hardening and darkening of their cuticle. Mature adults were then removed from plants with an aspirator and killed with ethyl-acetate vapours. Twenty-three adult specimens were obtained from this rearing – 9 males and 14 females. Two males were dissected (after clearing in 10 % KOH) for a microscopic examination of the genital segment needed for the identification to the species. The specimens have been dry-mounted on insect boards of an appropriate size. They are deposited in author's private collection.

An additional sample of infested leaves was taken for a laboratory examination of immatures. The nymphs of the fifth instar were collected from the infested leaves and transferred into 70% ethanol for subsequent slide-mounting. Permanent slides



**Fig. 3:** A leaf of *A. foetida* with pit-galls

from this material were prepared according to the slightly modified procedure by HODKINSON & WHITE (1979). Then the nymphs were mounted on two slides (6+4). Also these slides are deposited in the author's insect collection. The slide-mounted immatures were examined under a compound microscope (Nikon Eclipse Ni-U) and imaged with an attached digital camera (Nikon DS-U3). Measurements and counts were performed in the Nikon NIS Elements Documentation software.

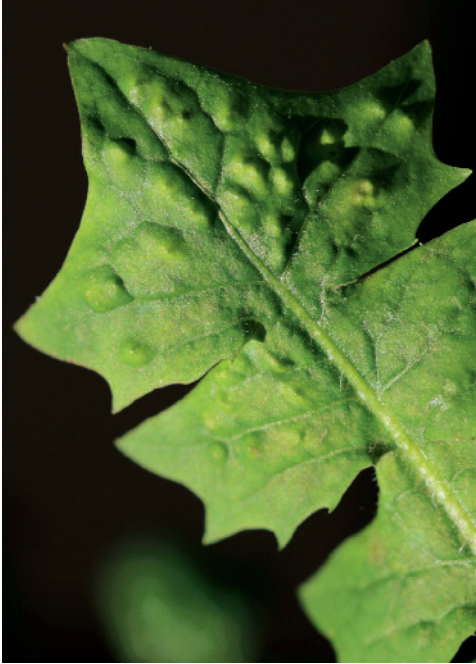
As a considerable proportion of immatures in the samples were heavily attacked by an unknown parasitoid wasp, emerged wasp specimens were collected too and preserved in 70% ethanol. A sample of these wasps was sent to Christer Hansson (Museum of Biology, Lund, Sweden) for the species identification.

A series of photographs were taken at the place of the occurrence as well as later from the samples taken home. The following equipment was used: camera Canon EOS 70D; lenses Canon EF 100mm f/2.8 Macro USM and Canon MP-E 65mm F/2.8 1-5X Macro and a flash Metz Mecablitz 15 MS-1.

The morphological terminology follows OSSIANNILSSON (1992). Currently accepted names for host-plants have been taken from the THE PLANT LIST (2018) database.

## Results

Adult specimens (Figures 7 and 8) obtained from rearing fully agree in all morphological characters with the description and illustrations of *Trioza foersteri* Meyer-



**Fig. 4:** Close-up of a leaf with pit-galls (upper side)



**Fig. 5:** *T. foersteri* - deposited eggs in pit-galls on the lower leaf side and a 1<sup>st</sup> instar larva

Dür, 1871 by DOBREANU & MANOLACHE (1962) and ŠULC (1913). The main diagnostic external characters are: a reddish orange body that may be slightly more brownish in males; relatively short and stout subparallel genal cones that are hardly half as long as the vertex; wings light yellowish with asymmetrically rounded apices, surface spinules moderately dense leaving only very narrow spinule-free bands along the veins; genital structures of the male and the female exactly as figured in DOBREANU & MANOLACHE (1962). The most distinctive characters for separating this species from the other representatives of the *T. dispar*-group (*T. dispar* Löw, 1878, *T. proxima* Flor, 1861, *T. megacerca* Burckhardt, 1983 and *T. tatrensis* Klimaszewski, 1965) are the male paramere with only a weak subapical constriction and the shape of the distal segment of the aedeagus with a broad terminal part and a distinctive subapical apophysis on the ventral side (cf. BURCKHARDT, 1983).

The immatures of *T. foersteri* were described by LÖW (1871) (under the name of *T. flavipennis* Foerster, 1848, which was, however, a misidentification) and briefly also by DOBREANU & MANOLACHE (1962). Only descriptions of the outer appearance of immatures and the host responses on the infestation were given, but no microscopic details were provided and illustrated. Therefore, a re-description of the fifth instar nymph is provided here and additionally documented with a series of photographs.



**Fig. 6:** *T. foersteri* - fifth instar immatures

**Fifth instar immature** (Figure 6). Body flattened, elongate ovoid; upper side more or less uniformly pale to ochrous yellow, getting some cast of orange with the age, especially in the middle of the abdomen; eyes red. Body margin with conspicuous white wax filaments of two types and sizes: the shorter ones on wing-pads are about  $\frac{1}{4}$  as long as the body width and collated in flattened waxy rays; very long, dense and thin rays of waxy filaments emerging from abdomen margins that may exceed the length of the body; on the head, there is a mixture of waxy filaments of both types.

Slide-mounted fifth instar immature (Figure 1): Body elongate ovoid; anterior head and posterior caudal plate margins rounded; dorsal cuticle bare and smooth, only submargin of abdomen slightly radially folded. Body margin completely bordered with sectasetae (except eyes); sectasetae on wing-pads of one type and size and arranged in a single row; 86–93 sectasetae on forewing-pads and 8–10 sectasetae on hindwing-pads; head margin bearing 3–4 rows of densely arranged sectasetae, these are of two types and sizes with the following arrangement: the upper two or sometimes three rows consist of shorter sectasetae that produce long and thin filaments and the lower row consists of longer and more slender sectasetae that produce shorter waxy rays; abdomen with 4, rarely 5 rows of densely arranged sectasetae that are of two types and sizes, these two types of sectasetae alternate in irregular rows – the upper and the third row consisting of shorter and broader sectasetae (produce long and thin waxy filaments), while the second and the fourth (lowest) row are formed by longer

and more slender sectasetae; posterior eye margin with a small lobe bearing a single sectaseta; sectasetae are completely absent from dorsum. Sectasetae are all truncate. Dimensions of poles (*sensu* OSSIANNILSSON, 1992) of different types of sectasetae are given in Table 1.

Antenna eight-segmented (the segments 3 and 4 are clearly divided and form together the outline of a fused segment 3 of many other trioqid species), with three rhinaria, one on the sixth and two on the eighth segments; terminal setae unequal in length, one truncated at tip, the other seta tapered and about 1.7 times as long as the truncate one. Humeral lobes of forewing-pads moderate, extending only to the posterior third of the eye margin.

Tarsal arolium broadly triangular (trapezoidal), longer than claws.

Anus situated ventrally, outer circumanal pore ring with single row of densely arranged elliptic pores.

**Table 1:** Morphometric characters of the fifth instar immatures of *T. foersteri*.

<b>Body measurements (mm)</b>	<b>n = 5</b>
Body length (BL)	1.62–1.95
Body breadth (BB)	1.05–1.22
Forewing pad length (WL)	0.77–0.92
Caudal plate length (CL)	0.57–0.78
Caudal plate width (CW)	0.87–1.03
Antenna length (AL)	0.36–0.40
Circumanal ring width (CRW)	0.19–0.22
Ratio BL/BB	1.54–1.63
Ratio AL/WL	0.41–0.50
Ratio CW/CL	1.30–1.52
Ratio CW/CRW	4.35–4.83
<b>Number of sectasetae</b>	
Head	3–4 rows, 2 types
Forewing pads	85–93
Hindwing pads	8–11
Abdomen	4–5 rows, 2 types
<b>Sectasetae measurements (µm)</b>	
<b>n = 15</b>	
<u>Wing-pads</u>	
Pole length (PL)	<u>15.0</u> (14.1–16.6)



Pole base width (PBW)	<u>6.4</u> (6.0–7.0)
Ratio PL/PBW	2.37 ± 0.13
<u>Head</u>	
- short sectasetae	
Pole length (PL)	<u>10.3</u> (9.5–11.7)
Pole base width (PBW)	<u>5.8</u> (5.5–6.1)
Ratio PL/PBW	1.77 ± 0.12
- long sectasetae	
Pole length (PL)	<u>15.6</u> (15.1–16.2)
Pole base width (PBW)	<u>5.8</u> (5.0–6.3)
Ratio PL/PBW	2.69 ± 0.29
<u>Abdomen</u>	
- short sectasetae	
Pole length (PL)	<u>11.1</u> (10.2–12.1)
Pole base width (PBW)	<u>5.8</u> (5.3–6.4)
Ratio PL/PBW	1.91 ± 0.12
- long sectasetae	
Pole length (PL)	<u>18.3</u> (16.2–19.9)
Pole base width (PBW)	<u>5.0</u> (4.5–5.7)
Ratio PL/PBW	3.7 ± 0.30

**Egg** (Figure 5). Oblong-oval, without pedicel; freshly laid eggs whitish, later becoming yellow. Eggs are laid on the lower sides of leaves (Fig. 10). A typical pit-gall develops soon around each egg, in which the immatures usually remain the whole life.

**Host plants.** Most published records of immatures and galls refer to *Lactuca* (= *Mycelis*) *muralis* (LÖW, 1871, 1888; DOBREANU & MANOLACHE, 1962; CONCI & AL., 1996; JERINIĆ-PRODANOVIĆ, 2010; MALENOVSKÝ & LAUTERER, 2012). *Prenanthes purpurea* was listed as a host for “*T. flavipennis*”, nec Foerster, by REIBER & PUTON (1880) and KIEFFER (1901) and this plant species was subsequently cited as a host for *T. foersteri* together with *Lactuca muralis* by several authors (HOUARD, 1909; ŠULC, 1913; VONDRÁČEK, 1957; DOBREANU & MANOLACHE, 1962; BUHR, 1965; BURCKHARDT 1989, 2002), probably just based on these two old papers. More recent records of *T. foersteri* on *P. purpurea* have been lacking and this host association is thus in need of verification (I. Malenovský, pers. comm.). Rearing of immatures to adults in this study unambiguously confirms that *Aposeris foetida* (Figure 2) is another host-plant



**Fig. 7:** *T. foersteri* - a male



**Fig. 8:** *T. foersteri* - a female

of this species. With this verification, all records of *T. dispar* previously associated with *A. foetida* should be reconsidered as concerning *T. foersteri*.

**Distribution:** *T. foersteri* is widespread from western North Africa through the Iberian Peninsula, central and eastern Europe to Turkey. It has been recorded from Morocco, Algeria, Spain, France, northern Italy, Switzerland, Germany, Austria, Poland, Czech Republic, Slovakia, Serbia, Greece, Romania, Belarus and Turkey (MEYER-DÜR, 1871; REIBER & PUTON, 1880; ŠULC, 1913; BAUDYŠ, 1931; VONDRÁČEK, 1957; DOBREANU & MANOLACHE, 1962; KLIMASZEWSKI, 1975; BURCKHARDT, 1988, 1989; CONCI & al., 1996; BURCKHARDT & ÖNUÇAR, 1993; BURCKHARDT & LAUTERER 2003; JERINIĆ-PROĐANOVIĆ, 2010; MALENOVSKÝ & LAUTERER, 2012; SERBINA & AL., 2015). In Slovenia, this species has not been reported under this name yet, but, as already mentioned above, erroneously under *T. dispar* (JANEŽIČ, 1989). All these previously published data from Slovenia are summarized below. My own data are added as well. Both are mapped out in Figure 12.

Janežič, 1989: Logatec (VL48); Drenov grič (VL49); Horjul (VL49); Planina nad Horjulom (VL49); Rakitna (VL58); Vnanje Gorice (VL59); Fara (VL66); Ig (VL68); Pijava gorica (VL68); Smrjene (VL68); Kočevje (VL85); Muljava (VL88); Stična (VL88); Višnja gora (VL88), 15.7.1979; Šentlovrenc (VL98); Trebnje (VL98); Golnik (VM43); Ljubljana - Rožnik (VM60), 15.6.1978; Volčji potok (VM71); Sv. Primož pri Kamniku (VM72); Novo mesto (WL17); Prečna pri Novem mestu (WL17); Šmarješke toplice (WL17); Raka pri Krškem (WL38); Velenje (WM03); Laze pri Velenju (WM13); Dobrna (WM13); Celje (WM22); Lipoglav (WM32); Kozje (WM40); Vojnik (WM52).

Author's own data: Mirtovički potok (VL84), 21.7.2013; Zgornja Sorica – 1120 m (VM22), 29.7.2016; Draga (Ig) (VL68), 19.5.2017.

**Parasitoids:** Even at the locality where the species was collected, it was obvious that the population of immatures was heavily affected by parasitoids. More than a half of specimens were dead and showed typical emergence holes of parasitoids (Figure 9). Many immatures were still alive but with a larva or pupa of a parasitoid inside (Figure 10). During the rearing assay, several dozen of small wasps emerged (Figure 11), which were collected for a subsequent identification. Female wasps clearly prevailed. The examination of the whole sample showed that all specimens belonged to one sole species, *Tamarixia upis* (Walker, 1839) (Hymenoptera: Eulophidae). According to the specialist CHRISTER HANSSON (pers. comm.), this eulophid wasp is widely distributed and common in Europe, but it has not been reported from Slovenia yet. So far only two hosts of this parasitoid wasp have been reported: *Bactericera femoralis* (Foerster, 1848) and *Trioza urticae* (Linnaeus, 1758) (ONILLON, 1969; BIN, 1972; NOYES, 2018). Hence, *T. foersteri* is a new, previously unknown host of this parasitoid wasp.

## Discussion and conclusions

*Trioza foersteri* is a western Palaearctic jumping plant-louse species. In the late 19<sup>th</sup> and early 20<sup>th</sup> centuries, it was misinterpreted, namely by Löw (1871, 1888) and



**Fig. 9:** Parasitized immatures of *T. foersteri*



**Fig. 10:** larva of *Tamarixia upis* on the lower side of a nymph of *T. foersteri* (turned upside down)

some of his followers (PUTON, 1899; OSHANIN, 1908; HOUARD, 1909), who considered it as a synonym of *T. flavipennis* Foerster. This uncertainty was later clarified by ŠULC (1913) who confirmed *T. foersteri* as a valid species. In contrast, there were no

inconsistencies regarding its host-plants, all referring to *Lactuca muralis* and *Prenanthes purpurea*. On the other hand, similar pit-galls expressed on leaves of *Aposeris foetida* (Figures 3 and 4) have never been associated with this species but with *T. dispar* exclusively. This is not surprising, as the immatures of both species are highly similar, both in terms of external morphology and micro-structures. Both produce very abundant and apparent waxy filaments all around the body margin, which are noticeably long and peculiar on the abdomen margins (Figure 6). Since I did not have the opportunity to examine immatures of *T. dispar*, I only could compare characteristics of the immatures of *T. foersteri* examined by myself with the description of *T. dispar* by OSSIANNILSSON (1992) and comments by I. Malenovský (in litt.) based on specimens collected on *Taraxacum* Sect. *Ruderalia* in the Czech Republic and Slovakia. The diagnostic characters of both species are summarized in Table 2. Considering the similarity in morphology of immatures and adults as well, *T. foersteri* and *T. dispar* are probably closely related species.

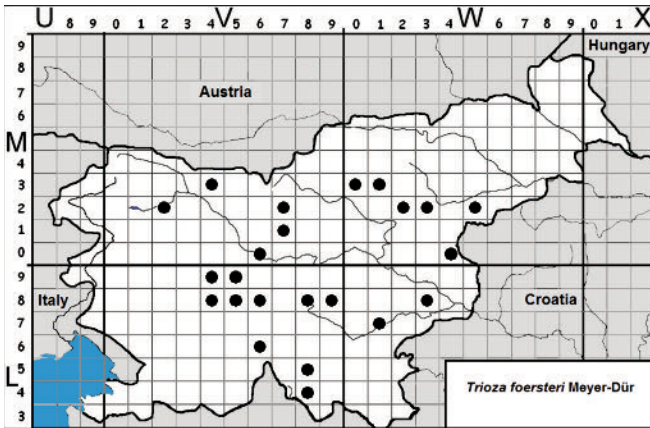
**Table 2:** Main morphological similarities and differences of the fifth instar nymphs between *T. foersteri* and *T. dispar*

Morphological character	<i>Triozia foersteri</i>	<i>Triozia dispar</i> (after Ossiannilsson, 1992 and I. Malenovský, in litt.)
Dark pattern on body dorsum	absent	mainly present, but variable
Forewing-pad sectasetae arrangement and shape	single row, one type	single row, one type
Forewing-pad sectasetae n°	85–93	80–106
Hindwing-pad sectasetae arrangement and shape	single row, one type	single row, one type
Hindwing-pad sectasetae n°	8–11	9–13
Head sectasetae arrangement and shape	3–4 irregular rows, 2 types and 2 sizes	3–4 irregular rows, 2 types and 2 sizes
Abdomen sectasetae arrangement and shape	4–5 irregular rows, 2 types and 2 sizes alternating by rows	3–5 irregular rows, 2 types and 2 sizes alternating by rows
Host-plant(s)	<i>Lactuca muralis</i> , <i>Aposeris foetida</i> , <i>Prenanthes purpurea</i> (?)	<i>Taraxacum officinale</i>

Findings derived from this study surely affect previous distributional data of *T. dispar* associated with *Aposeris foetida* (LÖW, 1888, from Austria; JANEŽIČ, 1989 and SELJAK, 2006, from Slovenia). According to this knowledge, all data referring to *T. dispar* on the host-plant *Aposeris foetida* have to be reassociated with *T. foersteri*. Since no other data or records referring to *T. dispar* exist, this species has to be removed from the list of species occurring in Slovenia.



**Fig. 11:** *Tamarixia upis* - a female (size: ~ 1,0 mm)



**Fig. 12:** *T. foersteri* - currently known distribution in Slovenia

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