

Tetraneura (Tetraneurella) nigriabdominalis* (Hemiptera: Aphidoidea) – a species extending its range in Europe, and morphological comparison with *Tetraneura (Tetraneura) ulmi

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The paper presents the first records of *Tetraneura (Tetraneurella) nigriabdominalis* (Sasaki, 1899) (Eriosomatinae, Eriosomatini) from Poland, an alien species that has been expanding its range northward, which is presumably connected with climate warming. Secondary hosts of this aphid are different plant species from the family Poaceae, including *Zea* L. Considering the steady increase in maize cultivation area in Europe, the species can become a potential threat to this cereal. We present the morphological characteristics of winged morphs developing in galls on trees from the genus *Ulmus* L. Those characteristics enable to distinguish this species from *Tetraneura (Tetraneura) ulmi* (Linnaeus, 1758), which dominates on elms in northwestern Europe. The data on the distribution of *T. (T.) nigriabdominalis* in Europe are also provided.

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1. Introduction

The genus *Tetraneura* Hartig, 1841 is represented by approximately 30 species worldwide (Blackman & Eastop 2016). Most of these species form galls on *Ulmus* spp., namely the holocyclic and heteroecious species, which during their development change their host, migrating from elm tree leaves to the roots of different

grass species. In warm regions of the world, some species may reproduce asexually (anholocyclically), feeding only on grass roots (Blackman & Eastop 2006).

The presence of two species of this genus has been hitherto confirmed from Poland: *Tetraneura (T.) ulmi* (Linnaeus, 1758) and *T. (T.) africana* Van der Goot, 1912 (Osładacz & Hałaj 2012, Wojciechowski *et al.* 2015). The former is a



Fig. 1. Distribution of *Tetraneura (T.) nigriabdominalis* in Europe. Black circle: new records in Poland (1. Kórnik, 2. Poznań—the Botanical Garden, 3. Poznań—Radojewo, 4. Lisówki); diagonal lines: published data (according to Zhuravlev 2008, Mifsud et al. 2009, Modic et al. 2012 & Nieto Nafria 2013).

heteroecious species that induces galls on elm trees. The latter was recorded from the roots of *Calamagrostis epigejos* (L.) (Olesiński & Szelegiewicz 1974), but gall formation by this species has not been reported so far.

Tetraneura (T.) nigriabdominalis is widely distributed worldwide, but its probable native range is East Asia (Blackman & Eastop 2016). In Europe, it has been recorded in Italy, Greece, Bulgaria, France, Spain, Portugal, the Czech Republic, Slovakia, Ukraine, and the British Isles, among other countries (Zhuravlev 2008, Mifsud et al. 2009, Modic et al. 2012, Nieto Nafria 2013) (Fig. 1). Its primary host constitutes different species of *Ulmus* (e.g. *U. canescens* Melville, *U. davidiana* var. *japonica* Rehder, *U. parvifolia* Jacq., *U. minor* Mill., *U. pumila* L.). Secondary hosts are numerous species of Poaceae family from the genera *Agropyron* Gaerth., *Digitaria* Haller, *Echinochloa* P. Beauv., *Eragrostis* Wolf, *Panicum* L., *Saccharum* L., *Setaria* P. Beauv., and *Triticum* L. (Holman 2009, Blackman & Eastop

2016). It also inhabits the roots of plant genera of high economic importance: *Oryza* L., *Sorghum* Moench and *Zea* L. (Modic et al. 2012). It is one of the most important rice pests (Heinrichs & Barrion 2004). Łabanowski (2008) recorded this species also from the tubers of *Freesia* Eckl. ex Klatt (Iridaceae) imported from Holland and grown in a greenhouse in Poland. This determination is doubtful, however, as freesia is not a host plant for this aphid (it does not belong to the family Poaceae).

A majority of the studies on *T. (T.) nigriabdominalis* focus on morphological, biological, and genetic research on the development of the aphid on grass roots over the course of generations (Gadiyappanavar & Channabasavanna 1973, Kuo et al. 2006, Modic et al. 2012). Few studies concern generations developing on elms (Galli & Manicardi 1998, Lee et al. 2012, Takei et al. 2015).

In northwestern Europe, the dominant species of gall-forming aphid on elms is *T. (T.) ulmi*. In

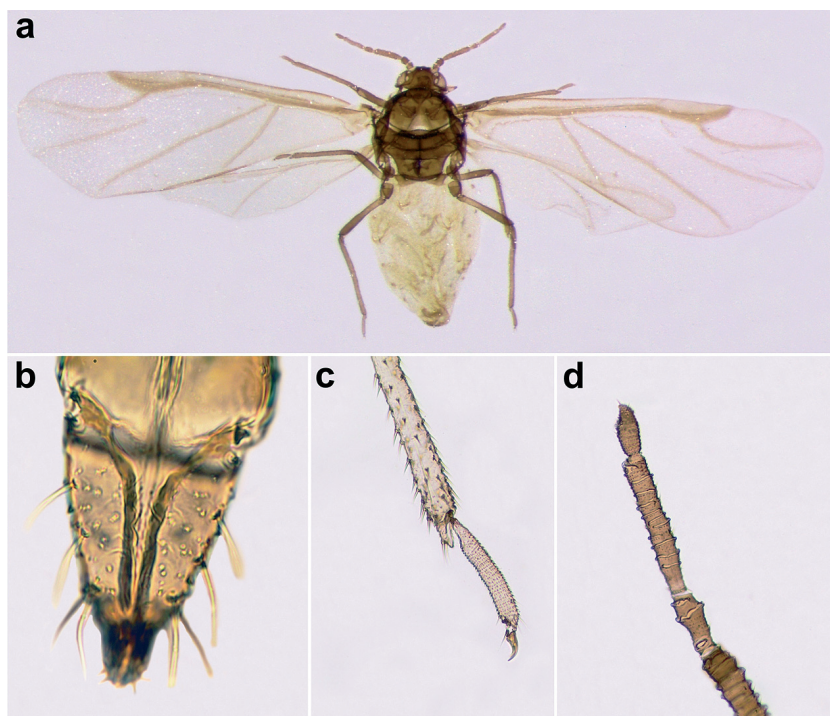


Fig. 2. Winged female (alate fundatrigenia) of *Tetraneura (T.) nigriabdominalis*. – a. Whole specimen. – b. Ultimate rostral segment (URS). – c. Hind tarsus II (HT II). – d. Antenna.

the following study, we present data on *T. (T.) nigriabdominalis*, a species that is new to Poland, and which has been expanding its range northward. The species poses a potential threat to maize cultivation and other cereals. It is connected with climate warming and a steadily and rapidly expanding cultivation area of this plant in Europe, especially in its east-central part.

Apart from the characteristics differentiating the two species according to literature, the data are here supplemented with additional characteristics (the length of legs, antennae, tibia, hind tarsus, and the number of rhinaria on antennal segments), which can be used to confirm the correct identification of the species. Some of the features are determined polygenically, and in consequence of that, they can be modified by environmental factors. Therefore, the more morphological characteristics are assessed, the more reliable the identification of the species is, which is critical for example from the practical point of view of planning pest control. The presented characteristics improve identification of winged morphs collected with Moericke traps and Johnson's aspirator (Heathcote 1957, Złotkowski 2008), both used when monitoring cereal pests.

2. Materials and methods

The material consisted of numerous specimens of winged aphids collected from galls on elm leaves. The specimens are deposited in Department of Entomology and Environmental Protection (Poznań University of Life Sciences, Poland) and are as follows:

Tetraneura (T.) nigriabdominalis

- Kórnik, Arboretum of the Institute of Dendrology of the Polish Academy of Sciences, UTM: XT49, *Ulmus* 'Wredei' (the hybrid elm cultivar *U. ×hollandica*), 15.VI.2015 and 6.VI.2016, U. Walczak leg.
- Poznań, the Botanical Garden of Adam Mickiewicz University, UTM: XU20, *U.* 'Wredei', 15.VI.2016, B. Borowiak-Sobkowiak & U. Walczak leg.
- Poznań–Radojewo, the edge of a riparian slope elm-ash wood (*Viola odoratae-Ulmetum*) adjacent to a field, UTM: XU31, *U. minor*, 16.VI.2016, U. Walczak leg.
- Lisówki, by Lake Tomickie in the buffer zone of Wielkopolska National Park, UTM: XT19, *U. minor*, 19.VI.2016, B. Wilkaniec leg.

Table 1. Morphological characters (lengths in mm) of winged females (alate fundatrigenia) of *Tetraneura (T.) nigriabdominalis* and *Tetraneura (T.) ulmi* based on this study and literature (Blackman & Eastop 2006, Zhuravlev 2008). Abbreviations: URS, ultimate rostral segment; HT II, hind tarsus II; Ant, antennal segment.

| | <i>Tetraneura (T.) nigriabdominalis</i> | | <i>Tetraneura (T.) ulmi</i> | |
|----------------------|---|-----------------------|------------------------------------|-----------------------|
| | This study Mean ± SD Min–Max | Literature Min–Max | This study Mean ± SD Min–Max | Literature Min–Max |
| Body length | 2.09 ± 0.099 1.95–2.35 | 1.4–2.3 | 1.9 ± 0.085 1.8–2.1 | 1.8–2.6 |
| Antennal segment III | 0.23 ± 0.015 | 0.21–0.25 | 0.22 ± 0.021 | 0.17–0.25 |
| Antennal segment V | 0.18 ± 0.012 | 0.17–0.2 | 0.13 ± 0.016 | 0.09–0.15 |
| Antennal segment VI | 0.07 ± 0.010 | 0.06–0.09 | 0.1 ± 0.005 | 0.09–0.1 |
| Ant V / Ant VI | 2.67 ± 0.354 2.12–3 | 1.7–2.8 | 1.27 ± 0.187 0.9–1.5 | 1.5–2 |
| URS | 0.078 ± 0.007 0.074–0.095 | 0.075–0.09 | 0.10 ± 0.013 0.07–0.13 | 0.11–0.15 |
| Accessory setae | 2–4 | 2–4 | 6–8 | 6–10 |
| URS/HT II | 0.48 ± 0.035 0.44–0.56 | 0.6 | 0.76 ± 0.125 0.51–0.86 | 0.7–0.9 |
| HT II | 0.16 ± 0.003 0.15–0.16 | | 0.13 ± 0.012 0.11–0.15 | |
| Tibia length | 0.73 ± 0.028 0.67–0.76 | | 0.67 ± 0.037 0.62–0.73 | |
| Rhinaria III | 11 ± 1.327 9–13 | | 11.7 ± 0.9 10–13 | |
| Rhinaria IV | 2.5 ± 0.671 2–4 | | 2.9 ± 0.7 2–4 | |
| Rhinaria V | 9 ± 0.895 8–11 | | 6.2 ± 1.077 5–9 | |
| Rhinaria VI | 0 | | 0.5 ± 0.5 0–1 | |

Tetraneura (T.) ulmi

- Kórnik, Arboretum of the Institute of Dendrology of the Polish Academy of Sciences, UTM: XT49, U. ‘Wredei’, 6.VI.2016, U. Walczak leg.
- Poznań–Radojewo, the edge of a riparian slope elm-ash wood (*Violo odoratae-Ulmetum*) adjacent to a field, UTM: XU31, *U. minor*, 16.VI.2016, U. Walczak leg.

To compare morphological characteristics of *T. (T.) nigriabdominalis* and *T. (T.) ulmi*, microscopic preparations with 10 winged specimens from both species were made. The following characteristics were analysed: body, length of tibia, length of hind tarsus II (HT II), lengths of

antennal segments III, V and VI, length of ultimate rostral segments (URS), number of accessory setae, and number of rhinaria.

3. Comparison of morphological characteristics of *T. (T.) nigriabdominalis* and *T. (T.) ulmi*

Winged female (alate fundatrigenia) of *T. (T.) nigriabdominalis*, its ultimate rostral segment, hind tarsus and antenna are shown in Fig. 2. The morphological characteristics that allow reliably distinguish *T. (T.) nigriabdominalis* and *T. (T.) ulmi* are summarized in Table 1. Here we note the characteristics as measured and counted in this

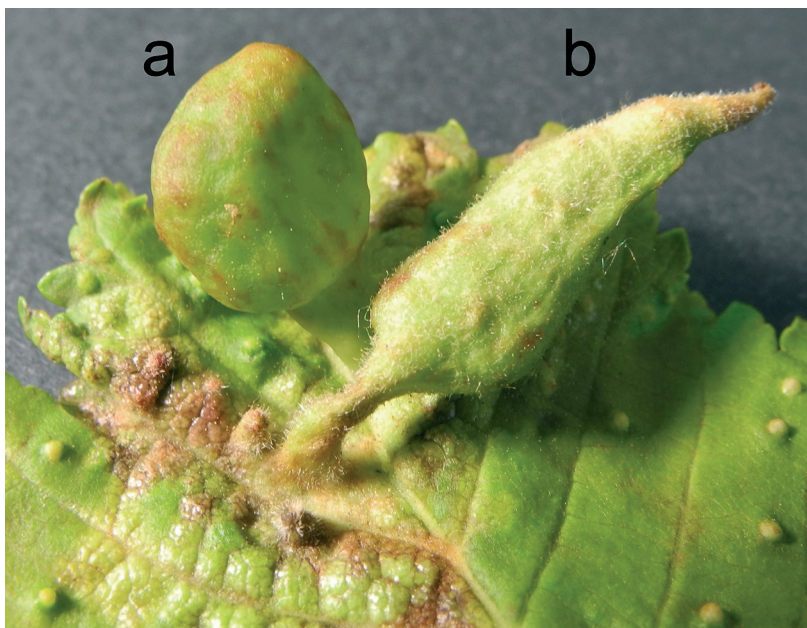


Fig. 3. Galls on *Ulmus* 'Wredei'. – a. *Tetraneura (T.) ulmi*. – b. *Tetraneura (T.) nigriabdominalis*.

study. For some of them, somewhat different values from literature are shown in Table 1. The length of the wax-covered body of winged females of *T. (T.) nigriabdominalis* varies 1.95–2.35 mm. There are 0–2 dark bands on abdominal tergites. Female of *T. (T.) ulmi* is slightly smaller, the length varies 1.8–2.1 mm. The most important morphological characteristics distinguishing the two species are listed below. In *T. (T.) nigriabdominalis* the ratio of the length of the antennal segment V to the antennal segment VI is 2.67 (± 0.354), while for *T. (T.) ulmi* it is 1.27 (± 0.187). *Tetraneura (T.) nigriabdominalis* has 2–4 accessory setae on the ultimate rostral segment, while *T. (T.) ulmi* has 6–8. The ratio of the ultimate rostral segment to hind tarsus is 0.48 (± 0.035) for *T. (T.) nigriabdominalis* and 0.76 (± 0.125) for *T. (T.) ulmi*.

4. Galls of *T. (T.) nigriabdominalis* and *T. (T.) ulmi*

Galls of both species are stalked and located on the upper side of a leaf. Galls of *T. (T.) nigriabdominalis* are hairy, elongate or pouch shaped, usually with a pointed apex, whereas the galls formed by *T. (T.) ulmi* are smooth and shiny and bean shaped (Fig. 3). When mature, the galls of *T.*

(T.) nigriabdominalis are usually bicoloured green and rose-red, and those formed by *T. (T.) ulmi* are reddish-green or yellowish. Galls of both species can co-occur on the same leaf blade (Fig. 3).

5. Discussion

Tetraneura (T.) nigriabdominalis is widely distributed in the warm regions of the world. Kuo *et al.* (2006) reported that the most suitable temperature for this species to develop on rice roots is 30 °C. Accordingly, the range expansion of the aphid towards the north is likely linked to climate warming.

In the closest vicinity of Poland, the species occurs in the Czech Republic, Slovakia and Ukraine (Zhuravlev 2008, Nieto Nafria 2013). The aphid spread to the north presumably via aerial dispersal through the Moravian Gate, a natural depression between the Sudetes and the Carpathian Mountains. The Moravian Gate constituted a significant path of Holocene migrations (Sternberg 1998) and still now serves as an ecological corridor for southern species that broaden their range to the north (Konvicka *et al.* 2003, Sierka *et al.* 2008). Furthermore, the possibility of transfer *T. (T.) nigriabdominalis* via nursery

stock (elm seedlings, ornamental grass) cannot be ruled out.

Ulmus minor, on which galls of *T. (T.) nigriabdominalis* were found, occurs often near fields, on the edges of forests, and in midfield shelterbelts. Cereals are the largest crop group in farmlands in Europe. Maize, the secondary host plant of this aphid, is an important species of cereal cultivated for grain, and its crop area is gradually increasing. There is a risk that this aphid might become a serious pest of these crops in the future, and therefore its occurrence should be monitored.

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