



Taxonomic notes and key to the West Palearctic *Antocha* (*Antocha*) Osten Sacken, 1860 (Diptera, Limoniidae) with description of a new species from Morocco

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Abstract

Background

The Mediterranean Region of the West Palearctic is one of the most species-rich biomes in the world, hosting a high level of endemism and relict species with important conservation value. The North Africa Atlas Mountains (spanning Morocco, Algeria and Tunisia) belong to a poorly-investigated region of the Mediterranean area, with overlooked aquatic biodiversity; hence, a number of species still remain to be discovered.

New information

The subgenus *Antocha* (*Antocha*) Osten Sacken, 1860 is recorded for the first time from Africa, with a description of *A. (A.) staryi* Keresztes & Mabrouki **sp. nov.** from hilly regions of the Middle Atlas region, Morocco. The unique design of the male terminalia differentiates well the newly-discovered species from its closely-related and range-restricted *A. (A.) phoenicia* Thomas and Dia, 1982. This is in contrast with the high intraspecific and geographically poorly-defined variability of the widespread *A. (A.) vitripennis* (Meigen, 1830), for which morphological variability of male genital structures is discussed.

Illustrations of male genital parts, distribution data and key to the species from the West Palearctic area are also provided.

Keywords

Antocha (*Antocha*), conservation, freshwater ecosystems, Mediterranean area, new species, the Middle Atlas region

Introduction

The Mediterranean area is one of the world's outstanding biodiversity hotspots with high conservation value within the West Palearctic (Delibes-Mateos et al. 2008). The geographic area surrounding the Mediterranean Sea hosts a unique biodiversity resulting from long-term evolutionary events in both terrestrial and aquatic ecosystems, with high numbers of relicts and/or endemic taxa, facing, nowadays, severe habitat loss and decline of some species (Barredo et al. 2016). The southern region of the Mediterranean area, including Morocco, has a special interest in nature conservation, because its geographical position, localised along the coastlines of northern Africa between the Atlantic Ocean and the Mediterranean Sea, supports high diversity ecosystems shaped by both the Mediterranean and the Saharan climate types (Abdul Malak et al. 2010). Despite its geographic position and extraordinary diversity of ecosystems, Morocco has been poorly investigated in general, especially regarding its aquatic Diptera fauna, including short-palped craneflies, Limoniidae (Pierre 1924, Séguy 1941a, Séguy 1941b, Vaillant 1956, Starý 1971, Starý 1974, Savchenko et al. 1992, Starý 2006, Pârnu et al. 2006, Starý and Oosterbroek 2008, Starý 2009, Starý 2011, Driauach et al. 2013, Driauach and Belqat 2015, Driauach and Belqat 2016, Adghir et al. 2018, Ebejer et al. 2019, Eiroa et al. 2020, de Jong et al. 2021, Taybi et al. 2021, Kettani et al. 2022).

Antocha Osten Sacken, 1860 is a relatively large genus of the subfamily Limoniinae (Diptera, Limoniidae), including 161 species according to Oosterbroek (2023), grouped into three subgenera, *Antocha* Osten Sacken, 1860, *Orimargula* Mik, 1883 and *Proantocha* Alexander, 1919. Species of this genus are distributed in almost all zoogeographical regions of the world, with high species diversity detected in the Oriental (83 species) and the East Palearctic (53 species) areas. A lower number of species was recorded from the

Afrotropics (21 species), Nearctic (7 species), Australasian/Oceanian (3 species) and Neotropics (1 species). In the West Palaearctic Region, members of only two subgenera occur. The subgenus *Antocha* is represented by four species, frequently collected in lower mountainous to hilly areas, while *A. (Orimargula)* has a single species, distributed mostly in the mountains belonging to this biogeographic area.

The subgenus *Antocha* contains small to medium-sized dipterans with body length ranging between 2.8 and 5.0 mm, up to 8.0 mm (Podenas and Byun 2013) and exceptionally up to 11 mm in the case of *A. (A.) uncollis* Alexander, 1968. A general revision of the species belonging to the subgenus was recently published by Podenas and Byun (2013), Podenas and Byun (2014), Podenas and Young (2015), Markevičiūtė et al. (2019), Markevičiūtė et al. (2021) who focused more on the Oriental fauna. The general colour of the species is brownish, brownish-yellow to dark brown or nearly black. The most important morphological characters of the species of *A. (Antocha)* are the following: antennae simple with rings of verticils at bases of flagellomeres or antennal flagellomeres short-oval and covered with long dense pubescence (Podenas and Byun 2013); wings are wide with large, well developed, prominent anal angle; male terminalia slightly wider than abdomen, gonocoxite elongate, oval or cylindrical and often with well-developed ventro-mesal lobe; two pairs of terminal gonostyli, with outer gonostylus usually darkened and strongly sclerotised and the inner gonostylus usually fleshy and curved downwards; ovipositor with a straight or slightly arched cercus, with the lower margin smooth or serrated (Podenas and Byun 2014, Podenas and Young 2015, Markevičiūtė et al. 2019). The four West Palearctic species included in this subgenus are: *A. (A.) hirtipes* Savchenko, 1971 (recorded from Georgia, only); *A. (A.) libanotica* Lackschewitz, 1940 (recorded from Georgia, Armenia, Azerbaijan, Cyprus, Lebanon, Iran, Turkmenistan, Tajikistan and Afghanistan), *A. (A.) phoenicia* Thomas and Dia, 1982 (only recorded from Lebanon) and *A. (A.) vitripennis* Meigen, 1830, widespread in the whole West Palearctic area and also recorded from the East Palearctic Region (Oosterbroek 2023).

Larvae are aquatic, apneustic, developing in the riffles, gravel or detritus of fast running streams and rivers (Fuller and Hynes 1987, Ujvárosi 2005, Vogtenhuber 2007). Adults are present in large numbers close to the larvae sites near the water margins and they are usually attracted to light or fall into Malaise-traps in suitable locations (Keresztes, pers. data). Hancock and Hewitt (2020) reported also a curious case of a large number of adult specimens trapped by the glandulous leaf of the butterwort plant *Pinguicularia* ssp. near the river margins in Spain.

Materials and methods

Material included in this study represent 201 male individuals of the subgenus *A. (A.)*, including the new species. Adult specimens were collected between 2001 and 2022 using entomological nets and light traps, with a large amount of material collected by entomologists from different parts of the West Palearctic Region (Fig. 1). All the material listed here is stored in 96% ethanol and deposited in the Diptera Collection of the Faculty of Biology and Geology, Babeş-Bolyai University, Cluj-Napoca, Romania. Holotype and

paratypes of the new species are deposited in the Museum of Zoology of the Babeş-Bolyai University (MZBBU), Cluj-Napoca, Romania. Male genitalia were left overnight in 10% potassium hydroxide (KOH) and for one hour in undiluted glacial acetic acid, to neutralise and wash out the soap that was created from the soft tissues. The male genitalia were then transferred to a larger amount of glycerol to wash out the acid. Afterwards, they were transferred to a drop of glycerol on a slide with rounded excavation. Male abdomens were dissected and examined under a microscope (Olympus CZ23). Photos were taken using a Canon EOS 650D digital camera, attached to the microscope, with an LM Digital SLR Adapter (MicroTechLab, Austria). Layer photos were combined using Zerene Stacker software. Nomenclature of the genital parts follows Kato and Tachi (2019) and Lv et al. (2023).

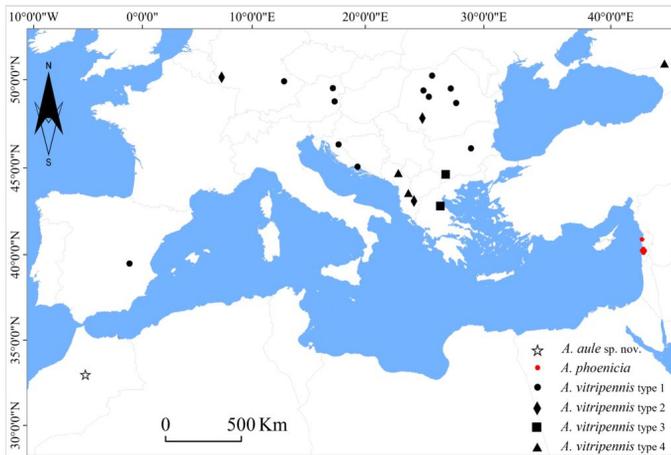


Figure 1. [doi](#)

Distribution data of *Antocha (Antocha)* species included in the present investigation.

Taxon treatments

Antocha (Antocha) staryi Keresztes & Mabrouki sp. nov.

- ZooBank [8F608A95-F4AA-443C-8634-4FA00F05FAAF](https://zoobank.org/8F608A95-F4AA-443C-8634-4FA00F05FAAF)

Materials

Holotype:

- scientificNameID: urn:lsid:zoobank.org:pub:8F608A95-F4AA-443C-8634-4FA00F05FAAF; class: Insecta; order: Diptera; family: Limoniidae; genus: *Antocha*; subgenus: *Antocha*; continent: Africa; waterBody: Cascade near Bakrit; country: Morocco; locality: Middle Atlas Range, Bakrit; verbatimElevation: 1640; verbatimSRS: WGS84; decimalLatitude: 33.049438; decimalLongitude: -5.272774; eventDate: 16-05-2021; eventRemarks: leg. Mabrouki, Y. & Taybi F.A.; sex: 1 male; lifeStage: adult; identifiedBy: Keresztes, L.; occurrenceID: CB927E68-C824-5E85-8FAE-964FC5DE2F27

Paratype:

- a. scientificNameID: urn:lsid:zoobank.org:pub:8F608A95-F4AA-443C-8634-4FA00F05FAAF; class: Insecta; order: Diptera; family: Limoniidae; genus: *Antocha*; subgenus: *Antocha*; continent: Africa; waterBody: Cascade near Bakrit; country: Morocco; locality: Middle Atlas Range, Bakrit; verbatimElevation: 1640; verbatimSRS: WGS84; decimalLatitude: 33.049438; decimalLongitude: -5.272774; eventDate: 16-05-2021; eventRemarks: leg. Mabrouki, Y. & Taybi F.A.; sex: 2 males, 4 females; lifeStage: adult; identifiedBy: Keresztes, L.; occurrenceID: D03EBE02-2C09-573C-8C87-2E409459F84C

Description

Male. Colour dark brown. Body length 5.3–5.5 mm, wing length 6.2–6.5 mm. General appearance as in Fig. 2a.

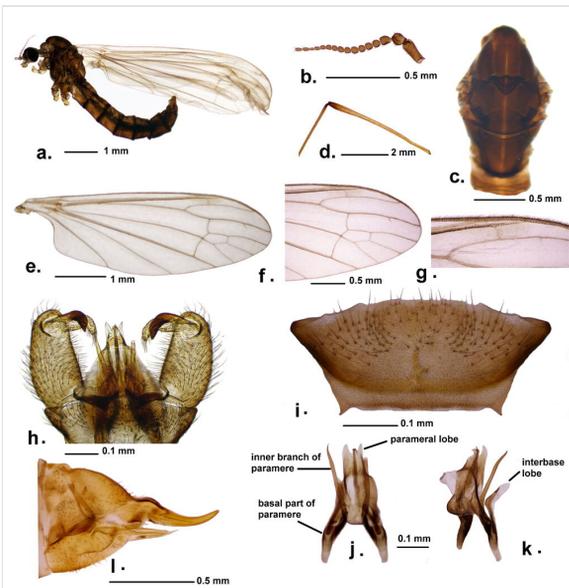


Figure 2. [doi](#)

Antocha (Antocha) staryi sp. nov. **a** male habitus, lateral view; **b** antenna; **c** thorax, dorsal view; **d** femur and part of tibiae, third left leg; **e** right wing; **f** tip of the right wing; **g** stigma on the right wing; **h** male hypopygium, dorsal view; **i** tergite 9, dorsal view; **j** aedeagal complex, dorsal view; **k** aedeagal complex, lateral view; **l** female terminalia, lateral view.

Head. Dark brown, with light brown rostrum. Palpus greyish-brown. Antennae brownish, with 16 segments (Fig. 2b). Scape long and cylindrical. Pedicel is large and short. Antennal flagellomeres short-oval and covered with long dense pubescence, except the last four segments which gradually become smaller and cylindrical, the last segment ending pointed. Short bristles present on every antennal segment, rings of verticils at bases of flagellomeres, mostly on its dorsal surface. Larger bristles are also present on the ventral surface of segments 13, 15 and 16.

Thorax. Prescutum with anterolateral region yellowish. Prescutum and presutural scutum with a broad brown median and two broad lateral bands (Fig. 2c). The lateral bands extending to scutellum. Basal third of presutural scutum with conspicuous dark brown triangle. Scutellum greyish-brown. The rest of the thorax lighter brownish. Legs long and slender, pubescent (Fig. 2d). Coxae lighter to yellowish, rest of the legs brownish. Wing nearly translucent to whitish, generally white and large, with nearly right-angled cell a₂ (Fig. 2e). Veins brownish-yellowish, with stronger bristles on C and R₁ (Fig. 2e, f and g). Stigma indistinct, nearly invisible (Fig. 2f and g). Halter with a yellowish stem and a whitish-greyish knob.

Abdomen. Dark brown, first segment lighter, with whitish-clouded tint dorsally, the last segments darker.

Male terminalia. Tergite 9 in the shape of transverse plate with posterior margin straight (Fig. 2i). Posterolateral angle extended, nearly triangular with darkened margin. Gonocoxite cylindrical, with long setae (Fig. 2h). Outer gonostylus strongly sclerotised, short and curved. Distal end shorter and thicker and less pointed with a hardly visible hump on the dorsal surface. Inner gonostylus fleshy, pubescent, distal end abruptly curved downwards. Aedeagal complex with interbase exteriorly-diverged (Fig. 2k). Inner branch of parameres straight and parallel, slightly bent near the apex (Fig. 2j). Parameres with basal parts stout and divergent, apical parts forming two parameral lobes on either side of aedeagus. Lateral edges of the lobes straight, tips pointed directed straight back (Fig. 2h, j and k).

Female. Colour similar to males. Body length 5.8 mm, wing length 6.7 mm. General habitus similar to males, except the dark brown triangle on metathorax reduced.

Ovipositor. Cerci and hypogynal valve long and slender (Fig. 2l).

Diagnosis

Antocha (*A.*) *staryi* sp. nov. can be recognised by dark brown body colouration, thoracic dark brown triangle, strongly sclerotised and curved outer gonostylus and tergite 9 having straight posterior margin and darkened, nearly triangular posterolateral lobes. Aedeagal complex with inner branch of parameres long, parameres apically forming slightly curved lobes.

The closest regional ally is *A.* (*A.*) *phoenicia*. Both species are similar in general features with *A.* (*A.*) *vitripennis* and are characterised by the long inner branch of the paramere, similar shape of parameral lobe and tergite 9 possessing extended posterolateral lobe. Still *A.* (*A.*) *staryi* sp. nov. can be separated from *A.* (*A.*) *phoenicia* by the unique apical part of the paramere (the parameral lobe) which is sharply narrowed to the distal end, longer and curved ventrally and also by details of tergite 9, with the posterior margin having a prominent and angular middle region in *A.* (*A.*) *phoenicia*, but less prominent, more or less straight in *A.* (*A.*) *staryi* sp. nov., but with posterolateral angle well developed, nearly triangular.

Antocha (*A.*) *staryi* sp. nov. is highly divergent from the European widespread *A.* (*A.*) *vitripennis*, as well as, in a series of morphological details in male genital structures, like the more or less straight posterior margin of tergite 9, but more sinuous in *A.* (*A.*) *vitripennis*, with a middle depression and two lateral humps. The exteriorly curved interbase lobe is well developed in *A.* (*A.*) *staryi* sp. nov., but less in *A.* (*A.*) *vitripennis*. Inner branch of the parameres parallel with aedeagus in *A.* (*A.*) *staryi* sp. nov., but highly divergent and sinuous in *A.* (*A.*) *vitripennis*. The apical part of the paramere with narrow and distally pointed parameral lobe in *A.* (*A.*) *staryi* sp. nov., but with a generally rounded lobe in *A.* (*A.*) *vitripennis*.

Etymology

Named after the outstanding crane-fly taxonomist Jaroslav Starý, honouring his 80th birth anniversary. A noun in genitive singular.

Distribution

The type locality of the new species, Bakrit, belongs to the Middle Atlas Range, which is located in the southwest to northeast of the Mediterranean part of Morocco. The scientific and socio-economic interests of the included aquatic ecosystems are no longer demonstrated as an area with rich and varied natural resources, which generally support the presence of an interesting aquatic biodiversity with high rates of endemism (Taybi et al. 2020, Ibrahim et al. 2021, Mabrouki et al. 2021). The newly-discovered species from here complete the diversity of aquatic fauna from this location and support conservation efforts for these unique aquatic ecosystems.

Ecology

The species was discovered in a single site in Morocco; therefore, we consider a range-restricted micro-endemic species of the Middle Atlas Range. Specimens were captured in Bakrit, a location in the Middle Atlas Range, a mountain range stretching over some 350 km, from southwest to northeast of the Mediterranean part of Morocco, located between the Rif Mountains and the High Atlas Mountains and covering a total area of 2.3 million hectares, i.e. 18% of Morocco's high altitude mountain domain (Fig. 3a). This chain belongs to the Atlas Mountains and more precisely, to one of the three elements of the Moroccan Atlas, the other two being the High Atlas and the Anti-Atlas (or Lesser Atlas). The heavy rainfall gives the Middle Atlas Mountains the form of a "water tower" (also via snowmelt hydrology) from both hydrogeological and hydrographic perspectives and is the main water supply for median and low reaches.

Bakrit Region is well-known for its rich superficial water resources, i.e. streams, waterfalls and springs and the new species was captured from the banks of a fast-flowing stream, with the type locality belonging to the Oum Errabiâ River Basin (Fig. 3b and c).



Figure 3. [doi](#)

Different landscape elements of the Bakrit region, Middle Atlas, Morocco, showing the habitat of the *Antocha (Antocha) staryi* sp. nov. **a** general view of the area; **b** detail on the Oum Errabiâ River; **c** waterfall on the Oum Errabiâ River.

Accompanying species: Different aquatic invertebrate species can be found in the habitat of *A. (A.) staryi* sp. nov. including the recently-described caddisfly *Tinodes atlasensis* Ibrahim, Mabrouki & Taybi, 2021 and freshwater gastropod *Pseudamnicola bouhaddiouii* Taybi, Glöer & Mabrouki, 2022, in addition to other invertebrate species, such as *Hydropsyche* sp. (Trichoptera); *Ecdyonurus rothschildi* (Navàs, 1929), *Rhithrogena* sp., *Baetis* sp., *Caenis* sp. (Ephemeroptera); *Calopteryx haemorrhoidalis* (Vander Linden, 1825), *Anax* sp., *Onychogomphus* sp., *Sympetrum* sp., *Orthetrum* sp. (Odonata); *Hydrometra stagnorum* (Linnaeus, 1758) (Heteroptera); *Atyaephyra desmarestii* (Millet, 1831) (Decapoda); *Physella acuta* (Draparnaud, 1805), *Ancylus fluviatilis* O.F. Müller, 1774; *Theodoxus* sp., *Melanopsis* sp. (Mollusca); *Simulium* sp., *Prosimulium* sp. (Diptera) (Ibrahim et al. 2021, Taybi et al. 2022).

***Antocha (Antocha) vitripennis* (Meigen, 1830)**

Limnobia vitripennis (Meigen, 1830) (type locality not given, ? near Stolberg, Germany Meigen (1830), Savchenko et al. (1992). Syn. *Antocha opalizans* auct. nec *opalizans* Osten Sacken, 1859: 220 (Geiger 1985).

Synonyms: *Antocha obscura* Strobl, 1906 (as variety of *A. opalizans*, type-locality Ronda, Spain), *Antocha fulvescens* Lackschewitz, 1940 (type locality Vernet-les-Bains, France, Savchenko et al. (1992)), synonymised with *A. vitripennis* by Geiger (1985).

Morphological variability of male terminalia of *A. (A.) vitripennis* (Meigen, 1830) in the West Palearctic Region

A number of 198 male individuals of *A. vitripennis* were investigated from the whole West Palearctic Region, representing 20 different populations from Albania, Austria,

Bulgaria, Croatia, Georgia, Germany, Greece, Montenegro, Romania and Spain (Table 1). A comparative analysis of the outer gonostylus, inner branch of parameres and parameral lobes of individual specimens shows high variability in the species within its whole distribution area, which allowed us to group individuals in at least four different morphological types (Fig. 4).

Table 1.

Sampling sites of *Antocha* (*Antocha*) *vitripennis* from the West Palearctic Region, included in this study, with number on individual males, localities, coordinates, altitude and name of the collectors. Morpho-types abbreviation sorted by country: **AV-TYPE 1** – *A. (A.) vitripennis*, type 1; **AV-TYPE 2** – *A. (A.) vitripennis*, type 2; **AV-TYPE 3** – *A. (A.) vitripennis*, type 3; **AV-TYPE 4** – *A. (A.) vitripennis*, type 4.

Species/ Type	Male	Country	Region	Longitude	Latitude	Data	Collectors
Av - type 1	25	Austria	Burgenland	47.373709°N	16.010401°E	19.06.2012	Graf, W.
Av - type 1	5	Austria	Vienna hills	48.136847°N	16.098223°E	15.06.2012	Graf, W.
Av - type 1	4	Bulgaria	Stara Planina	42.784125°N	25.912326°E	01.06.2013	Kolcsár, L- P, Török, E.
Av - type 1	7	Croatia	NP Plitvicka Jezera	44.925833°N	15.619167°E	30.06.2008	Ivkovic, M.
Av - type 1	6	Croatia	Omiš Forests	43.437297°N	16.757657°E	19.07.2005	Ivkovic, M.
Av - type 1	2	Germany	Danube lowland	49.026846°N	12.075860°E	13.07.2013	Graf, W.
Av - type 1	22	Romania	Rodnei Mts.	47.423995°N	24.548807°E	26.07.2003	Keresztes, L.
Av - type 1	33	Romania	Harghita Mts.	46.412488°N	25.745437°E	15.07.2001	Keresztes, L.
Av - type 1	37	Romania	Ciucas Mts.	45.534297°N	25.836821°E	21.07.2004	Keresztes, L.
Av - type 1	7	Romania	Trascaului Mts.	46.565262°N	23.675828°E	06.06.2001	Keresztes, L.
Av - type 1	8	Romania	Clujului Hills	46.755529°N	23.509461°E	24.08.2004	Keresztes, L.
Av - type 1	1	Spain	Serrania de Cuenca	39.503257°N	(-)1.900691°E	04.08.2009	Martinez, J.
Av - type 2	1	Albania	Korce	41.016258°N	20.513618°E	03.05.2019	Keresztes, L.
Av - type 2	12	Germany	Eifel hills	49.755204°N	6.735459°E	05.08.2007	Neu, P.

Species/ Type	Male	Country	Region	Longitude	Latitude	Data	Collectors
Av - type 2	6	Romania	Cerna Mts.	45.256819°N	22.814289°E	10.08.2004	Bálint, M.
Av - type 3	2	Bulgaria	Pirin Mts.	41.768952°N	23.426897°E	19.08.2003	Pauls, S.
Av - type 3	1	Greece	Olympus Mts.	40.079097°N	22.373471°E	14.07.2012	Rákosy, L.
Av - type 4	13	Albania	Domosdova Plain	41.075075°N	20.498387°E	01.05.2019	Keresztes, L.
Av - type 4	1	Georgia	North Caucasus	43.122052°N	42.750700°E	18.07.2012	Graf, W.
Av - type 4	5	Montenegro	Prokletje Mts.	42.550042°N	19.825639°E	02.05.2022	Dénes, A.

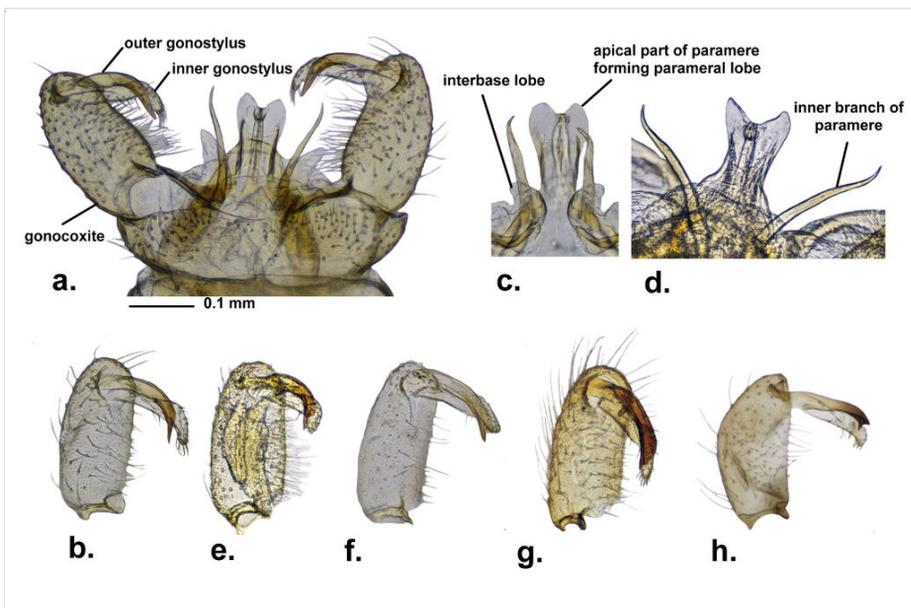


Figure 4. [doi](#)

Variability of the distal end of the outer gonostylus of the male genital structures of *Antocha* (*Antocha*) *vitripennis* from the West Palearctic area: **a** male terminalia, dorsal (Regensburg, Germany); **b** gonocoxite with outer gonostylus of type 1 (Germany); **c** type 1, aedeagus with parallel inner branch of parameres (Germany); **d** type 1, aedeagus with divergent inner branch of parameres (Austria); **e** gonocoxite with outer gonostylus of type 2 (Germany, Kassel); **f** gonocoxite with outer gonostylus of type 3 (Greece, Olympus); **g** gonocoxite with outer gonostylus of type 4 (Montenegro, Prokletje Mountains); **h** gonocoxite with outer gonostylus, special case of type 2 (Albania, Korçe).

Antocha* (*Antocha*) *vitripennis* (Meigen, 1830)*Materials**

- a. taxonRemarks: *Antocha* (*A.*) *vitripennis*, type 1; class: Insecta; order: Diptera; family: Limoniidae; genus: *Antocha*; continent: Europe; country: Austria; locality: Burgenland; verbatimSRS: WGS84; decimalLatitude: 47.373709; decimalLongitude: 16.010401; eventDate: 19-06-2012; eventRemarks: leg. Graf, W.; sex: 25 males; lifeStage: adult; identifiedBy: Keresztes, L.; occurrenceID: 79366A14-4113-5B33-A33D-F8A53400A6F5
- b. taxonRemarks: *Antocha* (*A.*) *vitripennis*, type 1; class: Insecta; order: Diptera; family: Limoniidae; genus: *Antocha*; continent: Europe; country: Austria; locality: Vienna hills; verbatimSRS: WGS84; decimalLatitude: 48.136847; decimalLongitude: 16.098223; eventDate: 15-06-2012; eventRemarks: leg. Graf, W.; sex: 5 males; lifeStage: adult; identifiedBy: Keresztes, L.; occurrenceID: 9DDFE354-5E4F-573E-942B-3843C0C0DB9B
- c. taxonRemarks: *Antocha* (*A.*) *vitripennis*, type 1; class: Insecta; order: Diptera; family: Limoniidae; genus: *Antocha*; continent: Europe; country: Bulgaria; locality: Stara Planina; verbatimSRS: WGS84; decimalLatitude: 42.784125; decimalLongitude: 25.912326; eventDate: 01-06-2013; eventRemarks: leg. Kolcsár, L.-P. & Török E.; sex: 4 males; lifeStage: adult; identifiedBy: Keresztes, L.; occurrenceID: 6A29D2D0-E4AF-5CE3-A81C-036A4BD20558
- d. taxonRemarks: *Antocha* (*A.*) *vitripennis*, type 1; class: Insecta; order: Diptera; family: Limoniidae; genus: *Antocha*; continent: Europe; country: Croatia; locality: NP Plitvicka Jezera; verbatimSRS: WGS84; decimalLatitude: 44.925833; decimalLongitude: 15.619167; eventDate: 30-06-2008; eventRemarks: leg. Ivkovic, M.; sex: 7 males; lifeStage: adult; identifiedBy: Keresztes, L.; occurrenceID: 2A66D0CC-CCD5-5A6E-9A20-A6D9334F252B
- e. taxonRemarks: *Antocha* (*A.*) *vitripennis*, type 1; class: Insecta; order: Diptera; family: Limoniidae; genus: *Antocha*; continent: Europe; country: Croatia; locality: Omiš Forests; verbatimSRS: WGS84; decimalLatitude: 43.437297; decimalLongitude: 16.757657; eventDate: 19-07-2005; eventRemarks: leg. Ivkovic, M.; sex: 6 males; lifeStage: adult; identifiedBy: Keresztes, L.; occurrenceID: 251B5C15-3723-56FD-B042-0C01B7967645
- f. taxonRemarks: *Antocha* (*A.*) *vitripennis*, type 1; class: Insecta; order: Diptera; family: Limoniidae; genus: *Antocha*; continent: Europe; country: Germany; locality: Danube lowland; verbatimSRS: WGS84; decimalLatitude: 49.026846; decimalLongitude: 12.075860; eventDate: 13-07-2013; eventRemarks: leg. Graf, W.; sex: 2 males; lifeStage: adult; identifiedBy: Keresztes, L.; occurrenceID: BECE70D5-B754-5935-9001-B81960BA27E7
- g. taxonRemarks: *Antocha* (*A.*) *vitripennis*, type 1; class: Insecta; order: Diptera; family: Limoniidae; genus: *Antocha*; continent: Europe; country: Romania; locality: Rodnei Mts.; verbatimSRS: WGS84; decimalLatitude: 47.423995; decimalLongitude: 24.548807; eventDate: 26-07-2003; eventRemarks: leg. Keresztes, L.; sex: 22 males; lifeStage: adult; identifiedBy: Keresztes, L.; occurrenceID: D66D3EC9-E42A-5987-97F1-822CA33263A1
- h. taxonRemarks: *Antocha* (*A.*) *vitripennis*, type 1; class: Insecta; order: Diptera; family: Limoniidae; genus: *Antocha*; continent: Europe; country: Romania; locality: Harghita Mts.; verbatimSRS: WGS84; decimalLatitude: 46.412488; decimalLongitude: 25.745437; eventDate: 15-07-2001; eventRemarks: leg. Keresztes, L.; sex: 33 males; lifeStage: adult; identifiedBy: Keresztes, L.; occurrenceID: DEDA028B-7B5B-55EF-8CA3-E2921DA7F57E
- i. taxonRemarks: *Antocha* (*A.*) *vitripennis*, type 1; class: Insecta; order: Diptera; family: Limoniidae; genus: *Antocha*; continent: Europe; country: Romania; locality: Ciucaș Mts.; verbatimSRS: WGS84; decimalLatitude: 45.534297; decimalLongitude: 25.836821;

- eventDate: 21-07-2004; eventRemarks: leg. Keresztes, L.; sex: 37 males; lifeStage: adult; identifiedBy: Keresztes, L.; occurrenceID: 2B539852-8D49-5E50-92FF-60D19C01A2FA
- j. taxonRemarks: *Antocha (A.) vitripennis*, type 1; class: Insecta; order: Diptera; family: Limoniidae; genus: *Antocha*; continent: Europe; country: Romania; locality: Trascaului Mts.; verbatimSRS: WGS84; decimalLatitude: 46.565262; decimalLongitude: 23.675828; eventDate: 06-06-2001; eventRemarks: leg. Keresztes, L.; sex: 7 males; lifeStage: adult; identifiedBy: Keresztes, L.; occurrenceID: AC7E5A4E-0B19-5CB6-8FE1-CC1ADB71D099
- k. taxonRemarks: *Antocha (A.) vitripennis*, type 1; class: Insecta; order: Diptera; family: Limoniidae; genus: *Antocha*; continent: Europe; country: Romania; locality: Clujului Hills; verbatimSRS: WGS84; decimalLatitude: 46.755529; decimalLongitude: 23.509461; eventDate: 24-08-2004; eventRemarks: leg. Keresztes, L.; sex: 8 males; lifeStage: adult; identifiedBy: Keresztes, L.; occurrenceID: 95346811-C0F2-5416-B99C-D741EE62D525
- l. taxonRemarks: *Antocha (A.) vitripennis*, type 1; class: Insecta; order: Diptera; family: Limoniidae; genus: *Antocha*; continent: Europe; country: Spain; locality: Serrania de Cuenca; verbatimSRS: WGS84; decimalLatitude: 39.503257; decimalLongitude: -1.900691; eventDate: 04-08-2009; eventRemarks: leg. Martinez, J.; sex: 1 male; lifeStage: adult; identifiedBy: Keresztes, L.; occurrenceID: B87A4D3A-E5F6-5EBB-8754-ECF5CC2BAE6E
- m. taxonRemarks: *Antocha (A.) vitripennis*, type 2; class: Insecta; order: Diptera; family: Limoniidae; genus: *Antocha*; continent: Europe; country: Albania; locality: Korce; verbatimSRS: WGS84; decimalLatitude: 41.016258; decimalLongitude: 20.513618; eventDate: 03-05-2019; eventRemarks: leg. Keresztes, L.; sex: 1 male; lifeStage: adult; identifiedBy: Keresztes, L.; occurrenceID: 0DBE5507-F359-5382-A5FE-55C18D749170
- n. taxonRemarks: *Antocha (A.) vitripennis*, type 2; class: Insecta; order: Diptera; family: Limoniidae; genus: *Antocha*; continent: Europe; country: Germany; locality: Eifel hills; verbatimSRS: WGS84; decimalLatitude: 49.755204; decimalLongitude: 6.735459; eventDate: 05-08-2007; eventRemarks: leg. Neu, P.; sex: 12 males; lifeStage: adult; identifiedBy: Keresztes, L.; occurrenceID: 460335F1-D823-5A08-B806-95B25AA9EBB1
- o. taxonRemarks: *Antocha (A.) vitripennis*, type 2; class: Insecta; order: Diptera; family: Limoniidae; genus: *Antocha*; continent: Europe; country: Romania; locality: Cerna Mts; verbatimSRS: WGS84; decimalLatitude: 45.256819; decimalLongitude: 22.814289; eventDate: 10-08-2004; eventRemarks: leg. Bálint, M.; sex: 6 males; lifeStage: adult; identifiedBy: Keresztes, L.; occurrenceID: 7BB55E4A-2ABA-5593-9558-7DA78E32C417
- p. taxonRemarks: *Antocha (A.) vitripennis*, type 3; class: Insecta; order: Diptera; family: Limoniidae; genus: *Antocha*; continent: Europe; country: Bulgaria; locality: Pirin Mts; verbatimSRS: WGS84; decimalLatitude: 41.768952; decimalLongitude: 23.426897; eventDate: 19-08-2003; eventRemarks: leg. Pauls, S.; sex: 2 males; lifeStage: adult; identifiedBy: Keresztes, L.; occurrenceID: EBFCE991-C43B-5700-AED9-87D6EC9239F8
- q. taxonRemarks: *Antocha (A.) vitripennis*, type 3; class: Insecta; order: Diptera; family: Limoniidae; genus: *Antocha*; continent: Europe; country: Greece; locality: Olympus Mts.; verbatimSRS: WGS84; decimalLatitude: 40.079097; decimalLongitude: 22.373471; eventDate: 14-07-2012; eventRemarks: leg. Rákossy, L.; sex: 1 male; lifeStage: adult; identifiedBy: Keresztes, L.; occurrenceID: 923E950B-71DF-5477-8CEF-6679A1C8E175
- r. taxonRemarks: *Antocha (A.) vitripennis*, type 4; class: Insecta; order: Diptera; family: Limoniidae; genus: *Antocha*; continent: Europe; country: Albania; locality: Domosdova Plain; verbatimSRS: WGS84; decimalLatitude: 41.075075; decimalLongitude: 20.498387; eventDate: 01-05-2019; eventRemarks: leg. Keresztes, L.; sex: 13 males; lifeStage: adult; identifiedBy: Keresztes, L.; occurrenceID: E1F6DA3B-BC17-5006-8729-BBFE1E25620C

- s. taxonRemarks: *Antocha* (*A.*) *vitripennis*, type 4; class: Insecta; order: Diptera; family: Limoniidae; genus: *Antocha*; continent: Europe; country: Georgia; locality: North Caucasus; verbatimSRS: WGS84; decimalLatitude: 43.122052; decimalLongitude: 42.750700; eventDate: 18-07-2012; eventRemarks: leg. Graf, W.; sex: 1 male; lifeStage: adult; identifiedBy: Keresztes, L.; occurrenceID: 15613FC2-197C-5AEA-AD73-E26DB524C721
- t. taxonRemarks: *Antocha* (*A.*) *vitripennis*, type 4; class: Insecta; order: Diptera; family: Limoniidae; genus: *Antocha*; continent: Europe; country: Montenegro; locality: Prokletje Mts.; verbatimSRS: WGS84; decimalLatitude: 42.550042; decimalLongitude: 19.825639; eventDate: 02-05-2022; eventRemarks: leg. Dénes, A.; sex: 5 males; lifeStage: adult; identifiedBy: Keresztes, L.; occurrenceID: 7E92A44E-7B20-570D-97A9-C782E16951D0

Taxon discussion

Type 1 corresponds to the “normal” shape of the inner gonostylus, according to Geiger (1985) and it is the most widespread amongst male individuals in the western part of Europe. The apical part of outer gonostylus tapered, ending in a single point, lacking protrusion or humps or teeth on its upper surface (Fig. 4a and b). Amongst this type, it is also important to point to the most frequently detected narrow and straight inner branch of parameres, slightly curved in the distal end (Fig. 4c), but also a number of individuals, even in the same population, where the inner branch of parameres are divergent and highly sinuous in shape (Fig. 4d), for example, in several individuals collected from Lafnitz, Austria. The parameral lobes are rounded, protruded or almost straight at their distal end (Fig. 4a, c and d).

Our data show that type 1 of the inner gonostylus is widespread also in the central and eastern parts of Europe and it was detected in the hilly regions from Germany, Spain, Austria, Croatia, Romania and also in the Balkan Range Mountains (Stara Planina), Bulgaria. Out of the 201 male individuals, 157 specimens belong to this type, also representing the majority of male individuals investigated by us (roughly 78%).

Type 2, distinct from type 1, has a bifurcated outer gonostylus tip. The upper arm is shorter, always wider, more or less rounded or triangular, while the lower point is narrower, longer and almost thorn-like (Fig. 4d, e and h). Male individuals examined by us from Germany (surrounding areas of the City of Kassel), Romania (Banat Region) and Albania (Korce Region) belong to this type, representing 9% of the total individuals collected by us. Inner branch of parameres almost parallel, slightly sinuous at the distal end. The parameral lobes similar to type 1.

Type 3 represents individuals with outer gonostylus ending in two points, similar to type 2, but the upper extension of the distal end is well developed, rounded and hump-like, while the lower part is more pointed and thorn-like (Fig. 4f). This type was completely absent from the material collected in the western part of Europe and we could only identify, in this case, a few specimens collected at high altitudes, in Bulgaria (Pirin Mountains, 1780 m) and Greece (Olympus Mountains, 2100 m) (less than 2% from the total individuals examined by us). Type 3 was collected from higher elevations,

above 1500 m (Table 1). Inner branch of parameres and parameral lobes similar to type 1 and type 2.

Type 4 corresponds with the outer gonostylus sharply curved inwards and rounded at the distal end. A more or less well-developed tooth-like extension can often be distinguished in its lower corner (Fig. 4g). However, this type is difficult to separate from the previous type 3, because we encountered a series of transitional forms amongst individuals collected in the Balkan Range, which also resembles type 2 in some cases (Fig. 4h). Type 4 was identified amongst individuals collected in Albania, Montenegro and Georgia and it is the dominating type in the Balkan area, representing 9% of the total individuals examined by us. Inner branch of parameres are more slender and sinuous. Parameral lobes with well-developed distal lobes.

Identification keys

Key to West Palearctic males of <i>Antocha</i> (<i>Antocha</i>)		
1	Wing without a pronounced anal lobe	<i>Antocha</i> (<i>Orimargula</i>)
–	Wing with a pronounced anal lobe	2
2	Inner branch of parameres wide, with 2 teeth-like points at distal end	<i>A. (A.) libanotica</i>
–	Inner branch of parameres slender and simple ending with one point at distal end	3
3	Outer gonostylus gradually narrowed at distal end, ending in one or two distinct points, slightly curved downwards, inner branch of parameres slender and sinuous, sometimes parallel with the aedeagal axis	<i>A. (A.) vitripennis</i>
–	Outer gonostylus sharply curved down at distal end, rounded, inner branch of parameres straight and parallel with the aedeagal axis	4
4	Parameral lobes weakly developed	<i>A. (A.) hirtipes</i>
–	Parameral lobes well developed	5
5	Parameral lobes wide at base, divergent distally	<i>A. (A.) phoenicia</i>
–	Parameral lobes narrow at base, parallel distally with aedeagal axis	<i>A. (A.) staryi</i> sp. nov.

Discussion

Antocha (*A.*) *vitripennis* has a long-debated taxonomy. The species was first described from the northern part of Germany (most probably around Stolberg) by Meigen (1830) as *Limnobia vitripennis* (syntypes deposited in the Muséum national d'Histoire naturelle, Paris (France), Diptera Collection (ED), specimen identification code MNHN-ED-ED2450), based on translucent or opalescent wings (*vitri* - window, *pennis* - wing, lat.), later transferred to the subgenus *Antocha* of the genus *Antocha* by Osten Sacken (1860).

The species is widely distributed in the whole West Palearctic area (Oosterbroek 2023), but also detected from Bashkortostan Republik in Russia (East Palearctic) (Kolcsár et al. 2021).

Antocha (*A.*) *fulvescens* Lackschewitz, 1940, very close to *A.* (*A.*) *vitripennis*, was described by Lackschewitz (1940) from Albania in 1940 and later identified also from France (Geiger 1985), based on a generally lighter colour of the specimens, shape of the outer gonostylus ending in two points and the divergent position of the inner branch of the parameres relative to the body axis. Based on comparative analyses of a large amount of material of *Antocha* from Europe, Geiger revised the taxonomic status of *A.* (*A.*) *fulvescens* and synonymised it with *A.* (*A.*) *vitripennis* because of the high variability of the male genital structures of individuals in sympatric populations, not only in the Balkan Range, but also from different European countries, like Switzerland, France and Germany (Geiger 1985). However, Mendl still argued on the possibility of the presence of more subspecies of *A.* (*A.*) *vitripennis* in Europe, especially in the Balkan Range (Mendl 1979).

Our result supports the work of Geiger (1985) on the presence of the single, but highly variable *A.* (*A.*) *vitripennis* in Europe, based on a large amount of fresh material collected from different parts of Europe. Examination of 201 male genital structures reveals highly-different morphological types of the outer gonostylus (here noted as type 1 to type 4), which is not followed by any other detectable differences in the other parts of the male terminalia. The geographic distribution of the identified differences does not draw out any clear clinal pattern (Fig. 1). The widely-distributed type 1 is very frequent in Western Europe and Central Europe and represented the majority of individuals investigated by us (78%), but were present sporadically also in the Balkan Range, mostly along some intermittent waters in the hilly area around the Plitvice Lakes (Croatia) and the Eastern Stara Planina Mountains (Bulgaria). Type 2, represents a morphological variability of male genital structures similar to *A.* (*A.*) *fulvipennis* (sensu Lackschewitz 1940) and was identified by us not only in the Balkan area (Albania), but also in Germany and Romania. Type 3, however, is a particular case of highly different morphology of the outer gonostylus, distinct from type 1 or type 2, collected only from the mountainous areas of Bulgaria and Greece, up to 1500 m altitude, which is also unusual for *A.* (*A.*) *vitripennis*, a species frequently collected at lower hilly or mountainous regions, but missing from high altitudes. Unfortunately, the small number of individuals (2 males) collected during our investigation did not allow us to support the presence of a separate *A.* (*A.*) *vitripennis* taxa in the Balkans, but points to the necessity for a more comprehensive revision of the subgenus in

its whole range. Type 4 is even more difficult to appreciate, but it is typical for a large number of individuals collected in the Southern Balkans, but also in the case of one male from Georgia and supports a wide range of transitional forms between type 2 and type 3, also highly similar with *A. (A.) hirtipes* Savchenko, 1971, described from Georgia by Savchenko in 1971. The detection variability of type 4 and its similarity to *A. (A.) hirtipes* makes the status of the later taxa in Georgia questionable. The single male individual of *A. (A.) vitripennis* collected by us in Georgia is not clearly different from the individuals of *A. (A.) vitripennis* from the Balkan area. However, in the original description of *A. (A.) hirtipes* (Savchenko 1971), the parameral lobes are not figured, but are clearly well developed in the male individuals collected by us. Based on these taxonomic challenges and also the recent discovery of *A. (A.) vitripennis* in the East Palearctic area (Kolcsár et al. 2021), a taxonomic revision of all members of the subgenus is highly recommended.

In conclusion, the subgenus *Antocha* is represented by five species in the West Palearctic area. Except for the high mountainous *Antocha (A.) libanotica*, which has a highly different shape of inner branch of parameres, ending in two points, the rest of the West Palearctic species, *A. (A.) hirtipes*, *A. (A.) phoenicia* and *A. (A.) vitripennis*, including the recently discovered *A. (A.) staryi* sp. nov., are mostly hilly species, highly similar in general habitus and shape of the male and female terminalia. The taxonomic status of type 3 of *A. (A.) vitripennis* remains challenged and this particular morphology of the outer gonostylus was detected in some few individuals only, collected at higher elevations in the Pirin Mountains, Bulgaria and Olympus Mountains, Greece. Further, morphological investigation supported by molecular data is highly recommended to test the taxonomic status of this particular morphology, as well as for the other members of the subgenus *Antocha*.

Despite the extremely high morphological variability of the male outer gonostylus in the case of *A. (A.) vitripennis*, a series of small, but constant details on other male genital structures, including the parameres and aedeagus, allow us to separate the five species of the subgenus *A. (Antocha)*, supported also by information from literature (Savchenko 1971, Thomas and Dia 1982).

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References

- Abdul Malak D, Cuttelod A, Garcia N (2010) The status and distribution of freshwater biodiversity in Northern Africa. IUCN. xiii+141pp
- Adghir A, De Jong H, Kettani K (2018) The Tipulidae (Diptera) of northern Morocco with a focus on the Rif region, including the description of a new species of *Tipula* (*Lunatipula*) and an updated checklist for Morocco. *Annales de la Société Entomologique de France* (N.S) 54 (6): 522-538. <https://doi.org/10.1080/00379271.2018.1530949>
- Barredo JI, Caudello G, Dosio A (2016) Mediterranean habitat loss under future climate conditions: Assessing impacts on the Natura 2000 protected area network. *Applied Geography* 75: 83-92. <https://doi.org/10.1016/j.apgeog.2016.08.003>
- de Jong H, Adghir A, Bosch E, Kettani K (2021) Taxonomy of *Nephrotoma guestfalica* (Westhoff, 1879) (Diptera, Tipulidae), with the description of a new subspecies from Morocco. *Tijdschrift voor Entomologie* 163: 31-45. <https://doi.org/10.1163/22119434-20192086>
- Delibes-Mateos M, Delibes M, Ferreras P, Villafuerte R (2008) Key role of European rabbits in the conservation of the Western Mediterranean basin hotspot. *Conservation Biology* 22: 1106-1117. <https://doi.org/10.1111/j.1523-1739.2008.00993.x>
- Driauch O, Belqat B, De Jong H (2013) A first checklist of the short-palped crane flies (Diptera: Limoniidae, Pediciidae) of Morocco. *Boletín de la Sociedad Entomológica Aragonesa* 53: 187-190.
- Driauch O, Belqat B (2015) A new species of the genus *Baeoura* from Morocco, with a key to the West Palearctic species (Diptera: Tipuloidea: Limoniidae). *ZooKeys* 532: 99-105. <https://doi.org/10.3897/zookeys.532.5994>
- Driauch O, Belqat B (2016) Additions to the Limoniidae and Pediciidae fauna of Morocco, with an updated checklist (Diptera, Tipuloidea). *ZooKeys* 563: 129-146. <https://doi.org/10.3897/zookeys.563.7384>
- Ebejer MJ, Kettani K, Gatt P (2019) First records of families and species of Diptera (Insecta) from Morocco. *Boletín de la Sociedad Entomológica Aragonesa* (S.E.A.) 64: 143-153.
- Eiroa E, Keresztes L, Martín L, González M, Martínez J (2020) Contribución al conocimiento de los Tipuloidea (Diptera) de Teruel (Aragón, este de la Península Ibérica). *Boletín de la Sociedad Entomológica Aragonesa* 67: 246-250.
- Fuller RL, Hynes HB (1987) The life cycle, food habits and production of *Antocha saxicola* Osten Sacken (Diptera: Tipulidae). *Aquatic Insects* 9: 129-135. <https://doi.org/10.1080/01650428709361285>
- Geiger W (1985) Limoniidae (Diptera), sous-famille Limoniinae de Suisse: synonymies nouvelles. *Mitteilungen der Schweizerischen Entomologischen Gesellschaft= Bulletin de la Société Entomologique Suisse* 58: 69-76.
- Hancock EG, Hewitt SM (2020) Craneflies (Diptera, Tipuloidea) trapped by the leaves of longleaved Spanish butterwort, *Pinguicula vallisneriifolia* Webb (Lentibulariaceae). *Dipterists Digest*, 2nd Series 27: 45-49.
- Ibrahimi H, Mabrouki Y, Taybi AF (2021) *Tinodes atlasensis* Ibrahimi, Mabrouki & Taybi sp. nov. (Trichoptera: Psychomyiidae), a new species from Atlas Mountains, Morocco. *Natura Croatica* 30 (2): 367-375. <https://doi.org/10.20302/NC.2021.30.23>

- Kato D, Tachi T (2019) Taxonomic notes on the genus *Elliptera* Schiner, 1863, of Japan. *Makunagi / Acta Dipterologica* 30: 1-7.
- Kettani K, Ebejer MJ, Ackland DM, Bächli G, Barraclough D, Barták M, Carles-Tolrá M, Černý M, Cerretti P, Chandler P, Dakki M, Daugeron C, De Jong H, Dils J, Disney H, Droz B, Evenhuis N, Gatt P, Gracioli G, Grichanov IY, Haenni J-P, Hauser M, Himmi O, Macgowan I, Mathieu B, Mouna M, Munari L, Nartshuk EP, Negrobov OP, Oosterbroek P, Pape T, Pont AC, Popov GV, Rognes K, Skuhrová M, Skuhrový V, Speight M, Tomasovic G, Trari B, Tschorsnig H-P, Vala J-C, Tschirnhaus M, Wagner R, Whitmore D, Woźnica AJ, Zatwarnicki T, Zwick P (2022) Catalogue of the Diptera (Insecta) of Morocco—an annotated checklist, with distributions and a bibliography. *ZooKeys* 1094: 1-466. <https://doi.org/10.3897/zookeys.1094.62644>
- Kolcsár L-P, Oosterbroek P, Gavryushin DI, Olsen KM, Paramonov NM, Pilipenko VE, Starý J, Polevoi A, Lantsov VI, Eiroa E, Andersson M, Salmela J, Quindroit C, d'Oliveira MC, Hancock EG, Mederos J, Boardman P, Viitanen E, Watanabe K (2021) Contribution to the knowledge of Limoniidae (Diptera: Tipuloidea): first records of 244 species from various European countries. *Biodiversity Data Journal* 9: e67085 <https://doi.org/10.3897/BDJ.9.e67085>
- Lackschewitz P (1940) Die paläarktischen Rhamphidiinen und Eriopterinen (Diptera) des Wiener Naturhistorischen Museums. *Annalen des Naturhistorischen Museums in Wien* 50 (1939): 1-67.
- Lv H, Sun J, Wang N, Yang D, Zhang X, et al. (2023) New species and records of the genus *Antocha* Osten Sacken (Diptera, Limoniidae) from Tibet, China with a key to species in Qinghai-Tibet region. *ZooKeys* 1156: 53-69. <https://doi.org/10.3897/zookeys.1156.86786>
- Mabrouki Y, Taybi AF, Glöer P (2021) Further records of freshwater Gastropods (Mollusca: Hydrobiidae, Lymnaeidae, Planorbidae) from Morocco. *Bonn Zoological Bulletin* 70 (2): 273-279. <https://doi.org/10.20363/BZB-2021.70.2.273>
- Markevičiūtė R, Sigita P, Saldaitis A (2019) A new species of *Antocha* Osten Sacken, 1860 (Diptera: Limoniidae) from Sichuan, China. *Zootaxa* 4661 (1): 118-132. <https://doi.org/10.11646/zootaxa.4661.1.5>
- Markevičiūtė R, Sigita P, Saldaitis A (2021) New *Antocha* Osten Sacken (Diptera: Limoniidae) from Sichuan, China. *Zootaxa* 4969 (2): 280-292. <https://doi.org/10.11646/zootaxa.4969.2.3>
- Meigen JW (1830) Systematische Beschreibung Der Bekannten Europäischen Zweiflügeligen Insekten. Smithsonian Libraries <https://doi.org/10.5962/bhl.title.13731>
- Mendl H (1979) Revision der Limoniiden-Sammlung von Hans Bangerter im Naturhistorischen Museum zu Berlin/Schweiz, Beitr. 29 (2). Ent, Berlin, 343 - 372 pp.
- Oosterbroek P (2023) Catalogue of the Craneflies of the World. Version: 4 March, 2023. URL: <http://nlbif.eti.uva.nl/ccw/index.php>
- Osten Sacken CR (1860) New genera and species of North American Tipulidae with short palpi, with an attempt at a new classification of the tribe. *Proceedings of the Academy of Natural Sciences of Philadelphia* 1859: 219.
- Pârvu C, Popescu-Mirceni R, Zaharia R (2006) Faunistic data on some dipteran families (Insecta: Diptera) from Morocco (Results of "Hamada" Expedition 2005). *Travaux du Muséum National d'Histoire Naturelle «Grigore Antipa» XLIX*: 271-281.

- Pierre C (1924) Nematocera *Polyneura recueillis* au Maroc par M.Charles Alluaud (3e liste, 1922-1923) (Insectes Diptères). Bulletin de la Société des Sciences Naturelles du Maroc 4: 198-201.
- Podenas S, Byun HW (2013) Antochini crane flies (Diptera: Limoniidae: Limoniinae) of Korea. Journal of Species Research 2 (2): 167-184. <https://doi.org/10.12651/JSR.2013.2.2.167>
- Podenas S, Byun HW (2014) New species of *Antocha* Osten Sacken, 1860 crane flies (Diptera: Limoniidae) for South Korea. Zootaxa 3900 (1): 117. <https://doi.org/10.11646/zootaxa.3900.1.7>
- Podenas S, Young CW (2015) *Antocha* crane flies from Taiwan (Diptera: Limoniidae: Limoniinae). Zootaxa 4048 (4): 523-537. <https://doi.org/10.11646/zootaxa.4048.4.4>
- Savchenko EN (1971) New Palaeartic species of Limoniid-flies (Diptera, Limoniidae). Dopovidi Akademii Nauk Ukrain's'koï RSR (B) 2. The genus *Antocha* O.-S.: 855-857. [In Ukrainian].
- Savchenko EN, Oosterbroek P, Starý J (1992) Family Limoniidae. Catalogue of Palaeartic Diptera 1: 183-369.
- Séguy E (1941a) Récoltes de R. Paulian et A. Villiers dans le haut Atlas marocain, 1938, (XVIIe note) Diptères. Revue Française d'Entomologie 8: 25-33.
- Séguy E (1941b) Diptères recueillis par M. Berland dans le sudmarocain. Annales de la Société Entomologique de France 110: 1-23.
- Starý J (1971) A new Palaeartic representative of the subgenus *Protogonomyia* Alexander (Diptera, Tipulidae). Acta Entomologica Bohemoslovaca 68: 319-321.
- Starý J (1974) The identity of *Gonomyia* (*Idiocera*) *sexguttata* (Diptera, Tipulidae). Acta Entomologica Bohemoslovaca 71: 136-140.
- Starý J (2006) *Hoplolabis* (*Parilisia*) species related to *H. (P.) punctigera* (Lackschewitz, 1940) and *H. (P.) spinosa* (Nielsen, 1953) with the description of a new species (Diptera, Limoniidae). Studia Dipterologica 13: 115-125.
- Starý J, Oosterbroek P (2008) New records of West Palaeartic Limoniidae, Pediciidae and Cylindrotomidae (Diptera) from the collections of the Zoological Museum Amsterdam. Zootaxa 1922: 1-20. <https://doi.org/10.5281/zenodo.184739>
- Starý J (2009) West Palaeartic species of the genus *Eloeophila* (Diptera: Limoniidae). European Journal of Entomology 106: 425-440. <https://doi.org/10.14411/eje.2009.054>
- Starý J (2011) Descriptions and records of the Palaeartic *Molophilus* Curtis (Diptera, Limoniidae). Zootaxa 2999: 45-62. <https://doi.org/10.11646/zootaxa.2999.1.5>
- Taybi AF, Mabrouki Y, Berrahou A, Dakki A, Millán A (2020) Longitudinal distribution of macroinvertebrate in a very wet North African basin: Oued Melloulou (Morocco). International Journal of Limnology 56 <https://doi.org/10.1051/limn/2020016>
- Taybi AF, Mabrouki Y, Keresztes L (2021) First record of *Phyllolabis savtshenkoi* (Diptera, Limoniidae) in Morocco. Travaux du Muséum National d'Histoire Naturelle "Grigore Antipa" 64 (1): 115-118. <https://doi.org/10.3897/travaux.64.e63917>
- Taybi AF, Glöer P, Mabrouki Y (2022) Four new species of the genus *Pseudamnicola* Paulucci, 1878 from Morocco (Gastropoda, Hydrobiidae). Invertebrates Zoology 19 (2): 191-198. <https://doi.org/10.15298/invertzool.19.2.07>
- Thomas AG, Dia A (1982) Les antocha (imago) du sud du Liban (Diptera, Limoniidae). Annales de Limnologie 18 (3): 319-326. <https://doi.org/10.1051/limn/1982007>

- Ujvárosi L (2005) Limoniidae and Pediciidae (Insecta, Diptera) assemblages along mountainous streams: additions to assess the biodiversity in wet habitats in Carpathians, Romania. *Acta Biologica Debrecina, Oecologica Hungarica* 13: 233-248.
- Vaillant F (1956) Research sur la fauna madicole (Hygroptérique s.l.) de France, de Corse et d'Afrique de Nord. *Memoires du Museum National d'Histoire Naturelle, Serie A, Zoologie* 11: 1-257.
- Vogtenhuber P (2007) Schnakenverwandte - tipuliformes - Diptera, Tipulimorpha. Erfassung der Biodiversität im Waldgebiet "Schnellert" (Gemeinde Berdorf). *Ferrantia* 50: 349-357.