

Hydrellia (Diptera: Ephydriidae) mining in *Stratiotes aloides*: a long history of confusion

Hydrellia (Diptera: Ephydriidae), минирующие *Stratiotes aloides*: долгая история недоразумений

J.-H. Stuke

Й.-Х. Штуке

Jens-Hermann Stuke , Roter Weg 22, 26789 Leer, Germany. E-mail: jstuke@zfn.uni-bremen.de

Abstract. Based on collecting records, rearing, examination of type specimens and analysis of published data, this paper discusses which species of the genus *Hydrellia* (Diptera: Ephydriidae) mine in Water Soldier, *Stratiotes aloides*. Seven species of *Hydrellia* have been reported as leaf miners of *S. aloides* in the literature during the last 100 years. All records are very likely to be *H. tarsata* Haliday, 1839, and three species described from the material reared from *S. aloides* are considered to be new junior synonyms of *H. tarsata*: *H. stratiotae* Hering, 1925, **syn. nov.**, *H. stratiotella* Wahlgren, 1947, **syn. nov.**, and *H. propingua* Wahlgren, 1947, **syn. nov.** Hence, only *H. tarsata* is known to live in *S. aloides*. Information on the bionomics and distribution of *H. tarsata* is reviewed.

Резюме. На основе сборов, выведений имаго, изучения типовых экземпляров и анализа литературных данных, в статье обсуждается, какие виды рода *Hydrellia* (Diptera: Ephydriidae) минируют телорез (*Stratiotes aloides*). Семь видов *Hydrellia* были отмечены в литературе за последние 100 лет как минирующие листья *S. aloides*. Все указания с большой вероятностью относятся к *H. tarsata* Haliday, 1839, а три вида, описанные на основе экземпляров, выведенных из *S. aloides*, рассматриваются в качестве новых младших синонимов *H. tarsata*: *H. stratiotae* Hering, 1925, **syn. nov.**, *H. stratiotella* Wahlgren, 1947, **syn. nov.** и *H. propingua* Wahlgren, 1947, **syn. nov.** Таким образом, только *H. tarsata* обитает в *S. aloides*. Приводится обзор информации о биологических особенностях и распространении *H. tarsata*.

Key words: mines, bionomics, *Stratiotes aloides*, Diptera, Ephydriidae, *Hydrellia*, new synonyms

Ключевые слова: мины, биологические особенности, *Stratiotes aloides*, Diptera, Ephydriidae, *Hydrellia*, новые синонимы

ZooBank Article LSID: ED1F6D9E-CADD-4758-BF0A-3D41C3DF64C0

Introduction

The ephydrid genus *Hydrellia* Robineau-Desvoidy, 1830 is the most species-rich genus of Ephydriidae, with about 200 species known to date. *Hydrellia* is distributed worldwide. The larvae of *Hydrellia* live as miners in various plants and have

a high preference for plants living in aquatic or semiaquatic conditions. Some species of *Hydrellia* are known to be serious pests (e.g. Deeming, 2002; Hesler, 1995; Litsinger et al., 2013). Other species are discussed as possible biological control agents against neophytes (e.g. Grodowitz et al., 1997; Häfliger et al., 2018; Smith et al., 2022). Species iden-

tification of *Hydrellia* is a serious problem. On the one hand, the diversity of the genus is only poorly understood, with several undescribed species even in Europe. On the other hand, the taxonomy of even the described species is confusing due to a high intraspecific and intersexual variability of coloration in several species. Collin (1966) was the first to describe the terminalia of several British species of *Hydrellia* and to point out the importance of terminalia for their identification. The identification of several species published before 1966 remains doubtful. This situation complicates the interpretation of host records for *Hydrellia*. Since Ulmer (1903) it has been known that *Hydrellia* live in the Water Soldier (*Stratiotes aloides* L.). To date, seven species of *Hydrellia* have been reported to live in *S. aloides*. Based on recent collecting of *Hydrellia* specifically from the stands of *S. aloides*, rearings, examination of the type material and analysis of the published data, this paper discusses which species of *Hydrellia* live in *S. aloides*.

Material and methods

This study is based on the original material collected in the northern German lowlands since 2003 and on several specimens from collections. In 2022, stands of *S. aloides* in northern Germany were specifically sought to record *Hydrellia*. Adult flies were swept over the *Stratiotes* stands with an insect net. The leaves with mines were placed in a petri dish and examined daily for hatched flies. Adult flies were collected by the author, double mounted and deposited in the author's collection unless otherwise stated. In the label data, the German Barcode Of Life (GBol) reference numbers are given. The Biological Museum (Entomology), Lund University is abbreviated as MZLU.

Nomenclature is based on the original descriptions. Identification of the material is discussed below. Morphological terminology in general is adopted from Cumming & Wood (2017) and specific terminology of the terminalia, from Mathis et al. (2021). To examine the male terminalia, the abdomen was dissected, macerated in an aqueous solution of sodium hydroxide for about three hours, neutralised with acetic acid and stored together with the specimen in a microvial filled with glycerine.

Results and discussion

In all places with stands of *Stratiotes aloides* visited by the author in 2022, *Hydrellia tarsata* Haliday, 1839 were recorded by sweeping above the plants. Obviously, the species was only rarely collected before 2022 when collecting activities of the author did not focus on stands of *S. aloides*. However, almost all the records were made at the sites with *S. aloides*. In addition, two males and two females of *H. tarsata* were reared from the leaves of *S. aloides* with mines collected in Hauptwieke Neukamperfeh, Lower Saxony (see Material examined for the details).

Order Diptera

Family Ephydriidae

Subfamily Hydrelliinae

Genus *Hydrellia* Robineau-Desvoidy, 1830

Hydrellia tarsata Haliday, 1839
(Figs 1–5)

Hydrellia (Hydrellia) tarsata Haliday, 1839: 403.

Hydrellia tarsata: Collin, 1966: 13 (in key), Pl. 21 (male genitalia); Beschovski, 2009: 134, Fig. 46 (redescription, male genitalia); Zatwarnicki, 2022: Figs 59–61 (male genitalia).

Hydrellia stratiotae Hering, 1925: 535, **syn. nov.**

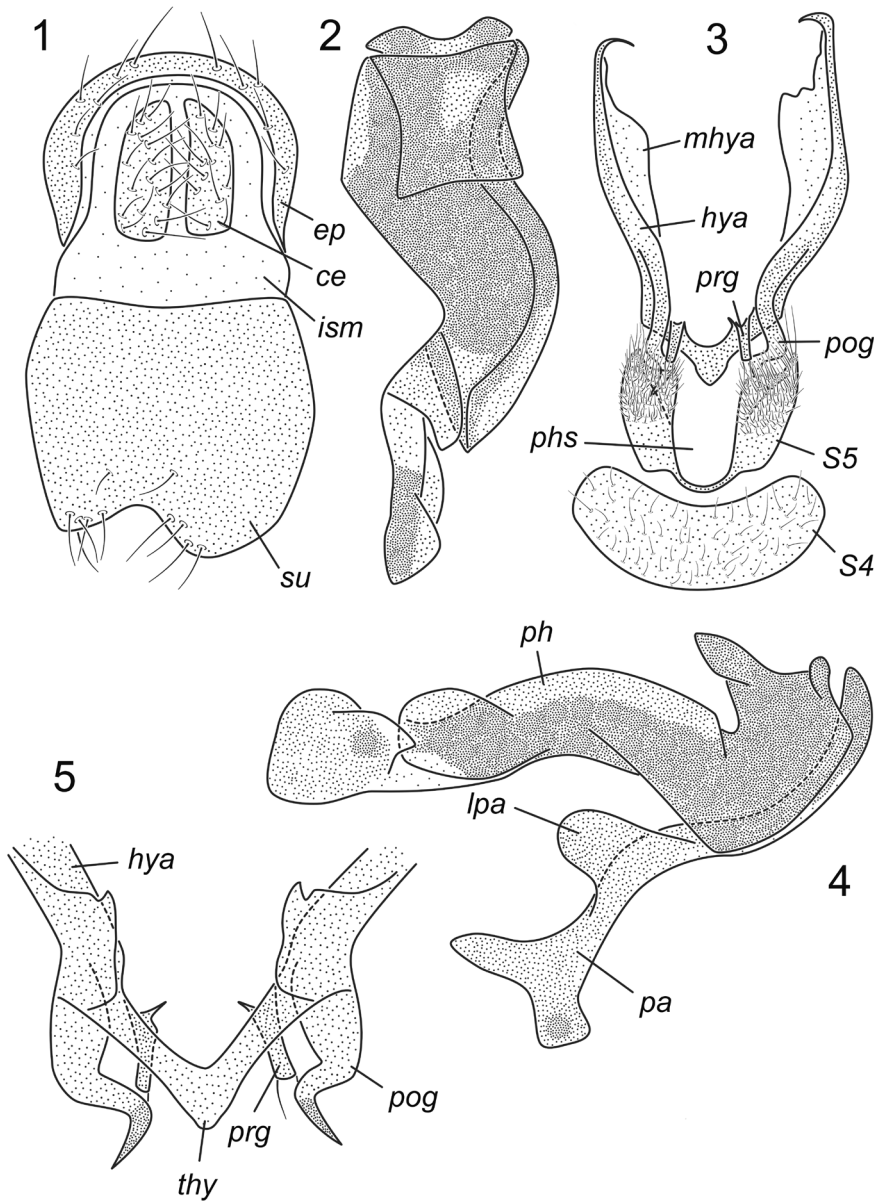
Hydrellia sera Cresson, 1932: 19, **syn. nov.** (synonymised with *H. stratiotae* by Zatwarnicki, 2022: 402).

Hydrellia propingua Wahlgren, 1947: 78, **syn. nov.**

Hydrellia stratiotella Wahlgren, 1947: 78, **syn. nov.**

Hydrellia asymmetrica Papp, 1983: 211, **syn. nov.** (synonymised with *H. stratiotae* by Zatwarnicki, 2022: 402).

Material examined. **Germany:** *Brandenburg:* 9 males, 6 females, Hundswiesen 2 km NE of Semlin [52.673°N 12.400°E], 18.VII.2022; 1 male, W of Wolfsmühle [52.517°N 12.292°E], ditches with *S. aloides*, 18.VII.2022; *Bremen:* 4 males, Westliches Hollerland [53.115°N 8.859°E], ditches with *S. aloides*, 27.V.2011, Katzenberger leg.; 4 males, ditto, 28.VI.2011, Katzenberger leg.; 1 male, Stadtwald [53.104°N 8.835°E], 26.VII.2018; *Mecklenburg-Vorpommern:* 1 female, Peenewiesen near Gützkow [53.914°N 13.396°E], 15.VI.2003; 10 males, 4 females, Recknitztal 1.8 km NE of Marlow [54.166°N 12.580°E], 3.VI.2016; 4 males (GBol 2594003–2594006), ditto; *Lower Saxony:* 1 male, Bingumgaste, Elsterweg [53.215°N 7.389°E], 20.VIII.2022; 27 males,



Figs 1–5. *Hydrellia tarsata* Haliday, 1839, male. Terminalia. **1**, epandrium, cerci and surstyli (dorsal view); **2**, phallus (dorsal view); **3**, hypandrium, sternites 4–5 (ventral view); **4**, phallus and phallus apodeme (lateral view); **5**, tip of hypandrium, postgonite and pregonite (dorsal view). *Abbreviations:* *ce* – cercus; *ep* – epandrium; *hya* – hypandrium arm; *lpa* – lateral evagination of phallus apodeme; *mhya* – muscle attachment of hypandrium arm; *ism* – intersegmental membrane between epandrium and proctiger; *pa* – phallus apodeme; *ph* – phallus; *phs* – phallus sheath of sternite 5; *pog* – postgonite; *prg* – pregonite; *S4* – sternite 4; *S5* – sternite 5; *su* – fused surstyli; *thy* – tip of hypandrium.

9 females, Bornhorster Huntewiesen [53.165°N 8.291°E], ditches with *S. aloides*, 27.VIII.2022; 2 males, 8 females, Dwarstief E of Tichelwarf, Püttenbollen [53.167°N 7.304°E], ditch with *S. aloides*, 26.VIII.2022; 2 males, Grauerort [53.677°N 9.492°E], 4.VIII.2008; 1 female, Elbe valley near Gorleben [53.052°N 11.354°E], 6.VIII.2008; 1 female, Holthusser Kolk [53.163°N 7.304°E], 26.VIII.2022; 2 males, Jadebusen, Vareler Schleuse [53.410°N 8.194°E], 19.VIII.2018; 1 male, channel in Westgroßefehn [53.383°N 7.542°E], 25.VII.2022; 4 males, 5 females, S of Swartwolder Kolk [53.220°N 7.339°E], ditches with *S. aloides*, 20.VIII.2022; 1 male (with *Laboulbeniales*), 1 female, Leer, Evenburgpark [53.230°N 7.494°E], 26.VI.2022; 2 males, Lübbertsfehn [53.387°N 7.510°E], 26.VI.2022; 4 males, 2 females, Neuenburger Urwald

[53.385°N 7.982°E], pond with *S. aloides*, 9.VII.2022; 18 males, 3 females, Neukamperfehn, Hauptwieke [53.352°N 7.547°E], 23.V.2022; 9 males, 5 females, ditto but 11.VI.2022; 18 males, 7 females, ditto but 26.VI.2022; 4 males, 6 females, ditto but 13.VII.2022; 12 males, 11 females, ditto but 25.VII.2022; 2 males, 4 females, ditto but 20.VIII.2022; 2 females, ditto but 28.VIII.2022; 1 male, 1 female, same locality, emerged on 10.VI.2022 from leaves with mines of *S. aloides* collected 27.V.2022; 1 male, ditto but emerged 11.VI.2022; 1 female, ditto but emerged 14.VI.2022; 6 females, Spetzerfehnkanal N of Timmeler Hauptweg [53.361°N 7.544°E], 28.VIII.2022; 1 male, 1 female, Stadersand [53.631°N 9.522°E], 4.VIII.2008; 4 males, 9 females, Thörenwald [53.329°N 9.553°E], pond with *S. aloides*, 3.VI.2005; 9 males, 5 females, ditto.

Type material examined (from photos). *Holotype* of *Hydrellia propinqua*. Female, **Sweden, Stockholm**, Nacka, reared from *Stratiotes*, 17.VII.1913, E. Wahlgren leg. (MZLU 00205679; type no. 2242: 1 Ephydriidae; 1994 391). (See Fig. 7 for the labels).

Syntype of *Hydrellia stratiotella*. Female, **Sweden, Stockholm**, Nacka, reared from *Stratiotes*, 14.VII.1913, E. Wahlgren leg. (MZLU 00205681). (See Fig. 8 for the labels).

Other material examined (from photos). 1 male, **Sweden, Stockholm**, Nacka, reared from *Stratiotes*, 24.VII.1913, E. Wahlgren leg. (MZLU 00125574); *Hydrellia mutata* E. Wahlgren det. (See Fig. 6 for the labels).

Diagnostic characters of H. tarsata. The identification of *H. tarsata* is based on the interpretation of Collin (1966) who first illustrated the male terminalia of this species. The separation of *H. tarsata* from *H. stratiotae* is discussed below.

Hydrellia tarsata can be identified by the combination of the following characters: male face golden dusted; female face more variable golden to golden-brown dusted and as an exception more or less grey dusted; male basal flagellomere usually orange to various extents, sometimes completely black or completely orange, scape and pedicel black; female antenna regularly completely black and at maximum indistinctly orange at base of basal flagellomere; palpus orange; arista with 4–8 aristal rays; presutural dorsocentral seta distinct, all dorsocentral setae equidistant and usually without any setulae in between; upper margin of anepisternum not clearly darker; greyish pleurae clearly contrasting with brown scutum; front coxa black and densely silver-white dusted; knees and apices of tibiae sometimes orange in light specimens; middle tibia slightly thickened; middle femur with scattered and inconspicuous setae posteroventrally; basal tarsomeres usually orange to light brown and contrasting with black apical tarsomere, all tarsomeres can be dark brown and appearing blackish; radial veins R_{2+3} and R_{4+5} clearly divergent; abdomen dorsally subshining, less dusted than strongly dusted ventral margins; male tergite 5 about as long as tergite 4 or at maximum slightly longer than tergite 4, its lateral margins convergent; female tergite 5 more than half the length of tergite 4 and its hind margin almost completely dusted, only medially it can be subshining; male sternites 4 and 5 as Fig. 3: partly strongly covered with strong black setulae

and connected only by a narrow round bridge, phallus-sheath of sternite 5 obvious; male terminalia as Figs 1–5: surstyli basally fused, asymmetrical; pregonite straight with two distinct setulae apically; process of postgonite S-shaped, its apex darker and flat, depending on viewing angle pointed or blunt; phallus large and asymmetrical, its distal part broad and separated by an area with any sclerotisation hardly developed.

Hydrellia tarsata males can be identified straightforward by the terminalia with the characteristically shaped surstyli (Fig. 1) and the large, asymmetrical phallus (Fig. 2), that is typical for several related species, which have differently-shaped surstyli. The identification of females is difficult and due to the lack of material of females of related species it is questionable if females can be identified safely without males from the same location. Mainly the combination of the (i) distinct presutural dorsocentral seta of the same length as other dorsocentral setae, (ii) golden dusted face, (iii) orange to brown tarsomeres, (iv) dorsally subshining abdomen contrasting with ventral margins of tergites, and (v) strongly dusted hind margin of tergite 5, allows one the identification of females. However, characters (ii) and (iii) are variable and atypical specimens may be misidentified or confused.

Critical review of previous records of *Hydrellia* mining in *Stratiotes aloides*

The most comprehensive and recent summaries concerning the occurrence of *Hydrellia* in *S. aloides* were given by Deonier (1971, 1998) and Mathis & Zatwarnicki (1995). The following discussion is based on these synopses and is supplemented with additional publications. Only papers that contain original material are considered.

Hydrellia concolor (Stenhammar, 1844)

Wahlgren (1947) corrected his previous identification of *H. concolor* as a leaf miner of *S. aloides* (Wahlgren, 1927). The record from Hering (1924) about rearing of *H. concolor* from *S. aloides* was corrected by Hering (1925). Stuke & Häfliger (2017) concluded in their review of host plants of *H. concolor* that it is a monophagous species only known to feed on *Butomus umbellatus* L.



Fig. 6. *Hydrellia mutata* sensu Wahlgren, 1947 (*H. tarsata* Haliday, 1839), male. Total lateral view; head and thorax in dorsal view; labels. Photos from MZLU.

Hydrellia griseola (Fallén, 1813)

Ruschka & Thienemann (1913) described the Braconidae *Gyrocampa thienemanni* Ruschka, 1913 [now considered as a synonym of *Chorebus*

uliginosus (Haliday, 1839)] with the material reared from pupae of “der in *Stratiotes* minierenden Muscide *Hydrellia griseola* Fall.” The adults were identified as *H. griseola* by Pius Sack (Frankfurt).



Fig. 7. Holotype of *Hydrellia propingua* Wahlgren, 1947 (female). Total lateral view; head in anterodorsal view; labels. Photos from MZLU.

Sack's identification is not documented further, and Sack himself was not an expert on Ephydriidae. Therefore, the identification is questionable as pointed out by Hering (1957). The females of *H. griseola* are very similar to the females of *H. tarsata* and can easily be confused. Summarising these publications, there is no proper documented record of *H. griseola* reared from *S. aloides*.

Hydrellia mutata (Zetterstedt, 1846)

Ulmer (1903) was first to report that *H. mutata* was reared from *S. aloides*. The identification is not documented; Georg Ulmer was not an expert on Diptera and therefore his identification is questionable. Ulmer (1911) did not use the name *H. mutata* in his description of *Hydrellia* larvae in

S. aloides anymore. Probably the record of Linnaniemi (1913) of *H. mutata* as a miner of *S. aloides* is based on Ulmer's record. Linnaniemi (1913) did not give supplementary data nor the source of his record.

Wahlgren (1947) reported five specimens of *Hydrellia* reared from *S. aloides*. Of these five specimens, he identified the only male as *H. mutata*, and the four females were described as new species, *Hydrellia stratiotella* and *Hydrellia propingua* (see discussion below). Wahlgren's identification of the male of *H. mutata* is based on the number of eight arista branches. *Hydrellia tarsata* has an arista with 4–8 rays. Although the additional characters given by Wahlgren (1947) to recognise *H. mutata* (i) "Antennen sind ganz schwarz", (ii) "das Gesicht graulich gelb" and (iii)



Fig. 8. Holotype of *Hydrellia stratiotella* Wahlgren, 1947 (female). Total lateral view; head in anterodorsal view; labels. Photos from MZLU.

“Lunula weiss” are remarkable, they might occur in *H. tarsata*. In addition, the character “Antennen sind ganz schwarz” excludes *H. mutata*. The photos of the reared specimen (Fig. 6) deposited at MZLU fit completely to the concept of *H. tarsata* as described above and do show that the basal flagellomere is in fact slightly orange to light brown at its base. Buhr (1954) published *H. mutata* as reared from *S. aloides* by Hering. Hering

(1957) included *H. mutata* in his list of *Hydrellia* species reared from *S. aloides* but did not mention whether this is based on his own observations or on published records. He repeated the same characters for the identification of *H. mutata* as Wahlgren (1947) and therefore it seems probable that he copied this information given by Wahlgren (1947). In summary, there are no trustworthy records of *H. mutata* mining in *S. aloides*.

***Hydrellia propingua* Wahlgren, 1947**

Wahlgren (1947) described one female *Hydrellia* specimen reared from *S. aloides* as *H. propingua* (Fig. 7). He described only two characters of this species that are unusual for *H. tarsata*: (i) silver dusting of the face and (ii) black tarsi. Both characters fall within the variability of *H. tarsata* females and this species should be treated as a synonym (**syn. nov.**), as was proposed by Wahlgren (1947) himself: “Ob diese Form eine eigene Art oder vielleicht eher eine Varietät von *H. stratiotella* sei, scheint zweifelhaft”. The photos of the holotype (Fig. 7) deposited at MZLU fit completely to the concept of *H. tarsata* as described above.

***Hydrellia stratiotae* Hering, 1925**

Hering (1925) described *H. stratiotae* based on one female reared from *S. aloides* leaves and later gave supplementary information concerning the biology (Hering, 1926, 1932). de Meijere (1928) reported *H. stratiotae* reared from *S. aloides* from Vreeland (Netherlands). Zatwarnicki (2022) published one additional specimen of *H. stratiotae* reared from *S. aloides*.

The description of the female holotype of *H. stratiotae* fits completely with *H. tarsata* as interpreted by Collin (1966) who examined the holotype of *H. tarsata* (O’Hanlon, pers. comm. by e-mail). The description of the larval biology of *H. stratiotae* fits with the observation of the author and the observations published by other authors (see below).

Only Zatwarnicki (2022) distinguished *H. stratiotae* from *H. tarsata* after the examination of the type material of both species (Zatwarnicki, 2022; O’Hanlon, pers. comm. by e-mail). He pointed out two characters to separate both the species: *Hydrellia tarsata* with (i) surstyli (= genital plate) slightly asymmetrical and (ii) postgonite elongated, with long apical process. *Hydrellia stratiotae* with (i) surstyli strongly asymmetrical and (ii) postgonite short with modified process. The terminalia of both species are illustrated with photos in Zatwarnicki (2022).

I do not agree with this separation for the following reasons: (i) Concerning the photos of *H. tarsata* and *H. stratiotae* terminalia in Zat-

warnicki (2022), the asymmetry of the surstyli of both species falls within the variation of the material collected by the author from *Stratiotes* stands. (ii) Shape and length of the tip of the postgonite process depends strongly on the viewing angle. The tip is roughly like a tip of a screwdriver and depending on the viewing angle, it can be blunt or pointed. I could see a pointed tip or a blunt tip in every postgonite examined. (iii) Comparing the shape of the phallus and the shape of the phallus apodeme as illustrated by Collin (1966) and Zatwarnicki (2022), I cannot find any differences, either. (iv) I do not know any *Hydrellia* species that are distinguished only by such subtle characters, but even closely related species always have unambiguous characters to be identified.

Therefore, I propose to treat *H. stratiotae* as a junior synonym of *H. tarsata* (**syn. nov.**). Consequently, *H. asymmetrica* Papp, 1983 and *H. sera* Cresson, 1932, which are placed as synonyms to *H. stratiotae* by Zatwarnicki (2022), must be treated as synonyms of *H. tarsata*, too (**syn. nov.**).

***Hydrellia stratiotella* Wahlgren, 1947**

Wahlgren (1947) described three female *Hydrellia* specimens reared from *S. aloides* as *H. stratiotella*. The description of this species and the photos of one syntype (Fig. 8) kept at MZLU fall within the variability of *H. tarsata* females and this species should be treated as a synonym of *H. tarsata* (**syn. nov.**).

***Hydrellia tarsata* Haliday, 1839**

Przhiboro (2005), Katzenberger et al. (2013) and Katzenberger & Zacharias (2015) report rearing of *H. tarsata* from *S. aloides*. No other species of *Hydrellia* was reared from the leaves of *S. aloides* in both investigations. The adults were identified by these authors according to Collin (1966). Kahanpää & Zatwarnicki (2015) reported *H. tarsata*, which were caught from *S. aloides* stands.

The identity of *H. tarsata* is not in doubt: the type material kept at the National Museum of Ireland was first examined by Collin (de Courcy Williams, 1989; O’Hanlon, pers. comm. by e-mail) whose concept of *H. tarsata* is followed and more recently by Zatwarnicki (O’Hanlon, pers. comm.

by e-mail); both of them considered the species without any doubt of the identity.

***Hydrellia* sp.**

Müller (1922) reported puparia collected in *S. aloides* that he did not rear. Due to the morphology of the puparia he assumed that the species is not conspecific with *H. griseola* but belongs to another unidentified *Hydrellia* species. The records of Diptera living within *S. aloides* that are even not identified to genus or family level are reported by Linhart (1999), Obolewski (2005) and Tarkowska-Kukuryk (2006).

Resuming the original data listed above and the literature review, *H. tarsata* is the only *Hydrellia* species known to mine in *S. aloides*. *Hydrellia tarsata* can only be identified since Collin (1966) published the genital drawings of this species and included the species in his key of British *Hydrellia*. Previously this species was almost always ignored, for example Becker (1926: 71) mentioned under *H. tarsata*: “Diese Art war mir bisher unbekannt und ist in meiner Tabelle nicht eingefügt”. The males of *H. tarsata* were obviously misidentified as *H. mutata*. The females of *H. tarsata* reared from *S. aloides* were wrongly reported as *H. griseola* or were described as *H. stratiotae*, *H. stratiotellae* and *H. propingua*. The synonymy of *H. tarsata* and *H. stratiotae* proposed here is recently discussed controversy and Zatwarnicki (2022) and Irwin (pers. comm., by e-mail) disagree. If both species are distinct, all records of *Hydrellia* mining in *Stratiotes* will belong to *H. stratiotae* and this will be the only taxon known from *S. aloides* so far.

Summary of the biology of *Hydrellia tarsata*

Eggs probably belonging to *H. tarsata* were found in small groups injected at the top of *S. aloides* leaves below the epidermis (Ruschka & Thienemann, 1913). Ulmer (1911, as *Hydrellia* spec.) and Hering (1924, as *H. concolor*; 1932, as *H. stratiotae*) described and illustrated the larvae and the mines of *H. tarsata*. The larvae can live in leaves above or below the water level and are therefore adapted to changing water levels that might be typical for *S. aloides* biotopes. Larvae

respire through the plant tissue, which they perforate with their hind spiracles (Ulmer, 1911). Larvae do not move within the mine but stay at the feeding point at the end of the mine that grows to the base of the leaf (Ulmer, 1911). Larvae are reported to move from one leaf to the other to start another mine (Ulmer, 1911). Przhiboro (2005) recorded 1600 immatures (larvae and puparia) per m² and measured the biomass of 1.86 g/m² in the *S. aloides* habitat in the littoral zone of a highly eutrophic lake in the Pskov Province of Russia. Hering (1924, as *H. concolor*) described *H. tarsata* pupating at the end of the mine at the base of the leaf or close to the midrib of the leaf. He observed the emergence of adults within 20 minutes after leaves become dry. Hering (1926, as *H. stratiotae*) interpreted this behaviour as an adaptation to sinking water level when emerging becomes easier for adults. He assumed that the completely developed adult fly remains within the puparium if the conditions for emerging are not suitable. Only Zatwarnicki (2022, as *H. stratiotae*) reported *Potamogeton lucens* L. as a second host plant for *H. tarsata*.

Adult *H. tarsata* usually stay at or close to the *S. aloides* plants, where they are easily swept. However, there are some records of specimens away from known *S. aloides* populations (pers. observation) and these may represent dispersing specimens. Adults of *H. tarsata* feed on flowers of *S. aloides* and pollinate *S. aloides* (Katzenberger et al., 2013; Katzenberger & Zacharias, 2015). Very probably also the record of Daumann (1931) of *Hydrellia flavilabris* (Stenhammar, 1844) (syn. of *H. cardamines* Haliday, 1839) visiting frequently the flowers of *S. aloides* is in fact an observation of *H. tarsata*. Additionally, the author swept the adults of *H. tarsata* at the flowers of *Anthriscus sylvestris* (L.) Hoffm. that are growing close to the *S. aloides* habitats. The flowers of *S. aloides* are used as a mating place of *H. tarsata* (Katzenberger & Zacharias, 2015). In northern Germany, adults, larvae and pupae of *H. tarsata* are recorded from May to August (Fig. 9) and a polyvoltine life cycle is most probable. Pupae may overwinter within leaves of the previous year.

One specimen of *H. tarsata* (see Material examined) was found with Laboulbeniales at the left and right fore coxae and at the left middle coxa.

The species is not identified so far but it is very probably *Stigmatomyces hydrelliae* Thaxter, 1901, which is the only species recorded from *Hydrellia* so far and which is recorded from 15 other *Hydrellia* species. All known internal parasites of *H. tarsata* are Braconidae that emerge from the puparia. Older records are summarised by Fulmek (1962) without giving sources and are here supplemented with new records: *Aedon decrescens* (Nees, 1811) (Fischer, 1997; from *H. stratiotae*, probably only copy of unknown source); *Chaenusa* cf. *punctulata* Burghele, 1960 (Katzenberger & Zacharias, 2015); *Chaenusa opaca* Stelfox, 1957 (Przhiboro, 2005); *Chorebus* cf. *densepunctatus* Burghele, 1959 (Katzenberger & Zacharias, 2015); *Chorebus uliginosus* (Haliday, 1839) (Ruschka & Thienemann, 1913, as *Gyrocampa thienemanni* from "*H. griseola*"; Thienemann, 1916); *Opius caesus* Haliday, 1837 (Przhiboro, 2005).

Distribution of *Hydrellia tarsata*

The known distribution of *H. tarsata* fits well with the distribution of *S. aloides* as figured by Efremov et al. (2019). *Hydrellia tarsata* is widely distributed all over Central Europe, southern Scandinavia and reaches eastwards to Novosibirsk (south of West Siberia, Russia): Austria (Zatwarnicki 2022, as *H. stratiotae*), Great Britain (Zatwarnicki, 2022, as *H. stratiotae*), Bulgaria (Beschovski & Zatwarnicki, 2001; Bescho-

vski, 2009), Czech Republic (Zatwarnicki et al., 2001), Finland (Kahanpää & Zatwarnicki, 2015), Germany (Cresson, 1932, as *H. sera*; Katzenberger & Zacharias, 2015; Katzenberger et al., 2013; Krivosheina, 2000; Stuke, 2010; Zatwarnicki, 2022, as *H. stratiotae*), Hungary (Papp, 1983, as *H. asymmetrica*; Zatwarnicki, 2022, as *H. stratiotae*), Ireland (Haliday, 1839), the Netherlands (de Meijere, 1928, as *H. stratiotae*; Zatwarnicki, 2022, as *H. stratiotae*), Poland (Beschovski & Zatwarnicki, 2001; Hering 1925, as *H. stratiotae*), Russia (Przhiboro, 2005, for European Russia; Zatwarnicki, 2022, as *H. stratiotae*, for West Siberia), Slovakia (Zatwarnicki, 1996, 2022, as *H. stratiotae*), Sweden (Wahlgren, 1947, as *H. propingua* and *H. stratiotella*; Zatwarnicki, 2022, as *H. stratiotae*). The known distribution extends between 6°W and 83°E and 43°N and 60°N. The records from northern Germany are shown on the map in Fig. 10.

Endangerment of *Hydrellia tarsata*

The collecting results of the author testify that all *Stratiotes aloides* stands in northern Germany are infested by the populations of *H. tarsata*. It is unknown whether these populations exchange individuals. In many areas, *S. aloides* is now a rare and localised plant with isolated populations. As the host plant *S. aloides* is endangered in most regions of Europe (Efremov et al., 2019), *H. tarsata* will also be endangered in these regions.

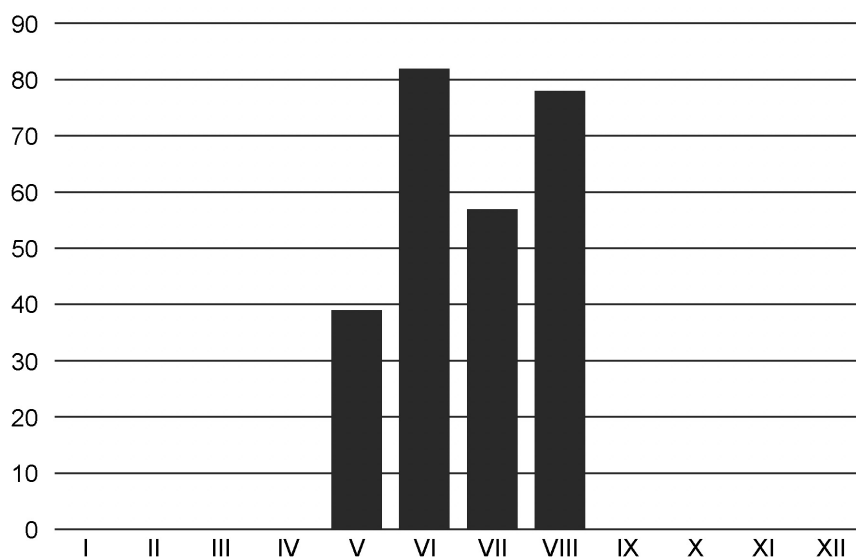


Fig. 9. Phenology of imagines of *Hydrellia tarsata* Haliday, 1839 in northern Germany (author's data for 2022). Abscissa, months; ordinate, numbers of specimens collected.

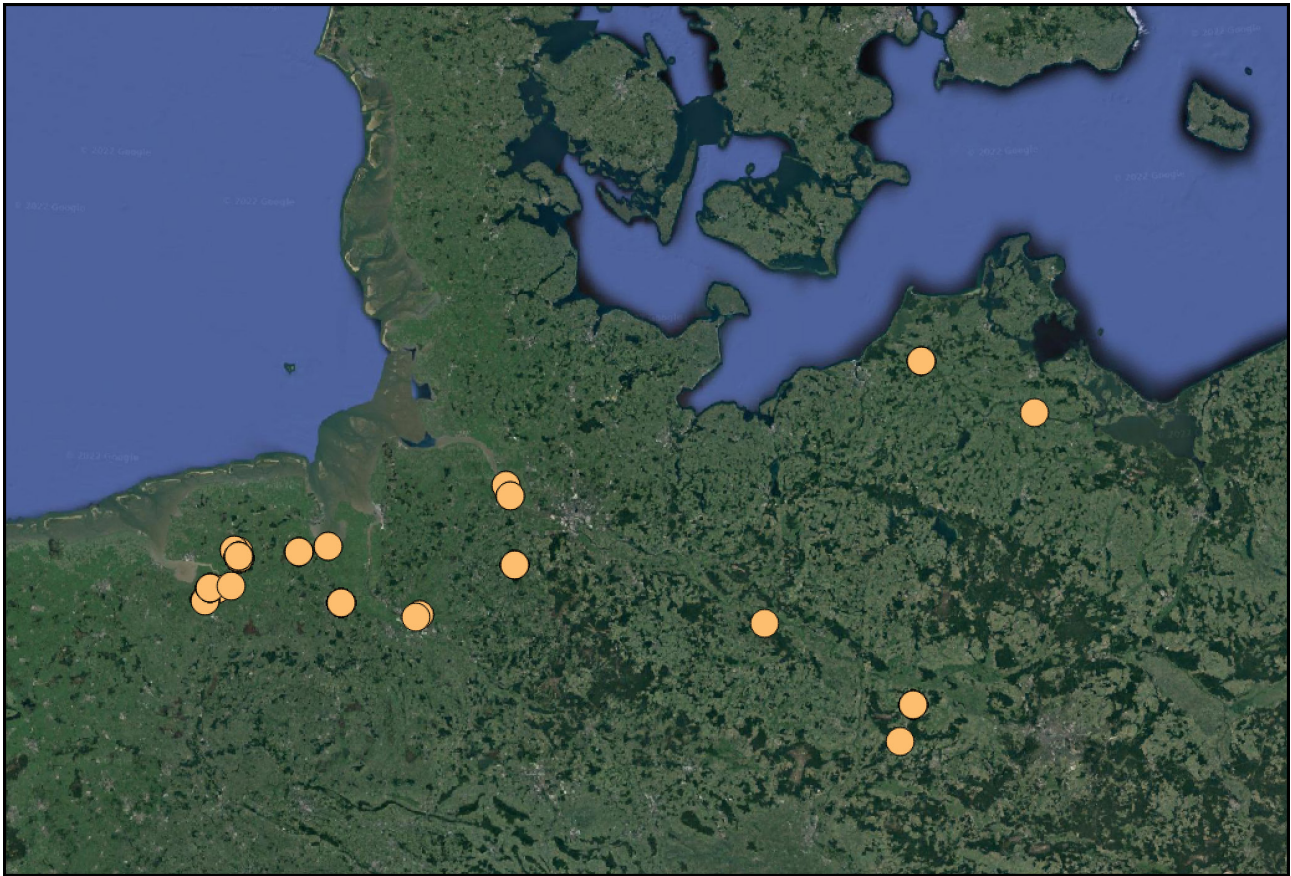


Fig. 10. Distribution of *Hydrellia tarsata* Haliday, 1839 in northern Germany.

Acknowledgements

Anja Pirscher (Oldenburg), Detlef Kolthoff (Bunde), Hartmut Fokken (Moormerland), Kay Fuhrmann (Oldenburg), Oliver Brauner (Eberswalde), Oliver Wallesch (Oldenburg), Ralf Becker (Oldenburg), Reinhard Jödicke (Westerstede) and Ruth I. Nüss (Bremen) provided information about growing places of *S. aloides* in Lower Saxony, Bremen and Brandenburg. Martin Spies (München), Wouter van Steenis (Amersfoort) and Ton van Haaren (Amsterdam-Duivendrecht) helped with literature search. Brad Sinclair (Ottawa) discussed a morphological term. Aidan O’Hanlon (Dublin) and Rune Bygebjerg (Lund) send information and photos of the type material deposited in the collections under their care. The Biological Museum, Lund University (MZLU) gave the permission to use the photos of *Hydrellia* specimens; Christoffer Fägerström (Lund) prepared the photos. Tony Irwin (Norfolk) checked the manuscript, gave several important comments, and patiently discussed the separation of *H. tarsata* and *H. stratiotae*.

References

- Becker Th.** 1926. 56a. Ephydriidae und 56b. Canacidae. In: **Lindner E.** (Ed.). *Die Fliegen der palaearktischen Region*, **6**(1): 1–115. Stuttgart: Schweitzerbart’sche Verlagsbuchhandlung.
- Beschovski V.L.** 2009. *Kraybrezhni mukhi* [shore flies] (Insecta: Diptera: Ephydriidae, Tethinidae, Canacidae). *Fauna na Bulgaria* [Fauna Bulgarica], **28**: 1–421. Sofia: “Prof. Marin Drinov” Academic Publishers. (In Bulgarian).
- Beschovski V.L. & Zatwarnicki T.** 2001. Faunistic review of the subfamily Hydrelliinae in Bulgaria (Insecta: Diptera: Ephydriidae) with some data from other European countries. *Acta zoologica Bulgarica*, **53**: 3–18.
- Buhr H.** 1954. Mecklenburgische Minen. V. Über neue und wenig bekannte Dipteren-Minen. *Archiv der Freunde der Naturgeschichte in Mecklenburg*, **1**: 238–288.
- Collin J.E.** 1966. A contribution to the knowledge of the male genitalia of species of *Hydrellia* (Diptera, Ephydriidae). *Bollettino del Museo Civico di Storia Naturale di Venezia*, **16**: 7–18 + 26 pl.

- Cresson E.T., Jr.** 1932. Studies in the dipterous family Ephydriidae. Paper IV. *Transactions of the American Entomological Society*, **58**: 1–34.
- Cumming J.M. & Wood D.M.** 2017. Adult morphology and terminology. In: **Kirk-Spriggs A.H. & Sinclair B.J.** (Eds). *Manual of Afrotropical Diptera. Volume 1. Introductory chapters and keys to Diptera families. Suricata*, **4**: 89–133.
- Daumann E.** 1931. Zur Morphologie und Ökologie der Blüte von *Stratiotes aloides* L. *Planta*, **14**: 766–776. <https://doi.org/10.1007/BF01917161>
- de Courcy Williams M.** 1989. A list of Irish Ephydriidae (Diptera) based on the Haliday collection in the National Museum of Ireland. *Irish Naturalists' Journal*, **23**(1): 6–11.
- de Meijere J.C.H.** 1928. Vierde supplement op de nieuwe naamlijst van Nederlandse Diptera. *Tijdschrift voor Entomologie*, **71**: 11–83.
- Deeming J. C.** 2002. Some species of the genus *Hydrellia* Robineau-Desvoidy (Diptera, Ephydriidae) in Africa and Arabia, with special reference to species of economic importance. *Deutsche entomologische Zeitschrift*, **49**: 47–59. <https://doi.org/10.1002/mmnd.20020490105>
- Deonier D.L.** 1971. A systematic and ecological study of Nearctic *Hydrellia* (Diptera: Ephydriidae). *Smithsonian Contributions to Zoology*, **68**: 1–147. <https://doi.org/10.5479/si.00810282.68>
- Deonier D.L.** 1998. A manual of the common North American species of the aquatic leafmining genus *Hydrellia* (Diptera: Ephydriidae). *Memoirs on Entomology, International*, **12**: viii + 1–354.
- Efremov A.N., Sviridenko B.F., Toma C., Mesterházy A. & Murashko Y.A.** 2019. Ecology of *Stratiotes aloides* L. (Hydrocharitaceae) in Eurasia. *Flora*, **253**: 116–126. <https://doi.org/10.1016/j.flora.2019.03.009>
- Fischer M.** 1997. Die paläarktischen Opiinae (Madenwespen) der Zoologischen Staatssammlung München (Hymenoptera, Braconidae). *Entomofauna*, **18**: 137–196.
- Fulmek L.** 1962. *Parasitinsekten der Blattminierer Europas*. 's-Gravenhage: W. Junk. 203 p. <https://doi.org/10.1007/978-94-010-3652-8>
- Grodowitz M.J., Center T.D., Cofrancesco A.F. & Freedman J.E.** 1997. Release and establishment of *Hydrellia balciunasi* (Diptera: Ephydriidae) for the biological control of the submerged aquatic plant *Hydrilla verticillata* (Hydrocharitaceae) in the United States. *Biological Control*, **9**: 15–23. <https://doi.org/10.1006/bcon.1997.0513>
- Häfliger P., Mann L., Zorzetto G., Hasanovic I., Bouraoui D., Toševski I., Ellison C. & Hinz H.L.** 2018. *Annual Report 2017. Biological control of flowering rush, Butomus umbellatus*. Delemont: CABI. 21 p.
- Haliday A.H.** 1839. Remarks on the generic distribution of the British Hydromyzidae (Diptera). *Annals and Magazine of natural History*, **3**: 217–224, 401–411. <https://doi.org/10.1080/03745483909443252>
- Hering E.M.** 1924. Minenstudien IV. *Zeitschrift für Morphologie und Ökologie der Tiere*, **2**: 217–250. <https://doi.org/10.1007/BF00419352>
- Hering E.M.** 1925. Minenstudien VI. *Zeitschrift für Morphologie und Ökologie der Tiere*, **4**: 502–539. <https://doi.org/10.1007/BF00408466>
- Hering E.M.** 1926. Die Ökologie der blattminierenden Insektenlarven. *Zoologische Bausteine*, **1**: 1–253 + 2 pl.
- Hering E.M.** 1932. Minerer an Wasserpflanzen. In: **Krancher O.** (Ed.). *Entomologisches Jahrbuch. Kalender für alle Insekten-Sammler*, **1932**: 69–76.
- Hering E.M.** 1957. *Bestimmungstabellen der Blattminen von Europa einschliesslich des Mittelmeerbeckens und der Kanarischen Inseln. Band 1-3*. 's-Gravenhage: Dr. W. Junk. 1185 + 221 p. <https://doi.org/10.1007/978-94-010-3702-0>
- Hesler L.S.** 1995. Bibliography on *Hydrellia griseola* Fallen (Diptera: Ephydriidae) and review of its biology and pest status. *Insecta Mundi*, **9**: 25–35.
- Kahanpää J. & Zatwarnicki T.** 2015. Notes on shore flies (Diptera: Ephydriidae) from Finland and north-west Russia. *Biodiversity Data Journal*, **3**: 1–39. <https://doi.org/10.3897/BDJ.3.e4701>
- Katzenberger J., Langbehn T. & Zacharias D.** 2013. Erstnachweis von *Hydrellia tarsata* (Diptera: Ephydriidae) für Bremen in Blüten von *Stratiotes aloides*. *Abhandlungen des Naturwissenschaftlichen Vereins zu Bremen*, **47**: 193–195.
- Katzenberger J. & Zacharias D.** 2015. Mutualism of *Stratiotes aloides* L. (Hydrocharitaceae) and *Hydrellia tarsata* Haliday (Diptera: Ephydriidae): Tritrophic interaction of macrophyte, leaf-mining dipteran pollinators and parasitoid Braconidae. *Journal of Pollination Ecology*, **15**: 23–29. [https://doi.org/10.26786/1920-7603\(2015\)3](https://doi.org/10.26786/1920-7603(2015)3)
- Krivosheina M.G.** 2000. Ephydriidae. In: **Ziegler J. & Menzel F.** (Eds). *Die historische Dipteren-Sammlung Carl Friedrich Ketel. Revision einer zwischen 1884 und 1903 angelegten Sammlung von Zweiflüglern (Diptera) aus Mecklenburg-Vorpommern. Nova Supplementa entomologica*, **14**: 162–163.
- Linhart J.** 1999. Phytophilous macrofauna in the *Stratiotes aloides* vegetation of the lake Łukie, Poland. *Acta Universitatis Palackianae Olomucensis Facultas Rerum Naturalium*, **37**: 67–76.

- Linnaniemi W.M.** 1913. Zur Kenntnis der Blattminierer, speziell derjenigen Finnlands I. *Acta Societatis pro Fauna et Flora Fennica*, **37**: 1–138.
- Litsinger J.A., Barrion A.T., Canapi B.L., Lumban M.D., Pantua P.C. & Aquino G.B.** 2013. The rice whorl maggot, *Hydrellia philippina* Ferino (Diptera: Ephydriidae) in the Philippines: A review. *The Philippine Entomologist*, **27**: 1–57.
- Mathis W.N. & Zatwarnicki T.** 1995. World catalog of shore flies (Diptera: Ephydriidae). *Memoirs on Entomology, International*, **4**: 1–423.
- Mathis W.N., Zatwarnicki T. & Irwin A.G.** 2021. Ephydriidae (shore flies). In: **Kirk-Spriggs A.H. & Sinclair B.J.** (Eds). *Manual of Afrotropical Diptera. Volume 3. Cyclorrhapha, excluding Calyptratae. Suricata*, **8**: 2193–2230.
- Müller G.W.** 1922. Insektenlarven an Wurzeln von Wasserpflanzen. *Mitteilungen aus dem Naturwissenschaftlichen Verein für Neu-Vorpommern und Rügen in Greifswald*, **48/49**: 30–47.
- Obolewski K.** 2005. Epiphytic macrofauna on water soldiers (*Stratiotes aloides* L.) in Słupia River oxbows. *Oceanological and hydrobiological Studies*, **34**: 37–54.
- Papp L.** 1983. New taxa of Ephydriidae (Diptera) from the Hortobágy National Park (Hungary). *Acta zoologica Academiae Scientiarum Hungaricae, Supplement* **29**: 209–217.
- Przhiboro A.** 2005. New data on *Hydrellia tarsata* (Diptera: Ephydriidae). *Zoosystematica Rossica*, **13**: 239–240. <https://doi.org/10.31610/zsr/2004.13.2.239>
- Ruschka F. & Thienemann A.** 1913. Zur Kenntnis der Wasserhymenopteren. *Zeitschrift für wissenschaftliche Insektenbiologie*, **9**: 82–87.
- Smith R., Coetzee J. & Hill M.P.** 2022. Best of both worlds: The thermal physiology of *Hydrellia egeriae*, a biological control agent for the submerged aquatic weed, *Egeria densa* in South Africa. *Bio-Control*, **67**: 365–374. <https://doi.org/10.1007/s10526-022-10142-w>
- Stuke J.-H.** 2010. Die Uferfliegen Niedersachsens und Bremens (Diptera: Ephydriidae) – Teil II. *Entomologische Zeitschrift*, **120**: 195–222.
- Stuke J.-H. & Häfliger P.** 2017. Hinweise zur Wirtspflanze von *Hydrellia concolor* (Stenhammar) (Diptera: Ephydriidae). *Studia dipterologica*, **23**: 137–138.
- Tarkowska-Kukuryk M.** 2006. Water Soldier *Stratiotes aloides* L. (Hydrocharitaceae) as a substratum for macroinvertebrates in a shallow eutrophic lake. *Polish Journal of Ecology*, **54**: 441–451.
- Thienemann A.** 1916. Ueber Wasserhymenopteren. *Zeitschrift für wissenschaftliche Insektenbiologie*, **12**: 49–54.
- Ulmer G.** 1903. Zur Fauna des Eppendorfer Moores bei Hamburg. *Verhandlungen des Naturwissenschaftlichen Vereins in Hamburg, neue Folge*, **3**(11): 1–25.
- Ulmer G.** 1911. *Unsere Wasserinsekten*. Heidelberg: Quelle & Meyer. 165 p.
- Wahlgren E.** 1927. Diptera. Andra Underordningen Cyclorapha. Andra Gruppen Schizophora. Fam. 21–26. *Svensk Insektfauna*, **11**: 323–416.
- Wahlgren E.** 1947. *Hydrellia*-Arten als Blattminierer in *Stratiotes aloides* L. (Dipt.). *Opuscula entomologica*, **12**: 77–79.
- Zatwarnicki T.** 1996. New records of Western Palearctic shore flies (Diptera: Ephydriidae). *Annals of the Upper Silesian Museum, Entomology*, **6–7**: 107–125.
- Zatwarnicki T.** 2022. Notes on selected genera of shore flies (Diptera: Ephydriidae), with removals to Drosophilidae, Heleomyzidae and Milichiidae. *Annales Zoologici*, **72**(3): 389–432. <https://doi.org/10.3161/00034541ANZ2022.72.3.003>
- Zatwarnicki T., Kubátová-Hiršová H. & Barták M.** 2001. Ephydriidae. In: **Barták M. & Vaňhara J.** (Eds). *Diptera in an industrially affected region (North Western Bohemia, Bílina and Duchcov environs). II. Folia Facultatis scientiarum naturalium Universitatis Masarykianae Brunensis (Biologia)*, **105**: 439–447.

Received 24 March 2023 / Accepted 20 June 2023. Editorial responsibility: A.A. Przhiboro