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Trichoptera of northeastern Algeria: New species, noteworthy records, and a review of the genus *Hydropsyche* (Hydropsychidae)

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Abstract. Freshwater biodiversity in the Maghreb region remains largely unexplored, providing significant opportunities for further discovery. Algerian caddisflies have received relatively little attention. The present study aims to fill gaps in caddisfly taxonomy and distribution by conducting a comprehensive survey of rivers and streams in northeastern Algeria, with a focus on collecting adult caddisflies. Through our research, we identified a total of 28 species from Algeria, and a new caddisfly species, *Hydropsyche tenerifa,* collected in the Canary Islands, expanding our knowledge of the caddisfly fauna in North Africa. Among these discoveries, we describe 15 new species (*H. cherfa*, *H. makhloufa*, *H. seybousa*, *H. algirica*, *H. dbabcha, H. farrahae*, *H. guitna*, *H. chenioura, H. edougha*, *H. louara*, *H. vinconi*, *H. linae*, *H. nardjissae*, *Agapetus ferrerasi*, *A. yasminae*) from Algeria and reclassify three subspecies or varieties as distinct species (*Wormaldia numidica*, *Thremma africanum*, *Mesophylax hoggarensis*). In addition, our surveys led to the discovery of three previously unrecorded caddisfly species (*Lype reducta*, *Lepidostoma kumanskii*, and *Adicella syriaca*) in Algeria, as well as the expansion of the known range of seven additional species. These results underscore the importance of the Maghreb's freshwater biodiversity and highlight the need for a more comprehensive understanding of caddisfly taxonomy in the region. By providing a clearer taxonomy and distributional framework for caddisflies, our research establishes a solid foundation for future monitoring and conservation initiatives targeting these important aquatic insects and the ecosystems they inhabit.

Keywords. Aquatic insects; caddisflies; freshwater biodiversity; distribution; Maghreb; taxonomy.

INTRODUCTION

The field of biodiversity conservation faces several challenges characterized by seven deficits or knowledge gaps. The best known of these are the Linnean, Wallacean, and Darwinian shortfalls (Diniz-Filho *et al.* 2013). These deficits relate to an inadequate understanding of taxonomy, distribution, and phylogeny. These knowledge gaps represent a significant obstacle to the effective conservation of biodiversity (Hortal *et al*. 2015). While it is widely recognized that sufficient taxonomic knowledge is critical for effective biodiversity conservation (Mace 2004), other knowledge gaps or deficits related to abundance, abiotic tolerance, species traits, and biotic interactions must also be addressed to enable evolution-based conservation planning and management that mitigates the effects of the current rapid erosion of biodiversity (Novacek & Cleland 2001, Mora & Sale 2011, Hortal *et al*. 2015). However, these approaches, which focus on filling knowledge gaps, are neither the only nor always the best option for biodiversity conservation, and they contrast with other approaches that favor the "save first, study later" line of action (Janzen 1986, Hoekstra 2005).The biodiversity crisis, triggered by global changes resulting from human activi-

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ties, has serious consequences, such as habitat loss and degradation, leading to rapid decline in species populations across all taxonomic groups (Janzen 2004, Laurance *et al*. 2012). Among the most threatened ecosystems are freshwater habitats, which are particularly affected by anthropogenic stressors such as land conversion, pollution, invasive species, and climate change (Dudgeon *et al*. 2006, Heino *et al*. 2009, Vörösmarty *et al*. 2010, Reid *et al*. 2019). This has led to documented declines in aquatic insects (Sánchez-Bayo *et al*. 2019), which account for about 80% of aquatic animal biodiversity (Dijkstra *et al*. 2014). There is therefore an urgent need to monitor riverine ecosystems to take effective action.

The Mediterranean region is recognized worldwide as a biodiversity hotspot and center of endemism, with remarkable biodiversity (Myers *et al*. 2000, Mittermeier *et al*. 2004). It is also one of the regions with the highest number of newly discovered freshwater insects (Morse 2016, Sánchez-Campaña *et al*. 2023), indicating that well-studied and developed areas of the world play a crucial role as reservoirs of previously unknown species (Fontaine *et al*. 2012). Similarly, Algeria, located on the southern shore of the Mediterranean Sea, has a rich freshwater biodiversity that includes a variety of micro-endemic aquatic insects, several of which have been recently documented (Yasri-Cheboubi *et al*. 2013, Samraoui *et al*. 2021b, 2021c).

Caddisflies (Trichoptera) play a critical role in stream and river communities and serve as important bioindicators of water quality and ecological integrity of river ecosystems (Wiggins 2004). Their occurrence and responses to environmental changes provide valuable insights into the overall condition of freshwater habitats (Houghton 2004). Therefore, a comprehensive understanding of caddisfly taxonomy and distribution is essential for implementing successful monitoring and conservation strategies.

Unfortunately, knowledge of caddisflies in Algeria has until recently been relatively neglected compared to neighboring Maghrebian countries such as Morocco (Dakki 1978, 1982, El Alami & Dakki 1998, Hajii *et al*. 2013, Mabrouki *et al*. 2020) and Tunisia (Malicky & Lounaci 1987, Allaya 2003, Allaya *et al*. 2003).

The first studies on caddisfly biogeography began in the late 19th century with pioneering studies by McLachlan (1880) and Morton (1896, 1898). A detailed account of subsequent research which extended into the following century was provided by Dambri *et al.* (2020) and Samraoui *et al*. (2020). In the last two decades, however, there has been a marked increase in publications on Algerian caddisflies. These recent publications (Arab *et al*. 2004, Sekhi *et al*. 2016, 2019, Bemmoussat-Dekkak *et al*. 2021a, 2021b, 2021c, Khettar *et al*. 2022) have been instrumental in expanding our understanding of the caddisfly fauna in Algeria and addressing the previous lack of comprehensive research in this area.

Given the limited knowledge of Algerian caddisflies, this study fills a gap in the literature by providing results of a survey conducted in northeastern Algeria. The main focus of this study was on two aspects: (1) The collection, identification, and distribution of adult caddisflies, as these life stages provide important taxonomic and ecological information and (2) development of a deeper comprehension of the evolutionary patterns within *Hydropsyche* Pictet, 1834 (Hydropsychidae) by investigating potential trends in the evolution of phallic traits.

MATERIALS AND METHODS

Study area. Three regions (El Kala, Wadi Seybouse, and Mount Edough) were selected for caddisfly sampling which was carried out across various catchments of three geographically different regions situated in northeastern Algeria (Figs 1, 2; Table 1). Two additional specimens were collected outside of the three specified sampling regions, one collected at Tizagban, Collo (Boucenna *et al.* 2023) (37°0’39.41”N, 6°22’ 29.57”E) and the other at Tenerife in the Canary Islands (28°22’1.71” N, 16°42’49.52”W). The climate of the study area is typically Mediter

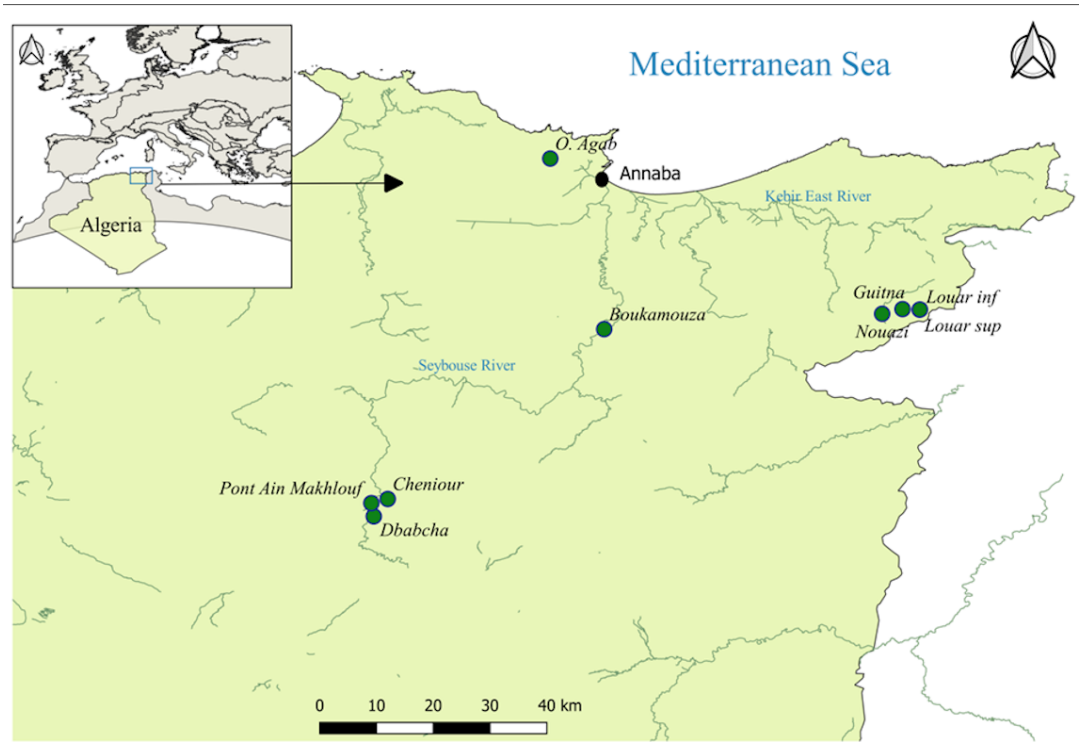

Figure 1. Map of Algeria (inset) and the study area, including the sampling sites where adult caddisflies were collected.

Figure 2. Views of sampling sites in northeastern Algeria. 2a, Nouazi, El Kala. 2b, O. Agab, Mount Edough. 2c, Dbabcha, Seybouse River, 2d, Tizagban, Collo.

Table 1. Sampling sites for adult caddisflies in the El Kala, Seybouse, Collo and Mount Edough regions, northeastern Algeria.

Region	Name	Latitude (N)	Longitude (E)	Altitude (m)	Stream type	Substrate
El Kala						
	Louar sup	36°37'01"	8°22'47"	593	Intermittent	Coarse
	Louar inf	36°37'02"	8°22'49"	588	Intermittent	Coarse
	Guitna inf	36°37'05"	8°20'47"	476	Intermittent	Coarse
	Nouazi	36°36'32"	8°18'24"	296	Intermittent	Mixture
O. Seybouse						
	Dbabcha	36°12'50"	7°18'58"	610	Intermittent	Mixture
	Cheniour	36°14'52"	7°20'36"	602	Permanent	Coarse
	Aïn Makhlouf Bridge	36°14'23"	7°18'41"	590	Intermittent	Coarse
	Boukhamouza	36°34'44"	7°45'54"	53	Permanent	Mixture
Mount Edough						
	O. Agab	36° 54.708'	7°39.605'	750	Intermittent	Coarse

ranean, characterized by a hot, dry period between May and October, and a mild, rainy season from November to April. However, the El Kala region and Mount Edough are characterized by a climate ranging from humid to subhumid. Conversely, the climate along the Wadi Seybouse exhibits a gradient, varying from a subhumid climate near Annaba, where it meets the Mediterranean Sea, to semi-arid climate in its upstream reaches. The Maghreb (sensu stricto) consists of Tunisia, Algeria, and Morocco. The Great Maghreb or Grand Maghreb is a cultural and political entity made up of Libya, Tunisia, Algeria, Morocco, and Mauritania. The word Oued/wadi (intermittent stream/ river) is abbreviated as " O.".

The El Kala region in the Wilaya of El Tarf is located close to the Algerian-Tunisian border. This region includes a variety of ecologically important wetlands that serve as habitat for numerous breeding and migratory waterfowls. In addition, the area is recognized as an Afrotropical relict pocket for freshwater organisms and is home to several endangered species (Samraoui *et al*. 1993). The hills and mountains in the El Kala region are drained by the Oued El Kebir East, whose tributaries are refuges for several Algerian or Maghrebian endemic aquatic insects (Yasri-Cheboubi *et al*. 2016, Samraoui *et al*. 2021b, 2021c).

The Seybouse River, the most important waterway in the region, is fed by two main tributaries: Wadi Cherf and Wadi Bouhamdane. These tributaries originate in the eastern Hauts Plateaux at an elevation of about 900 meters, flow northward, and eventually join to form the Seybouse River. From there, the river continues its course toward the Mediterranean Sea, flowing through Annaba and encompassing the largest catchment area in northeastern Algeria. The upper reaches of the Seybouse River are characterized by scattered settlements and agricultural and pastoral activeties, while the lower reaches are mainly characterized by intensive agriculture, industrial facileties, and urban settlements. The Seybouse River provides invaluable ecosystem services throughout its course and serves as a refuge for three threatened odonate species on the IUCN Red List for North Africa (Samraoui *et al*. 2010): *Calopteryx exul* Selys, 1853 (EN), *Coenagrion mercuriale* (Charpentier, 1840) (EN), and *Gomphus lucasii* Selys, 1849 (VU) (Bouhala *et al*. 2019).

Mount Edough lies above the city of Annaba in north-east Algeria and is one of the wettest regions in North Africa with an annual rainfall of often more than 1200 mm. The mountain is adorned with lush forests consisting mainly of *Quercus suber* and *Quercus faginea*. A dense understory of *Pteridium aquilinum*, *Erica arborea* and *Rubus ulmifolius* thrives under the canopy (Samraoui & Alfarhan 2015).

Sampling. Monthly sampling was conducted over a period of at least one year at 51 different sites, from January 2020 to June 2023. This comprehensive census included three distinct regions: A collection of 20 sites distributed across the O. El Kebir-East and Oum Teboul watersheds (Sam-

raoui *et al*. 2021a, 2021b), and an additional cluster of 30 sites along the Seybouse River and its main tributary, O. Cherf (Samraoui *et al*. 2021a). In addition, one site (O. Agab) on Mount Edough was also sampled (Samraoui & Alfarhan 2015).

At each of these sites, a 15-minute diurnal sampling of adults was conducted. Flying adults were captured with a butterfly net, while resting adults were captured by sweeping the net through vegetation or, if they were moving on rocks, with tweezers. Following collection, all specimens were preserved in ethanol and carefully sorted under a stereomicroscope. The abdominal segments of the male genitalia were carefully separated and then subjected to a clearing process. They were heated in a 10% KOH solution at 70°C for 30 minutes and thoroughly cleaned with superfine-tipped forceps for examination. The morphological terminology used for adult genitalia follows Oláh and Johanson (2008). The illustrations were made using a Wild drawing tube with a Wild Type 308700 stereomicroscope from Heerbrugg, Switzerland. For higher magnifycation, we also used a Carl Zeiss drawing tube in conjunction with a Carl Zeiss compound microscope. Maps of sampling sites where adult caddisflies were collected were drawn using QGIS 3.8.

*Depositories.*Voucher specimens, including type specimens, are deposited in the following institutions:

- British Museum (Natural History), London (BMNH)
- Oláh Private Collection, Debrecen, Hungary, under national protection by the Hungarian Natural History Museum, Budapest (OPC).
- Musée Cantonal de Zoologie de Lausanne, Switzerland (MCZL).
- Private Collection of Hans Malicky, Lunz am See, Austria (CHM)).

*Taxonomy***.** In our revision of the possibly new taxa within the genera *Wormaldia*, *Hydropsyche*, *Agapetus*, *Thremma*, and *Mesophylax* in Algeria, we applied the principles and procedures of our refined phenomics approach, defined as fine-structure analysis of reproductive traits, particularly stable and consistent morphological divergences at the paramere and aedeagus of the phallic organ. Therefore, we focused primarily on non-neutral adaptive speciation traits. In particular, we examined the structures of the paraproct and phallic organ that play critical roles in mating. These structures likely led to reproductive isolation through prezygotic processes, including cryptic female choice (Oláh *et al.* 2014, 2015, 2017).

RESULTS

A total of 103 adult caddisflies were examined, comprising 28 species from Algeria and one species from the Canary Islands (Table 2). The distribution of *Hydropsyche* spp. and *Agapetus* spp. in the study area is shown in Fig. 3.

TAXONOMY

Philopotamidae Stephens, 1829

Wormaldia numidica Vaillant, 1974 stat. nov.

Wormaldia variegata numidica Vaillant, 1974:981. "La saillie dorsale du segment abdominal X est bien plus rapprochée de son extrémité que chez *W. variegata vercorsica* et la position est la même que chez *W. variegata variegata*. Phallus: 4 épines à peu près de même taille, mais celle que j'ai nommée B est parfois dédoublée, les deux éléments restant alors l'un contre l'autre." Six spécimens ont été examinés. Ils proviennent d'un gîte madicole dans les gorges du Chabet el Akra, entre Bougie et Kherrata, Algérie, 220 m."

Type material: Syntype: ALGERIA, Chabet el Akra, between Béjaïa et Kherrata, 14.ii.1950, leg François Vaillant (1 male, MCZL, GBIFCH 00331276).

Material examined. ALGERIA: Mount Edough, Oued Agab, 5.vi.2021, leg Boudjéma Samraoui (2 males, OPC). Collo, Tizagban, 24.xii.2022, leg Boudjéma Samraoui (2 males, OPC).

Remarks. The original detailed drawings that were published perfectly indicate the divergences

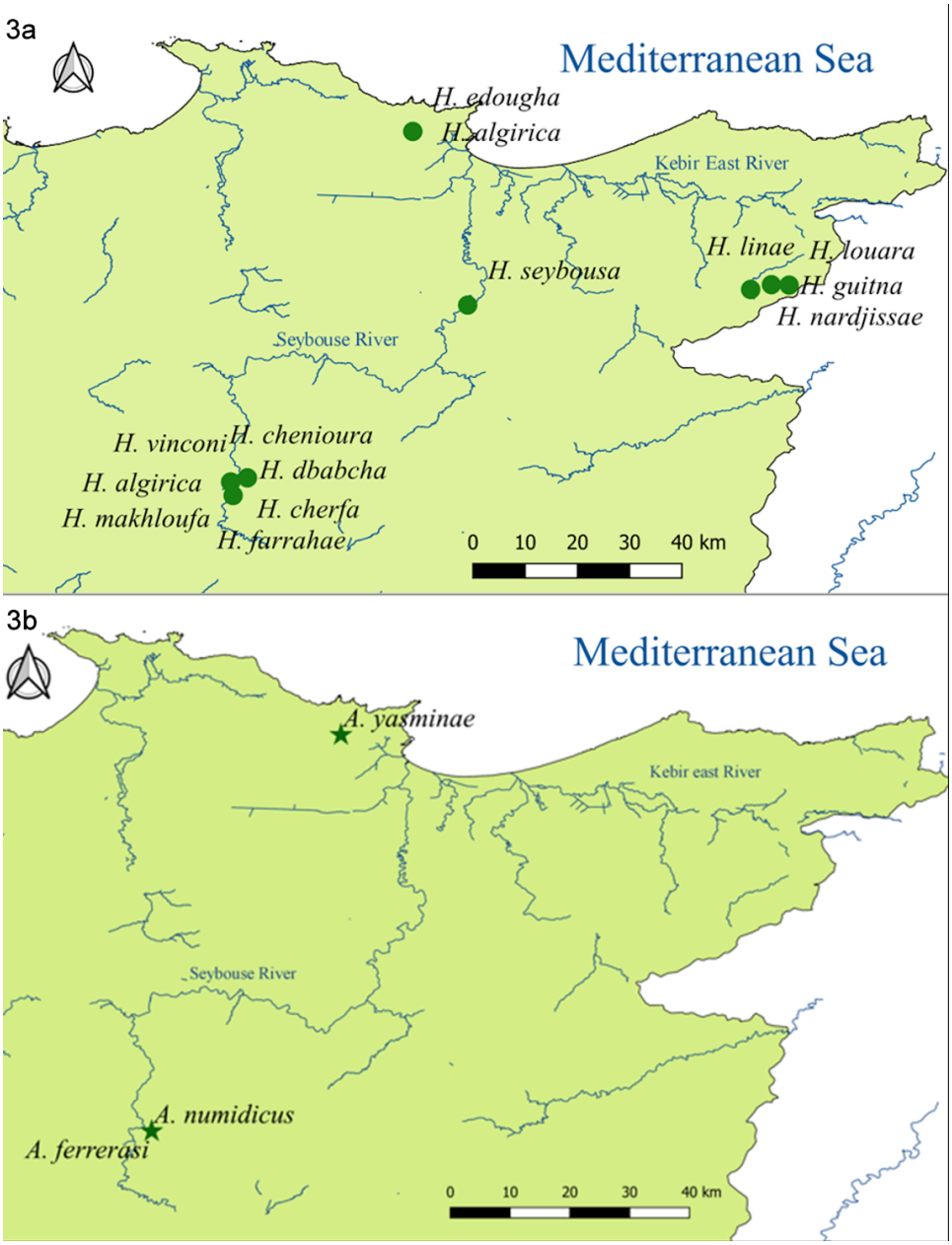

Figure 3. Distributions of *Hydropsyche* spp. and *Agapetus* spp. in this study. 3a, *Hydropsyche* spp. 3b, *Agapetus* spp.

between *Wormaldia variegata* Mosely, 1930 and *Wormaldia numidica* Vaillant, 1974 (Vaillant 1974). The fine structure of the head of segment X exhibits a different shape. The upward and anterior turn of the head is less pronounced, more pointed, and longer. The cerci are characterized by a low apical region. The four spines of the endotheca are less curved and are accompanied by an integrated smaller spine. Based on the genital divergences, as well as the theories of the phylogenetic species concept that exclude subspecies and race from scientific classification (Burbrink 2022), we elevate the subspecies status of *Wormaldia variegata numidica* Vaillant, 1974 to the species rank as *Wormaldia numidica* Vaillant, 1974.

Psychomyiidae Walker, 1852

***Lype reducta* (Hagen, 1868)**

Material examined. ALGERIA: Mount Edough, O. Agab, 26.iv.2021, leg. Boudjéma Samraoui (1 male, OPC). Mount Edough, O. Agab, 5.vi.2021, leg Boudjéma Samraoui (1 male, OPC).

Remark. This is a new addition to the caddisfly fauna of Algeria.

Hydropsychidae Curtis, 1835

***Cheumatopsyche lepida* (Pictet, 1834)**

Material examined. ALGERIA: Nouazi, 16.vi. 2021, leg. Boudjéma Samraoui (1 male, OPC).

Remark. The status of the closely related *C. atlantis* deserves further investigation (Arab *et al.* 2004).

***Hydropsyche* Pictet, 1834**

Hydropsyche, one of the largest caddisfly genera, has an almost worldwide distribution, and thrives in various types of streams. This genus contributes significantly to nature's ecosystem services as its huge populations produce immense biomass in the world's largest rivers (Morse *et al.* 2019). To gain a deeper understanding of evolutionary patterns within this genus, we conducted a comprehensive analysis of phallic organization, tracing the possible trends from a simple membranous structure to more intricate forms of sclerotized phallothecal terminalia. Research successfully identified nine species groups, nine species clades, and ten species clusters within this important genus (Oláh & Johanson 2008). Since these assemblages were identified solely on the basis of diagnostic characters without the use of phylogenetic analysis, we will henceforth replace 'lineage' with 'subgroup' and 'clade' with 'unit'.

In the Maghreb faunal region, which includes Algeria, all known *Hydropsyche* species belong to the *Hydropsyche angustipennis* Species Group. These species exhibit immovable, sclerotized endothecal processes that are completely fused to the apical region of the phallotheca. In the various ranges of the Atlas Mountains spanning Morocco, Algeria, and Tunisia, the highly specialized species group of *Hydropsyche angustipennis* is represented by three distinct subgroups: The *Hydropsyche guttata* Subgroup, the *Hydropsyche instabilis* Subgroup, and the *Hydropsyche pellucidula* Subgroup.

This study is the first comprehensive taxonomic study of adult *Hydropsyche* in Algeria. Previous taxonomic studies focused mainly on larvae (Bemmoussat-Dekkak *et al*. 2021a, 2021c).

Our results show a remarkably high diversity of filter-feeding caddisflies in the largest country in Africa. Each of the sites studied has a unique species composition, with multiple species often observed in the adult stage, suggesting that they may colonize different microhabitats within streams.

***Hydropsyche angustipennis* Species Group**

The *Hydropsyche* genus comprises various groups with immovable, highly sclerotized, and fused endothecal processes (Oláh & Johanson 2008). Most species groups within the *Hydropsyche* genus exhibit well-developed, membranous, or sclerotized endothecal processes, which are often diverse in shape, number, and complexity. However, in the *H. angulata*, *H. asiatica*, and *H. burgersi* Species Groups, these endothecal processes are reduced to a pair of small, scleratized lobes that are still somewhat movable. In the *H. angustipennis* Species Group, which is distributed in the Palearctic and Nearctic faunal regions, the endothecal processes take the form of reduced lobe-like structures. These structures are firmly and completely fused to the phallothecal head, creating a tube-like formation without any visible sutures. The *Hydropsyche angustipennis* Species Group comprises three distinct Subgroups: *Hydropsyche guttata*, *Hydropsyche pellucidula*, and *Hydropsyche instabilis*.

Hydropsyche guttata Species Subgroup

Species in this Subgroup are characterized by the fused sclerotized endothecal processes, absence of an angular, subapical lateral projection before the cleaved apex of the phallotheca of the *Hydropsyche pellucidula* Subgroup, and absence of digitiform apicoventral setose lobes otherwise found in the *Hydropsyche instabilis* Subgroup. Based upon the basal curvature of the phallic organ in lateral view, we have identified two units within the *H. guttata* Species Subgroup, each containing several species complexes (Oláh *et al*. 2020). The *Hydropsyche angustipennis* Unit displays a deep curvature, while the *Hydropsyche modesta* Unit exhibits a shallow curvature.

Hydropsyche angustipennis Species Unit

This unit has a deep or high basal curvature in the lateral view of the phallic organ. The phallic organ is tubular, with a phallotheca headed by sclerotized and fully fused endothecal processes. The basal curvature of the phallotheca tube is downward and deeply curved rather than shallowly curved or arched.

Hydropsyche cherfa Oláh & B. Samraoui, sp. nov.

(Figures 4a–4e)

Material examined. Holotype: ALGERIA: Pont Ain Makhlouf, O. Cherf, main tributary of the Seybouse River, 4.vii.2021, leg Boudjéma Samraoui (male, OPC).

Diagnosis. This new species belongs to the *Hydropsyche guttata* subgroup. It is characterized by fused, sclerotized endothecal processes, absence of a digitiform, apicoventral, setose lobe, and absence of angular, subapical lateral projecttions anterior to the cleft apex of the phallotheca. It also has a strong basal curvature of the phallic organ, which makes it a member of the *Hydropsyche angustipennis* Species Unit (Oláh *et al*. 2020). This species is small and light brown and has similarities with *Hydropsyche seybousa* sp. nov. However, it differs in having a narrow dorsal keel of the segment IX (as opposed to a broad keel), a shallow intersegmental profile (as opposed to a deep profile), less pronounced ventroapical setose lobes, clavate harpagones (as opposed to parallel sided harpagones), and a distinct lateral and ventral profile of the phallic organ.

Description. Male (in ethanol). Small sized species; length of each forewing 7 mm (n = 1). Body light brown; dorsal thoracic sclerites darker. Forewing brown, marbled with lighter spotted pattern.

Male genitalia. Segment IX fused-annular and short, particularly on its ventrum; its dorsomedian keel narrow, longer than following dorsum of segment X; apical lobe on posterolateral margin short and rounded-triangular. Intersegmental profile between segments IX and X shallow, triangular. Segment X short with less-produced, triangular, setaless winglets in lateral view and triangular lobes in dorsal view; lateral setose area (cerci) circular and located in midlength position; ventroapical setose lobes less produced. Coxopodite of each gonopod not quite reaching apex of segment X; harpago clavate in caudal view. Phallic organ with parallel-sided tube arching high in lateral view; subapicolateral dilatation on phallic head weakly produced, long, and without any preceding dilatation in ventral view.

Etymology. Coined from the name of the type locality, as a noun in apposition.

Hydropsyche makhloufa Oláh & B. Samraoui, sp. nov.

(Figures 4f–4j)

Material examined. Holotype: ALGERIA: Pont Ain Makhlouf, O. Cherf, main tributary of the Seybouse River, 31. iii. 2023, leg Boudjéma Samraoui (male, OPC). Paratype: ALGERIA: Pont Ain Makhlouf, O. Cherf, main tributary of the Seybouse River, 22. iii. 2023, leg Boudjéma Samraoui (1 male, OPC).

Diagnosis. This new species belongs to the *Hydropsyche guttata* Subgroup. It is characterized by fused, sclerotized endothecal processes, ab

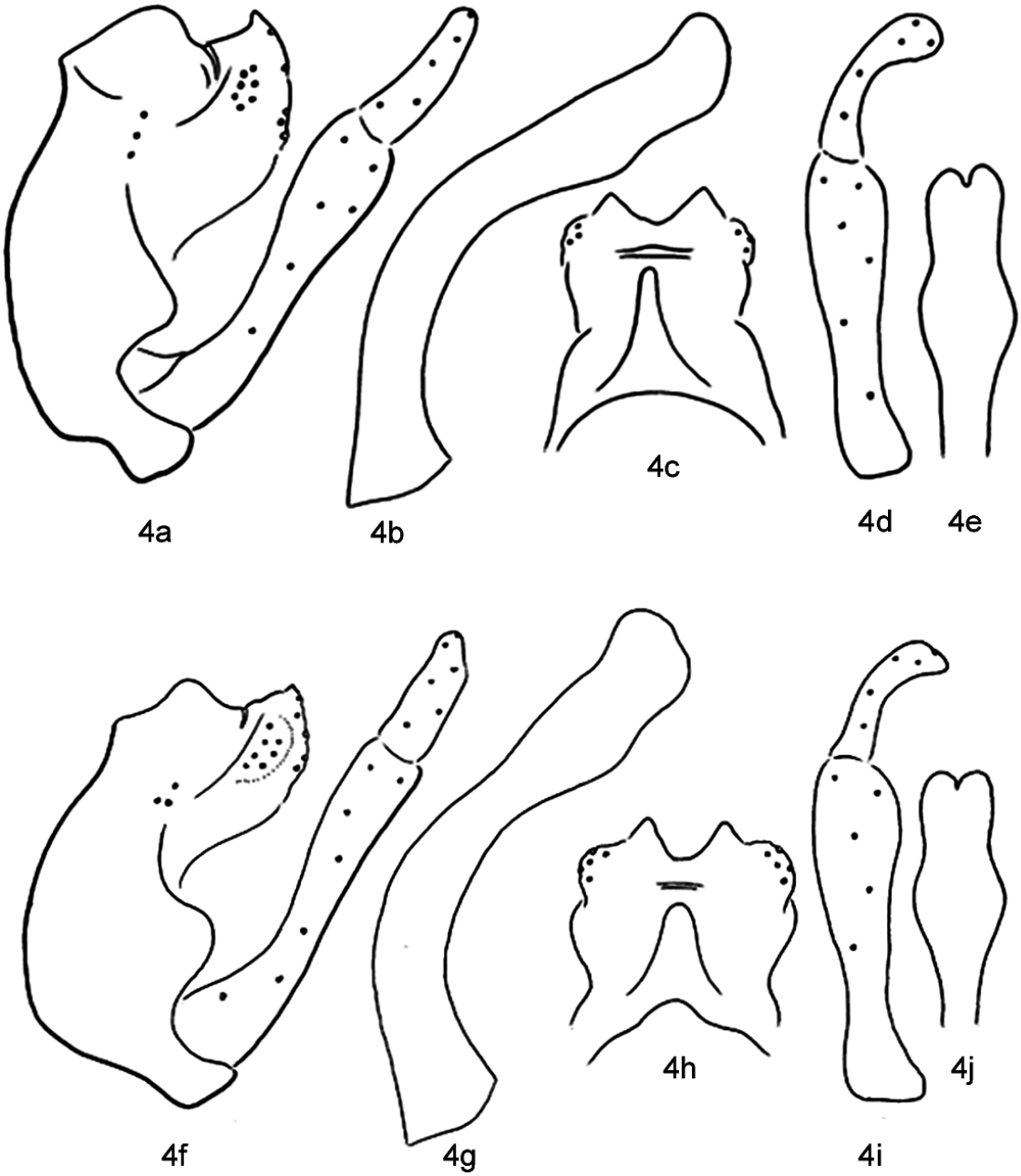

Figure 4. Genitalia of *Hydropsyche* spp. 4a–4e, *Hydropsyche cherfa* Oláh & B. Samraoui sp. nov. Holotype: 4a = left lateral; 4b = phallic organ, left lateral; 4c = segments IX and X, dorsal; 4d = left gonopod, ventral; 4e = phallic apex, ventral. 4f–4j, *Hydropsyche makhloufa* Oláh & B. Samraoui sp. nov. Holotype: 4f = left lateral; 4g = phallic organ, left lateral; 4h = segments IX and X, dorsal; 4i = left gonopod, ventral; 4j = phallic apex, ventral.

sence of a digitiform, apicoventral setose lobe, and absence of angular, subapical lateral projections anterior to the cleft apex of the phallotheca. In addition, it has a strong basal curvature of the phallic organ, which makes it a member of the *Hydropsyche angustipennis* Species Unit (Oláh *et al*. 2020). This medium-sized species has a dark, castanea-brown coloration. Although it shares some similarities with *Hydropsyche cherfa* sp. nov., it differs in several aspects. First, it is not

small and is light brown. It also differs from *Hydropsyche cherfa* sp. nov. in having a broad dorsal keel of segment IX instead of a narrow one, a concave lateral profile of the dorsal keel instead of a straight one, a different dorsal pattern on segment X, and a narrowing harpago instead of a clavate one. It also has a different lateral profile of the phallic organ.

Description. Male (in ethanol). Medium sized species. Body dark brown, almost castanean black; dorsal thoracic sclerites even darker. Forewing dark brown; length of each forewing 8 mm.

Male genitalia. In lateral view, segment IX fused annular and longitudinally short, particularly on ventrum; dorsomedian keel broad; apical lobe on each posterolateral margin short and round-triangular; intersegmental profile between segments IX and X triangular. Segment X short with tiny triangular setaless winglets in lateral view and small triangular lobes in dorsal view; lateral setose area (cerci) circular and located in mid-length position; ventroapical setose lobes less produced. Coxopodite of each gonopod extending to apex of segment X; harpago tapering. Phallic organ with parallel-sided tube arching high in lateral view; subapicolateral dilatation on phallic head well produced, short, and without any preceded dilatation in ventral view.

Etymology. Coined from the name of the type locality, as a noun in apposition.

Hydropsyche seybousa **Oláh & B. Samraoui, sp. nov.**

(Figures 5a–5b)

Material examined. Holotype: ALGERIA: Boukamouza, Seybouse River, 26.ii.2020, leg Boudjéma Samraoui (male, OPC).

Diagnosis. This new species belongs to the *Hydropsyche guttata* Subgroup. It is characterized by fused, sclerotized endothecal processes, the absence of a digitiform, apicoventral setose lobe, and the absence of angular, subapical lateral projections anterior to the cleaved apex of the phallotheca. In addition, it has a strong basal curvature of the phallic organ, which places it in the *Hydropsyche angustipennis* Species Unit (Oláh *et al*. 2020). This medium-sized species is brown in color and bears some resemblance to *Hydropsyche cherfa* sp. nov. However, there are notable differences between them. First, this species has a broad dorsal keel in segment IX instead of a narrow one. Second, the intersegmental profile is deep rather than shallow. It also has a more pronounced ventroapicalsetose lobe, a parallel-sided harpago instead of a clavate one, and distinct lateral and ventral profiles of the phallic organ.

Description. Male (in ethanol). Medium sized species. Body brown; dorsal thoracic sclerites darker. Forewing brown, marbled with lighter spotted pattern. Length of forewing 9 mm.

Male genitalia. Segment IX fused annular and short, particularly on ventrum; median keel broad, longer than following dorsum of segment X; apical lobe on posterolateral margin short and rounded. Intersegmental profile between ninth and tenth segments deep triangular. Segment X short with produced triangular setaless winglets in lateral view and triangular lobes in dorsal view; lateral setose area, cerci circular and located in apical position; ventroapical setose lobes produced. Coxopodite of gonopod slightly shorter than apex of segment X; harpago parallel-sided. Phallic organ with parallel-sided tube arching high in lateral view; subapical lateral dilatation on phallic head less produced long and followed by small dilatation in ventral view.

Etymology. Coined from the name of the type locality, as a noun in apposition.

Hydropsyche modesta **Species Unit**

This unit exhibits a shallow or low curvature in the lateral view of the phallic organ. The tube-like phallotheca, characterized by the sclerotized and completely fused endothecal processes, displays a basal curvature. The downward-directed section of the phallothecal tube curves or arches only slightly.

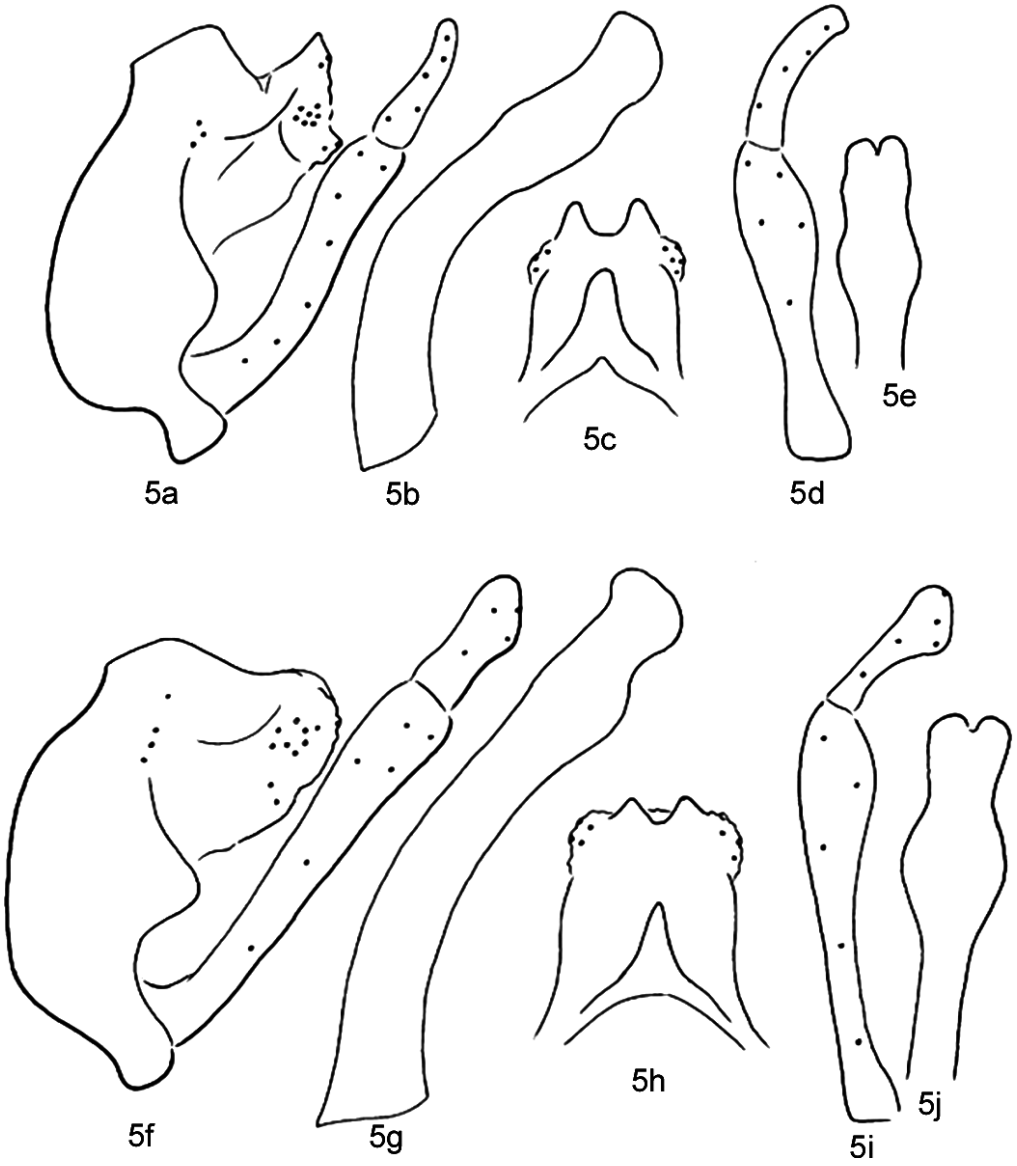

Figure 5. Genitalia of *Hydropsyche* spp. 5a–5e, *Hydropsyche seybousa* Oláh & B. Samraoui, sp. nov. Holotype: 5a = left lateral; 5b = phallic organ, left lateral; 5c = segments IX and X, dorsal; 5d = left gonopod, ventral; 5e = phallic apex, ventral. 5f–5j, *Hydropsyche algirica* Oláh & B. Samraoui, sp. nov. Holotype: 5f = left lateral; 5g = phallic organ, left lateral; 5h = segments IX and X, dorsal; 5i = left gonopod, ventral; 5j = phallic apex, ventral.

Hydropsyche exocellata Species Complex

This species complex, characterized by a shallow or low curvature in the lateral profile of the phallic organ, exhibits a significant and pronounced subapical dilation. This dilatation is observed in certain species within the *Hydropsyche angustipennis* Species Unit, which is associated with a deep or high curvature. The ventral view provides the best visibility of this subapical dilation. This particular character state is so prominent that other character states are often overlooked and not thoroughly examined through fine phenomics. It is possible that many cryptic species are concealed under the name of *Hydropsyche maroccana* and could be distinguished through proper preparation, particularly by examining the genital complex of segment X.

Another important character state is the well-exposed lateral and vertical profile of the phallic organ, which can be observed without requiring additional preparation. The following species belong to this complex: *H. algirica* sp. nov.; *H. dbabcha* sp. nov.; *H. demavenda* Malicky, 1977; *H. exocellata* Dufour, 1841; *H. farrahae* sp. nov., *H. gemecika* Malicky, 1981; *H. guitna* sp. nov.; *H. integrata* Mey, 1981; *H. maderensis* Hagen, 1865; *H. maroccana* Navas, 1935; *H. nador* Ibrahimi, 2023; *H. resmineda* Malicky, 1977; *H. rovnaka* Oláh, 2020; *H. sattleri* Tobias, 1972; *H. tenerifa* sp. nov.

Hydropsyche algirica Oláh & B. Samraoui, sp. nov.

(Figures 5f–5j)

Material examined. Holotype: ALGERIA: Mount Edough, O. Agab, 16.v.2021, leg. Boudjéma Samraoui (male, OPC). Paratypes: Pont Ain Makhlouf, 31.iii.2023, leg Boudjéma Samraoui (1 male, OPC), Pont Ain Makhlouf, 1.ii.2023, leg Boudjéma Samraoui (1 male, OPC).

Diagnosis. This new species belongs to the *Hydropsyche guttata* Subgroup. It is characterized by fused sclerotized endothecal processes, the absence of a digitiform apicoventralsetose lobe, and the absence of angular, subapical lateral projections before the cleaved apex of the phallotheca (Oláh & Johanson 2008). With a low basal curvature of the phallic organ, it is classified as a member of the *Hydropsyche modesta* Species Unit (Oláh *et al*. 2020). This small and light species is part of the *Hydropsyche exocellata* Species Complex, but it differs from other members of the complex through a combination of distinct character states. These include a very dilated, almost triangular head of the harpago in ventral view, a short and narrow triangular dorsal keel of segment IX, a highly developed and elongated subapical dilation of the phallic organ in ventral view, as well as a particularly unique lateral fine structure of the phallic apical region in lateral view.

Description. Male (in ethanol). Small sized species. Body yellowish light brown; dorsal thoracic sclerites slightly darker. Forewing brown, marbled with lighter spotted pattern. Length of forewing 8 mm.

Male genitalia. Segment IX fused annular and short, particularly on ventrum; median keel short, shorter than following dorsum of segment X; long triangular in dorsal view with granulose dorsal surface, less produced keel representing entire dorsum of segment IX shifted posterad; apical lobe on posterolateral margin rounded triangular. Intersegmental profile between ninth and tenth segments just downward directed slope. Segment X short semicircular, with much reduced setaless winglets in lateral view and triangular lobes in dorsal view; lateral setose area, cerci circular and located in apical position; ventroapical setose lobes vestigial. Coxopodite of gonopod slightly longer than apex of segment X; harpago with highly dilated apex. Phallic organ with parallel-sided tube arching low in lateral view; subapical lateral dilatation on phallic head highly produced and long in ventral view.

Etymology. Coined from the name of the type locality, as a noun in apposition.

Hydropsyche dbabcha Oláh & B. Samraoui, sp. nov.

(Figures 6a–6e)

Material examined. Holotype: ALGERIA: Dbabcha, 28.v.2020, leg Boudjéma Samraoui (male, OPC).

Diagnosis. This new species belongs to the *Hydropsyche guttata* Subgroup within the *H. angustipennis* Species Group. With a slight basal curvature of the phallic organ, it is classified as a member of the *Hydropsyche modesta* Secies Unit (Oláh *et al*. 2020). This small brown species is part of the *Hydropsyche exocellata* Species Complex and has some similarities with *Hydropsyche nador* Ibrahimi, Mabrouki & Taybi, 2023 (Mabrouki *et al*. 2023). However, there are sig

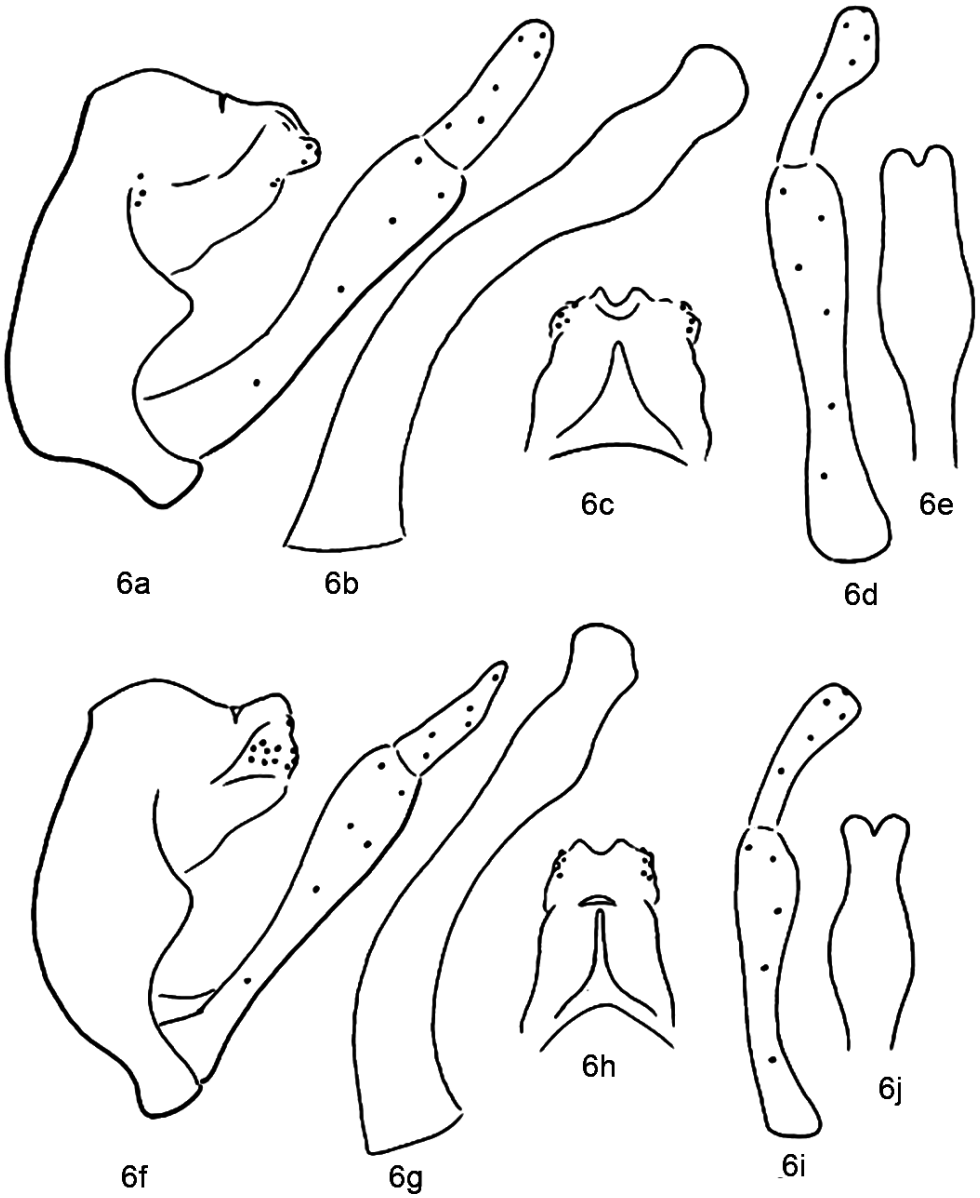

Figure 6. Genitalia of *Hydropsyche* spp. 6a–6e, *Hydropsyche dbabcha* Oláh & B. Samraoui, sp. nov. Holotype: 6a = left lateral; 6b = phallic organ, left lateral; 6c, segments IX and X, dorsal; 6d = left gonopod, ventral; 6e, phallic apex, ventral. 6f–6j, *Hydropsyche farrahae* Oláh & B. Samraoui, sp. nov. Holotype: 6f = left lateral; 6g = phallic organ, left lateral; 6h = segments IX and X, dorsal; 6i = left gonopod, ventral; 6j = phallic apex, ventral.

nificant differences between them. First, this species has a longer dorsal keel in segment IX. Second, it has a triangular apical lobe on the posterolateral margin of segment IX. It also has a more pronounced apicoventral setose lobe fused to the cercus. The harpago is spatulate, and the fine structure of the phallic organ differs in both lateral and ventral profiles. The dilated section is longer, and the apical lobes are rounded and not inclined laterally.

Description. Male (in ethanol). Medium sized species. Body light brown; dorsal thoracic sclerites slightly darker. Forewing brown, marbled with lighter spotted pattern. Length of forewing 8 mm.

Male genitalia. Segment IX fused annular and short, particularly on ventrum; median keel long triangular, longer than following dorsum of segment X; apical lobe on posterolateral margin triangular. Intersegmental profile between ninth and tenth segments just downward directed slope. Segment X short semicircular, with much reduced setaless winglets in lateral view and triangular lobes in dorsal view; lateral setose area, cerci circular and located in apical position; fused with ventroapical setose lobes. Coxopodite of gonopod slightly longer than apex of segment X; harpago with highly dilated apex. Phallic organ with parallel-sided tube arching low in lateral view; subapical lateral dilatation on phallic head highly produced and long, slightly decreasing to apex in ventral view.

Etymology. Coined from the name of the type locality, as a noun in apposition.

Hydropsyche farrahae Oláh & B. Samraoui, sp. nov.

(Figures 6f–6j)

Material examined. Holotype: ALGERIA: Dbabcha, 10.ix.2020, leg Boudjéma Samraoui (male, OPC). Paratypes: Dbabcha, 5.ix.2020, leg Boudjéma Samraoui (1 male, OPC), Dbabcha, 14.vii.2020, leg Boudjéma Samraoui (2 males, OPC), Dbabcha, 28.viii.2020, leg Boudjéma Samraoui (1 male, OPC).

Diagnosis. This new species belongs to the *Hydropsyche guttata* Subgroup within the *H. angustipennis* Species Group. With a slight basal curvature of the phallic organ, it is classified as a member of the *Hydropsyche modesta* Species Unit (Oláh *et al*. 2020). This small, pale species is a member of the *Hydropsyche exocellata* Species Complex, but differs from the other members by a distinct combination of character states. These include a slightly and gradually dilating head of the harpagos in ventral view, a very long and narrow dorsal keel of segment IX, a strongly pronounced and long subapical dilatation of the phallic organ followed by laterally pronounced apical lobes in ventral view, and a particularly shaped lateral fine structure of the phallic apical region in lateral view.

Description. Male (in ethanol). Small sized species. Body yellowish light brown; dorsal thoracic sclerites slightly darker. Forewing brown, marbled with lighter spotted pattern. Length of forewing 6 mm.

Male genitalia. Segment IX fused annular and short, particularly on ventrum; median keel long, much longer than following dorsum of segment X; long and very narrow in dorsal view with granulose dorsal surface; apical lobe on posterolateral margin short, rounded triangular. Intersegmental profile between ninth and tenth segments forming shallow concavity. Segment X short quadrangular, with reduced setaless winglets in lateral view and triangular lobes in dorsal view; lateral setose area, cerci circular and located in middle position; ventroapical setose lobes vestigial. Coxopodite of gonopod slightly longer than apex of segment X; harpago with slightly dilating apex. Phallic organ with parallel-sided tube arching low in lateral view; subapical lateral dilatation on phallic head highly produced and long and followed by dilating apical lobes in ventral view.

Etymology. This new species is dedicated to the first author's wife in honour of her contribution and permanent support to these studies.

Hydropsyche guitna Oláh & B. Samraoui, sp. nov.

(Figures 7a–7e)

Material examined. Holotype: ALGERIA: El Kala region, Guitna inf, 7.v.2021, leg Boudjéma Samraoui (male, OPC).

Diagnosis. This newly discovered species belongs to the *Hydropsyche guttata* Subgroup within the *H. angustipennis* Species Group. Due to its low basal curvature of the phallic organ, it is classified as a member of the *Hydropsyche modesta* Species Unit (Oláh *et al*. 2020). Despite belonging to the *Hydropsyche exocellata* Species Complex, this species is distinguished from the other members by the following combination of

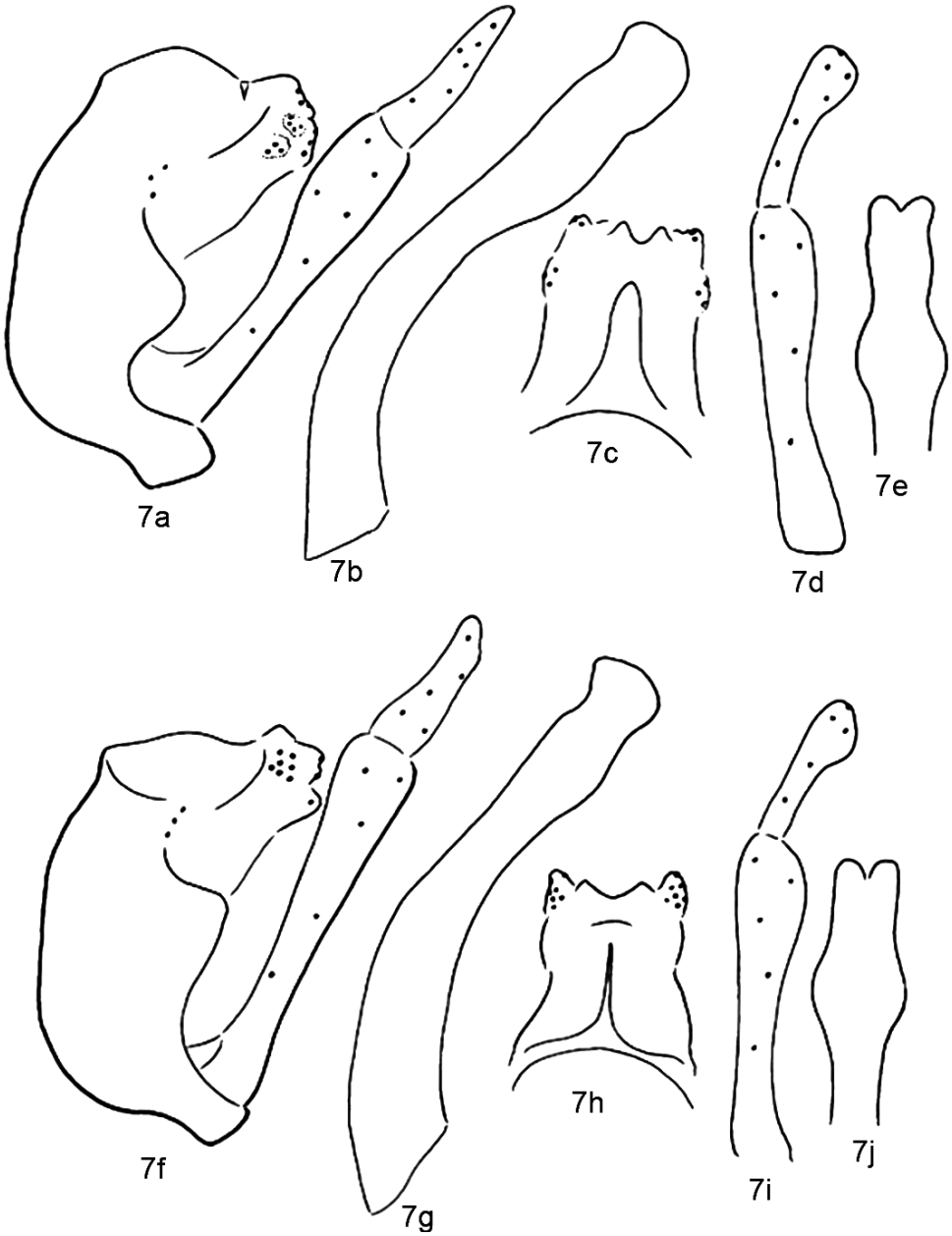

Figure 7. Genitalia of *Hydropsyche* spp. 7a–7e, *Hydropsyche guitna* Oláh & B. Samraoui, sp. nov. Holotype: 7a = left lateral; 7b = phallic organ, left lateral; 7c = segments IX and X, dorsal; 7d = left gonopod, ventral; 7e = phallic apex, ventral. 7f–7j, *Hydropsyche tenerifa* Oláh, sp. nov. Holotype: 7f = genitalia in left lateral view, 7g = phallic organ in left lateral view, 7h = segments IX and X in dorsal view, 7i = left gonopod in ventral view, 7j = phallic apex in ventral view.

character states: a slightly dilating head of the harpago in ventral view, a long and broad dorsal keel of segment IX; a produced and short subapical dilatation of the phallic organ followed by a small recognizable dilatation in front of the apex in ventral view, and a distinct lateral fine structure of the phallic apical region in lateral view.

Description. Male (in ethanol). Small sized species. Body light brown; dorsal thoracic sclerites slightly darker. Forewing brown, marbled

with lighter spotted pattern. Length of forewing 6 mm.

Male genitalia. Segment IX fused annular and short, particularly on ventrum; median keel long, much longer than the following dorsum of segment X; long and broad in dorsal view with granulose dorsal surface; apical lobe on posterolateral margin short, rounded triangular. Intersegmental profile between the ninth and tenth segments forming a rounded triangular shallow concavity. Segment X short quadrangular both in lateral and dorsal views, with reduced setaless winglets in lateral view and triangular lobes in dorsal view; lateral setose area, cerci subdivided and located in middle position; ventroapical setose lobes vestigial. Coxopodite of gonopod slightly longer than apex of segment X; harpago with slightly dilating apex. Phallic organ with parallel-sided tube arching low in lateral view; subapical lateral dilatation on phallic head highly produced, short and followed by small dilatation in ventral view.

Etymology. Coined from the name of the type locality, as a noun in apposition.

***Hydropsyche tenerifa* Oláh, sp. nov.**

(Figures 7f–7j)

Material examined. Holotype: CANARY ISLANDS: Tenerife, Icod de Los Vinos, 150 m, leg. K. M. Guichard & P. H. Ward, 12.vii.1966, (male, OPC). Paratypes: same as holotype (2 males, OPC). Tenerife, El Pinalete, 200 m, leg. K. M. Guichard & P. H. Ward, 13.vii.1966, (3 males, BMNH).

Diagnosis. This new species belongs to the *Hydropsyche guttata* Subgroup within the *H. angustipennis* Species Group.. Due to its low basal curvature of the phallic organ, it is classified as a member of the *Hydropsyche modesta* Species Unit (Oláh *et al*. 2020). This small and light species is part of the *Hydropsyche exocellata* Species Complex but differs from others within the complex through a combination of distinct character states. These include a dilated, rounded triangular head of the harpago in ventral view, a long and very narrow dorsal keel of segment IX that resembles a knife-like shape, a highly developed and elongated subapical dilation of the phallic organ in ventral view, as well as a particularly unique lateral fine structure of the phallic apical region in lateral view.

Description. Male (in ethanol). Small sized species. Body light brown; dorsal thoracic sclerites slightly darker. Forewing brown, marbled with lighter spotted pattern. Length of forewing 8 mm.

Male genitalia. Segment IX fused annular and short, particularly on ventrum; median keel long, longer than following dorsum of segment X; long narrow in dorsal view with granulose dorsal surface, narrow, knife-like produced keel representing entire dorsum of segment IX shifted posterad; apical lobe on posterolateral margin rounded triangular. Intersegmental profile between ninth and tenth segments forming a small triangular concavity. Segment X short trilobed in lateral view, with much reduced pair of setaless winglets triangular both in lateral and dorsal views; lateral setose area, cerci circular and located in apical position; ventroapical setose lobes small. Coxopodite of gonopod slightly longer than apex of segment X; harpago with highly dilated apex. Phallic organ with parallel-sided tube arching low in lateral view; subapical lateral dilatation on phallic head highly produced and long in ventral view.

Etymology. Coined from the name of the type locality, as a noun in apposition.

***Hydropsyche instabilis* Species Subgroup**

The species of this Subgroup show a complete fusion of the sclerotized endotheca with the apex of the phallotheca. The apical region of the phallic organ may or may not have an angular subapical lateral projection preceding the cleft apex of the phallotheca, while it consistently has digitized apicoventral setose lobes of varying development.

***Hydropsyche chenioura* Oláh & B. Samraoui, sp. nov.**

(Figures 8a–8e)

Material examined. Holotype: ALGERIA: Cheniour, 1.vii.2021, leg Boudjéma Samraoui (male, OPC). Paratypes: Cheniour, 10.v.2021, leg Boudjéma Samraoui (1 male, OPC), Cheniour, 8.ii.2021, leg Boudjéma Samraoui (2 males, OPC).

Diagnosis. This newly discovered species belongs to the *Hydropsyche instabilis* Subgroup within the *H. angustipennis* Species Group. It is characterized by fused, sclerotized endothecal processes that have a digitiform, apicoventral, setose lobe, and the presence or absence of angular, subapical, lateral projections anterior to the split apex of the phallotheca (Oláh & Johanson 2008). However, the angular subapical projection is absent in this species. It resembles *Hydropsyche morla* Malicky & Lounaci, 1987, but differs in the longer dorsal keel of segment IX, the presence of longer, setaless winglets on segment X, the ventral position of the digitiforms (instead of dorsal), and the divergent fine structure of the phallic organ, both in lateral and dorsal view.

Description. Male (in ethanol). Medium sized species. Body brown; dorsal thoracic sclerites darker. Forewing brown, marbled with lighter spotted pattern. Length of forewing 9 mm.

Male genitalia. Segment IX fused annular and short, particularly on ventrum; median keel long and broad in dorsal view with granulose dorsal surface, well produced keel representing entire dorsum of segment IX shifted posterad; apical lobe on posterolateral margin well produced, rounded triangular. Intersegmental profile between ninth and tenth segments short and shallow concavity. Segment X as long as keel, with produced elongated setaless winglets in lateral view and elongated trough in dorsal view; lateral setose area, cerci circular and located in middle position; ventroapical setose lobes forming short digitiform process with apical setae accompanied by small ventroapical setose rounded lobe in lateral view. Coxopodite of gonopod as long as apex of segment X, harpago parallel-sided with slight apical dilatation and mesad curving in ventral view. Phallic organ almost parallel-sided tube, basal bending very low in lateral view; subapical lateral projection on phallic head lacking, apical region slightly constricted.

Etymology. Coined from the name of the type locality, as a noun in apposition.

***Hydropsyche edougha* Oláh & B. Samraoui, sp. nov.**

(Figures 8f–8j)

Material examined. Holotype: ALGERIA: Mount Edough, O. Agab, 1.vii.2021, leg Boudjéma Samraoui (male, OPC). Paratypes: Mount Edough, O. Agab, 20.vi.2021, leg Boudjéma Samraoui (1 male, OPC), Mount Edough, O. Agab, 11.vii.2021, leg Boudjéma Samraoui (1 male, OPC), Mount Edough, O. Agab, 5.vi.2021, leg Boudjéma Samraoui (1 male, OPC).

Diagnosis. This new species belongs to the *Hydropsyche instabilis* Subgroup in the *H. angustipennis* Species Group. The angular subapical projection being almost lacking or vestigial. In terms of the shape of the long dorsal keel of segment IX, it closely resembles *H. obscura* Navas, 1928. However, it differs from *H. obscura* in having a shorter segment IX and a lower apical lobe of segment IX, which are more similar to *H. morla* Malicky & Lounaci, 1987. Furthermore, both the lateral and ventral shape of the phallic organ distinguishes it from both species.

Description. Male (in ethanol). Small sized species. Body dark brown; dorsal thoracic sclerites darker. Forewing brown, marbled with lighter spotted pattern. Length of forewing 8 mm.

Male genitalia. Segment IX fused annular and short, particularly on ventrum; median keel long, slightly dilated on midway in dorsal view with granulose dorsal surface, well produced keel representing entire dorsum of segment IX shifted posterad; apical lobe on posterolateral margin

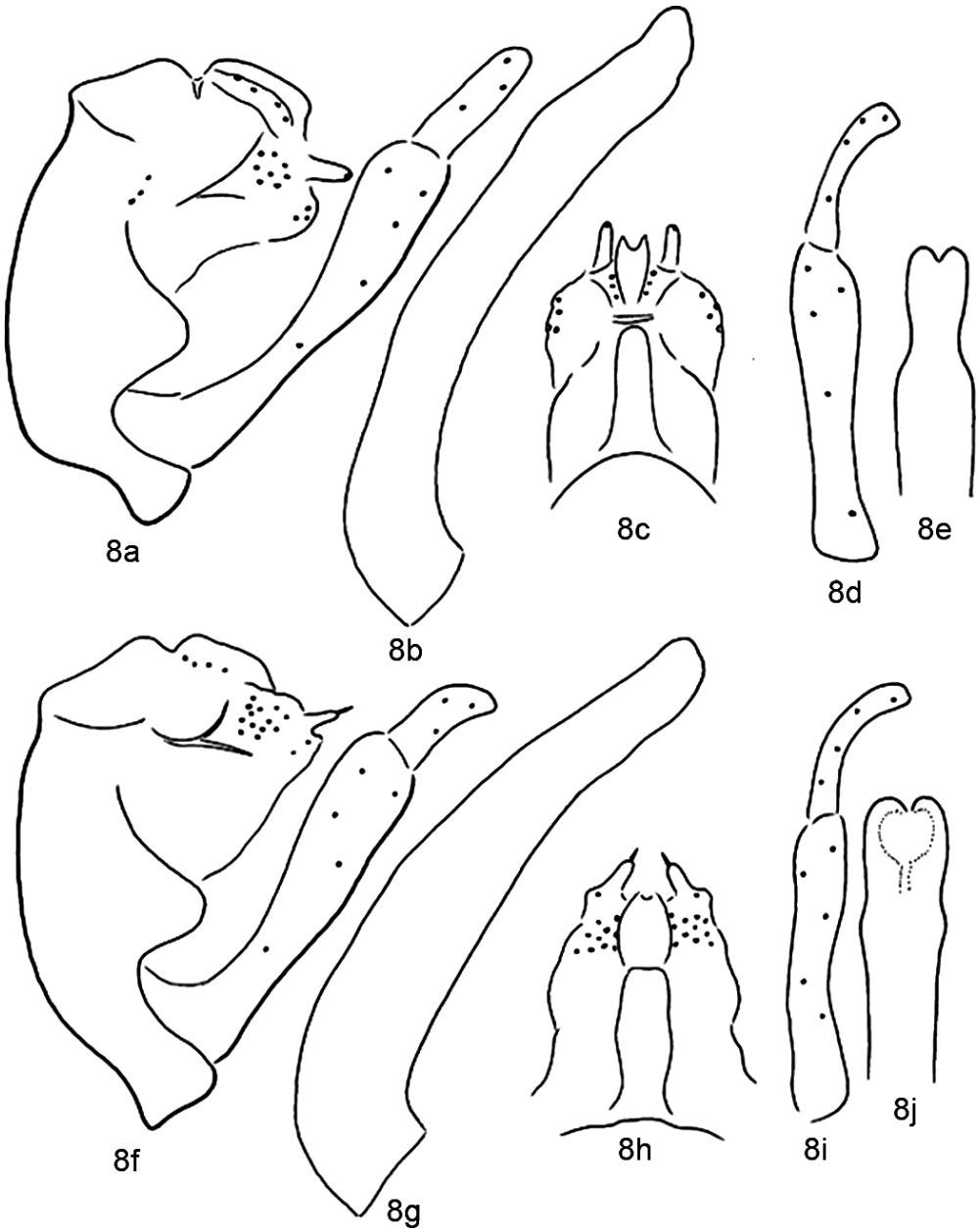

Figure 8. Genitalia of *Hydropsyche* spp. 8a–8e, *Hydropsyche chenioura* Oláh & B. Samraoui, sp. nov. Holotype: 8a = genitalia in left lateral view, 8b = phallic organ in left lateral view, 8c = segments IX and X in dorsal view, 8d = left gonopod in ventral view, 8e = phallic apex in ventral view, 8f–8j, *Hydropsyche edougha* Oláh & B. Samraoui, sp. nov. Holotype: 8f = genitalia in left lateral view, 8g = phallic organ in left lateral view, 8h = segments IX and X in dorsal view, 8i = left gonopod in ventral view, 8j = phallic apex in ventral view.

rounded triangular. Intersegmental profile between ninth and tenth segments small triangular. Segment X short triangular, with produced elongated setaless winglets in lateral view and elongated trough in dorsal view; lateral setose area, cerci circular and located in apical position; ventroapical setose lobes forming short digitiform process with apical setae accompanied by small ventroapical setose lobe in lateral view. Coxopodite of gonopod as long as apex of segment X, harpago parallel-sided and mesad curving in ventral view. Phallic organ with robust basal two

thirds and slightly narrower on apical third, basal bending very low in lateral view; subapical lateral projection on phallic head vestigial, almost lacking.

Etymology. Coined from the name of the type locality, as a noun in apposition.

Hydropsyche louara Oláh & B. Samraoui, sp. nov.

(Figures 9a–9e)

Material examined. Holotype: ALGERIA: El Kala region, Louar inf., 22.v.2021, leg Boudjéma Samraoui (male, OPC).

Diagnosis. This newly discovered species belongs to the *Hydropsyche instabilis* Subgroup within the *H. angustipennis* Species Group. The angular subapical projection is present in this species. Although it bears a resemblance to *Hydropsyche edougha* sp. nov., it can be distinguished by several features. First, the dorsoapical setose lobe is displaced anteriorly. Second, it has upwardly directed, triangular, setaless winglets on segment X. Third, the digitiform processes are located ventrally rather than dorsally. In addition, the fine structure of the phallic organ differs in both lateral and dorsal views. It looks more slender and has a distinct apical area in both lateral and ventral views.

Description. Male (in ethanol). Large sized species. Body brown; dorsal thoracic sclerites darker. Forewing brown, marbled with lighter spotted pattern. Length of forewing 11 mm. *Male genitalia*. Segment IX fused annular and short, particularly on ventrum; median keel long and broad in dorsal view with granulose dorsal surface, well produced keel representing entire dorsum of segment IX shifted posterad; apical lobe on posterolateral margin well produced, rounded triangular. Intersegmental profile between ninth and tenth segments very short and shallow gap, occupied by anterad shifted dorsoapical setose lobe accompanying setaless winglets. Segment X as long as keel, with upward produced triangular setaless winglets in lateral view and elongated trough in dorsal view; lateral setose area, cerci circular and located in middle position; ventroapical setose lobes forming short digitiform process with apical setae accompanied by small, almost vestigial ventroapical setose rounded lobe in lateral view. Coxopodite of gonopod as long as apex of segment X, harpago parallel-sided and mesad curving in ventral view. Phallic organ almost parallel-sided tube, basal bending very low in lateral view; subapical lateral projection on phallic head present and small.

Etymology. Coined from the name of the type locality, as a noun in apposition.

Hydropsyche vinconi Oláh & B. Samraoui, sp. nov.

(Figures 9f–9j)

Material examined. Holotype: ALGERIA: Cheniour, 15.iv.2023, leg Boudjéma Samraoui (male, OPC). Paratypes: Cheniour, 22.iv.2021, leg Boudjéma Samraoui (2 males, OPC), Cheniour, 8.v. 2021, leg Boudjéma Samraoui (3 males, OPC).

Diagnosis. This newly discovered species belongs to the *Hydropsyche instabilis* Subgroup within the *H. angustipennis* Species Group. The angular subapical projection is present in this species. Although it bears similarity to *Hydropsyche morla* Malicky & Lounaci, 1987, it can be distinguished by several features. First, it differs by having a much more pronounced dorsal keel of segment X. It also has upwardly directed, traingular, setaless winglets on segment X. The digitiform processes are located inferiorly rather than dorsally. In addition, the fine structure of the phallic organ differs in both lateral and dorsal views. In ventral view, it is characterized by a more pronounced basal curvature and a subapical constriction instead of a dilation subapicad.

Description. Male (in ethanol). Large sized species. Body brown; dorsal thoracic sclerites darker. Forewing brown, marbled with lighter spotted pattern. Length of forewing 11 mm.

Male genitalia. Segment IX fused annular and short, particularly on ventrum; median keel long

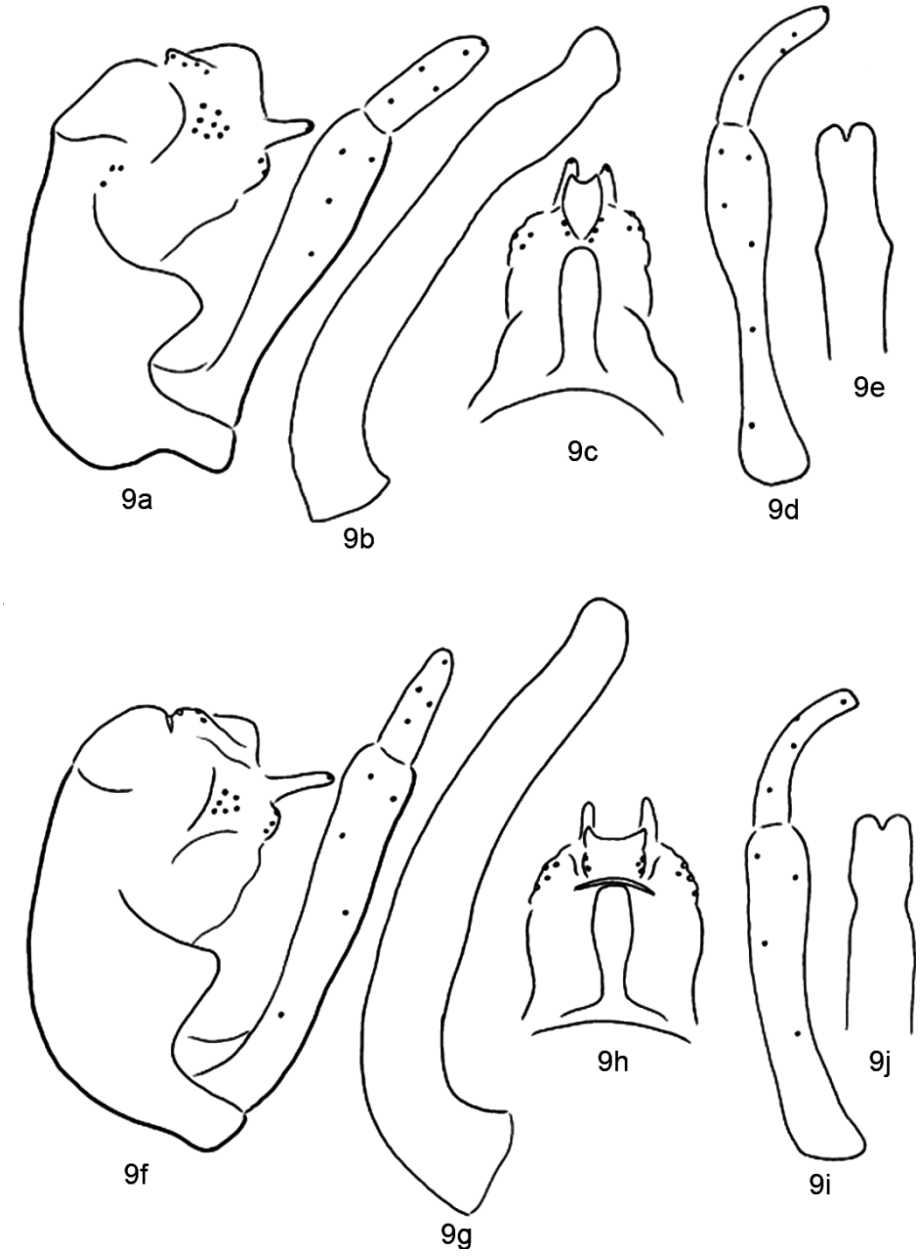

Figure 9. Genitalia of *Hydropsyche* spp. 9a–9e, *Hydropsyche louara* Oláh & B. Samraoui sp. nov. Holotype: 9a = genitalia in left lateral view, 9b = phallic organ in left lateral view, 9c = segments IX and X in dorsal view, 9d = left gonopod in ventral view, 9e = phallic apex in ventral view, 9f–9j, *Hydropsyche vinconi* Oláh & B. Samraoui sp. nov. Holotype: 9f = genitalia in left lateral view, 9g = phallic organ in left lateral view, 9h=segments IX and X in dorsal view, 9i = left gonopod in ventral view, 9j = phallic apex in ventral view.

and broad in dorsal view with granulose dorsal surface, well produced keel representing entire dorsum of segment IX shifted posterad; apical lobe on posterolateral margin well produced, triangular. Intersegmental profile between ninth and tenth segments very short and shallow gap, occupied by anterad shifted dorsoapical setose lobe accompanying setaless winglets. Segment X as long as keel, with upward produced triangular setaless winglets in lateral view and elongated

trough in dorsal view; lateral setose area, cerci circular and located in middle position; ventroapical setose lobes forming short digitiform process with apical setae accompanied by small, ventroapical setose rounded lobe in lateral view. Coxopodite of gonopod as long as apex of segment X, harpago parallel-sided and mesad curving in ventral view. Phallic organ almost parallel-sided tube, basal bending produced in lateral view; subapical constriction on phallic head present in ventral view.

Etymology. Named in honour of the renowned French entomologist, Gilles Vinçon, who has dedicated his scientific life to aquatic insects.

Hydropsyche pellucidula species Subgroup

The species of this Subgroup show a complete fusion of the sclerotized endotheca with the apex of the phallotheca. The apical region of the phallic organ is characterized by an angular subapical lateral projection in front of the cleaved apex of the phallotheca, although the digitiform apicoventral setose lobes are absent.

We have discovered two new species, *Hydropsyche linae* and *Hydropsyche nardjissae*, which we assign to the species Subgroup of *Hydropsyche pellucidula*. It is worth noting that although the subapical lateral projection of the phallic organ is not perfectly angular but appears rounded, especially in *H. nardjissae* sp. nov., the lateral profile of their short and stout phallic organ establishes a clear relationship between them. In addition, the lateral projection of *H. linae* sp. nov. shows similarity to *Hydropsyche lobata* McLachlan, 1884; *Hydropsyche brevis* Mosely, 1930; and *Hydropsyche artax* Malicky & Lounaci, 1987, all of them belong to the *H. pellucidula* Subgroup.

It is important to note, however, that such character incongruences are not uncommon in the process of lineage formation. In the context of speciation, chimerism is supported by both morphological character analysis and molecular taxonomy (Bapteste *et al*. 2013). Tree species often have an infinite number of incongruent traits. Species are inherently more chimeric than Mayr's species concept allows. Reticulation tends to dominate over branching, and retigeny or dictiongeny takes precedence over phylogeny (Oláh *et al*. 2019).

Hydropsyche linae Oláh & B. Samraoui, sp. nov.

(Figures 10a–10e)

Material examined. Holotype: ALGERIA: El Kala region, Nouazi, 16.vii.2021, leg. Boudjéma Samraoui (male, OPC).

Diagnosis. This new species belongs to the *Hydropsyche pellucidula* Subgroup within the *H. angustipennis* Species Group. It is characterized by fused, sclerotized endothecal processes, the absence of a digitiform, apicoventral, setose lobe, and the presence of angular subapical and lateral projections anterior to the split apex of the phallotheca (Oláh & Johanson 2008). The angular subapical projection is present but not distinct. The species bears a resemblance to *Hydropsyche artax* Malicky & Lounaci, 1987, but can be distinguished by several features. These include a longer but narrower dorsal keel on segment X, the presence of small triangular winglets without upwardly projecting setae on segment X, the presence of a recognizable apicoventral setose lobe on segment X, and distinct differences in the fine structure of the phallic organ when viewed both laterally and dorsally. In addition, the basal curvature is less pronounced, almost rudimentary, resulting in an almost straight horizontal dorsum instead of a curved dorsum. In lateral view, the tip of the phallotheca narrows and shifts downward.

Description. Male (in ethanol). Small sized species. Body light brown; dorsal thoracic sclerites darker. Forewing brown, marbled with lighter spotted pattern. Length of forewing 8 mm.

Male genitalia. Segment IX fused annular and short, particularly on ventrum; median keel long and narrow in dorsal view with granulose dorsal surface, well produced keel representing entire dorsum of segment IX shifted posterad; apical lobe on posterolateral margin well produced,

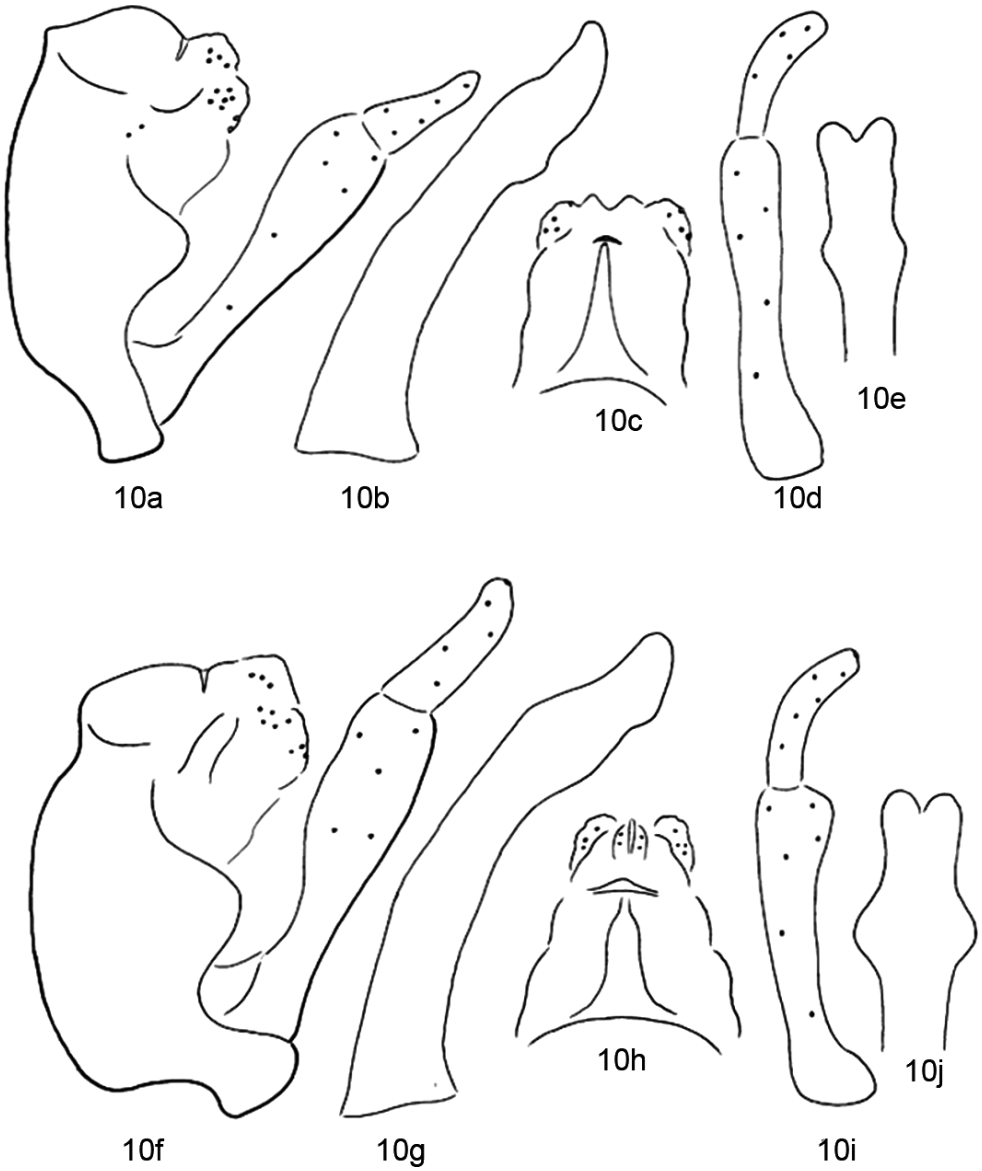

Figure 10. Genitalia of *Hydropsyche* spp. 10a–10e, *Hydropsyche linae* Oláh & B. Samraoui, sp. nov. Holotype: 10a = genitalia in left lateral view, 10b = phallic organ in left lateral view, 10c = segments IX and X in dorsal view, 10d = left gonopod in ventral view, 10e = phallic apex in ventral view. 10f–10j, *Hydropsyche nardjissae* Oláh & B. Samraoui, sp. nov. Holotype: 10f = genitalia in left lateral view, 10g = phallic organ in left lateral view, 10h = segments IX and X in dorsal view, 10i = left gonopod in ventral view, 10j = phallic apex in ventral view.

rounded triangular. Intersegmental profile between ninth and tenth segments very shallow triangular gap. Segment X half as long as keel, with upward produced small triangular setaless winglets in lateral view and triangular lobe in dorsal view; dorsoapical setose lobe present below setaless winglets; lateral setose area, cerci circular and located in subapical position; ventroapical setose lobes present and small in lateral view. Coxopodite of gonopod as long as apex of segment X, harpago parallel-sided and mesad curving in ventral view. Phallic organ forms an almost horizontal tube short and broad without basal bending; subapical lateral projection present, but small and rounded and followed by tiny just discernible dilatation before apex.

Etymology. Named in honour of the first author's twin daughter Halima Lina.

Hydropsyche nardjissae Oláh & B. Samraoui, sp. nov.

(Figures 10f–10j)

Material examined. Holotype: ALGERIA: El Kala region, Nouazi, 14.v.2023, leg. Boudjéma Samraoui (male, OPC). Paratypes: El Kala region, Nouazi, 16.vi.2023, leg. Boudjéma Samraoui (2 males, OPC), El Kala region, Nouazi, 25.vii.2023, leg. Boudjéma Samraoui (2 males, OPC).

Diagnosis. This new species belongs to the *Hydropsyche pellucidula* Subgroup within the *H. angustipennis* Species Group. The subapical lateral projection on the phallic organ of *Hydropsyche nardjissae* is present and strongly developed, but it is rounded rather than angular. These subapical lobes resemble those of the *Hydropsyche exocellata* Species Complex of the *Hydropsyche modesta* Species Unit. However, the overall structure of the phallic organ resembles that of *Hydropsyche linae* sp. nov., which associates this species with the *Hydropsyche pellucidula* Species Subgroup. *Hydropsyche nardjissae* sp. nov. differs from *Hydropsyche linae* sp. nov. in several aspects. These include the broader dorsal keel of segment X, the more pronounced development of segment X, and the distinct fine structure of the phallic organ in both lateral and dorsal views. The subapical lateral lobes are also larger and rounded, and the apical region is displaced downward and less pointed.

Description. Male (in ethanol). Medium sized species. Body brown; dorsal thoracic sclerites darker. Forewing brown, marbled with lighter spotted pattern. Length of forewing 10 mm.

Male genitalia. Segment IX fused annular and short, particularly on ventrum; median keel long and broad in dorsal view with granulose dorsal surface, well produced keel representing entire dorsum of segment IX shifted posterad; apical lobe on posterolateral margin well produced, rounded triangular. Intersegmental profile between ninth and tenth segments almost without any gap or depression, only vestigial suture visible delineating fusion line of segment IX and X. Segment X little more than half as long as keel, with upward produced small triangular setaless winglets dorsoapicad in lateral view; dorsoapical setose lobe present below setaless winglets; lateral setose area, cerci circular and located in subapical position; ventroapical setose lobes present and small in lateral view. Coxopodite of gonopod as long as apex of segment X, harpago parallel-sided and mesad curving in ventral view. Phallic organ forms an almost horizontal tube short and broad without basal bending; subapical lateral projection present, large and rounded.

Etymology. Named in honour of the first author's twin daughter Nardjissa Nesrine.

Rhyacophilidae Stephens, 1836

Rhyacophila munda McLachlan, 1862

Material examined. ALGERIA: El Kala region, O. Louar sup, 25.ii.2020, leg. Boudjéma Samraoui (1 male, 1 female, OPC).

Remark. This species starts flying before the end of the winter.

Glossosomatidae Wallengren, 1891

Agapetinae Martynov, 1913

Agapetus Curtis, 1934

The genus *Agapetus* occurs primarily in first-order streams and is mainly observed in habitats that remain unaffected by anthropogenic stressors (Figs. 11a-d). This particular characteristic makes *Agapetus* a potentially valuable indicator species for assessing and monitoring the ecological integrity of freshwater ecosystems (Nijboer 2004). The genus *Agapetus* is characterized by a phallic organ that exhibits various stages of development, often with reduced structural components. In more complex character states, the phallic organ consists of the phallobase, endotheca, and aedeagus with dorsal and ventral arms and typically a single fused paramere on the dorsal side. How-

ever, the phallic organ is usually deeply retracted into the genitalia, so its structure is often hidden, poorly visible, and sometimes even unrecognizable. For this reason, its structure is rarely described in detail in species descriptions.

Agapetus incertulus Species Complex

The *Agapetus incertulus* Species Complex includes a small group of species such as *Agapetus dakki* Malicky & Lounaci, 1987; *A. ferrerasi* sp. nov.; *A. fuscus* Vaillant, 1954; *A. incertulus* McLachlan, 1884; *A. numidicus* Vaillant, 1954; and *A. yasminae* sp. nov. These species possess a phallic organ consisting of the phallobase, the variously developed phallotheca, the endotheca, the aedeagus, and the paramere. The aedeagus consists of a dorsal branch and a ventral branch. The dorsal branch is formed by the independently developed ejaculatory duct. The bilobed apex of the ventral branch is greatly elongated, forming a divergent structure that has diagnostic potential for distinguishing closely related, incipient sibling species. Unfortunately, the original descriptions of the species in this complex do not clearly depict the complex structure of the phallic organ. However, in this study, we use the lateral profile structure of the bilobed ventral branch of the aedeagus to distinguish two new species from Algeria within the complex without performing a comprehensive revision of the entire complex. A comprehensive review would require a larger number of specimens for each species, including type specimens that are not currently available. In addition to the lateral profile of the bilobed ventral arm of the aedeagus, we have identified the fine structure of the lateral profile of the gonopods and the spine-like ventral process of the sternite VI as reliable diagnostic characters.

Agapetus ferrerasi Oláh & B. Samraoui, sp. nov.

(Figures 12a–12d)

Material examined. Holotype: ALGERIA: Cheniour, 10.ix.2020, leg. Boudjéma Samraoui (male, OPC). Paratype: same as holotype (1 male, OPC).

Diagnosis. This new species is closely related to *Agapetus numidicus* Vaillant, 1954, but differs in the fine phenomics of genital structure. In particular, the lateral profile of the spine-like ventral process of sternite VI is characterized by a short, upwardly curved structure with a blade-like apex rather than a simple digitiform shape. In addition, the bilobed ventral arm of the aedeagus has a capitate-like appearance rather than a slight constriction in the anterior region. In addition, the gonopod of this new species is straight with a ventral concavity and a tapering apex, in contrast to the upwardly curved shape with a blunt apex in *Agapetus numidicus*.

Description. Small, almost black animal. Forewing length is just over 3 mm. General body and colour character states are almost identical with *Agapetus numidicus*.

Male genitalia. Segment IX subquadrangular in lateral view forms a complete fused ring-like structure with ventral suture or sulcus, remnant of pleuron and sternite fusion. Segment X less pigmented, except narrow basoventral more sclerotized strengthening structure. Cerci are lacking. Paraproct difficult to discern, but present as sclerotized lateral vertical plate supporting phallic organ, somehow copying shape of sclerotized part of segment X. Gonopod narrowing apicad with some ventral concavity in lateral profile; in ventral view with three mesal teeth and with single basal tooth. Phallic organ comprised of phallobase, endotheca, aedeagus and paramere; bilobed ventral arm of aedeagus capitate abruptly narrowing anterad.

Etymology. Species is named in honour of the first author's friend, Professor Manuel Ferreras Romero, a Spanish entomologist, who has dedicated his scientific life to aquatic insects.

Agapetus numidicus Vaillant, 1954

Material examined. ALGERIA: Cheniour, 10.ix.2020, leg. Boudjéma Samraoui (5 males, OPC), Cheniour, 8.iv.2021, leg. Boudjéma Sam raoui (15 males, OPC), Cheniour,ix. 3.2020, leg. Boudjéma Samraoui (10 males, OPC).

Figure 11. *Agapetus numidicus'* mating behavior (a, b, c). Stone with larvae of *A. numidicus* (d).

Remarks. The type specimen collected in Algeria, more precisely in the 'Ruisseau des Singes' near La Chiffa (Atlas de Bilda) between 210 and 300 m, was not available for our study. Therefore, we compare our two new species with the high-quality and detailed original drawings in the species description of Vaillant (1954). This species is relatively common at Cheniour and closely matches the original description and drawings. The gonopods have a slightly upcurved shape and are characterized by a rounded apex in lateral view, which is more rounded compared to *Agapetus yasminae* sp. nov. and *A. ferrerasi* sp. nov. The lateral profile of the bilobed ventral arm of the aedeagus tapers gradually anteriorly rather than abruptly. The species description does not include a drawn illustration of the lateral profile of the spine-like ventral process of the sternite VI; it is merely described as being as long as that of *A. fuscipes*. In our study, we provide detailed and finely drawn illustrations of the spine-like process for the two new species. The spine-like process on segment VI of our *Agapetus numidicus* specimens collected at Cheniour differs from that of *Agapetus yasminae* sp. nov. and *A. ferrerasi* sp. nov.

Agapetus yasminae Oláh & B. Samraoui, sp. nov.

(Figures 12e–12h)

Material examined. Holotype: ALGERIA: Mount Edough, O. Agab, 19.vi.2021, leg Boudjéma Samraoui (male, OPC).

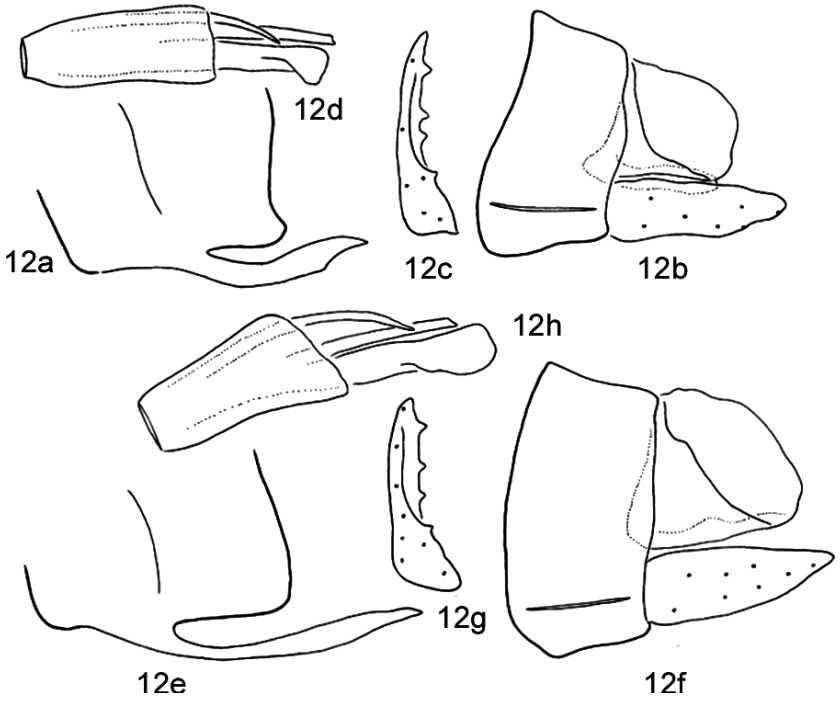

Figure 12. Genitalia of *Agapetus* spp. 12a–12h, *Agapetus ferrerasi* Oláh & B. Samraoui, sp. nov. Holotype: 12a = sternite VI with spine-like ventral process, 12b = genitalia in left lateral view, 12c = left gonopod in ventral view, 12d= phallic organ in left lateral view. (12e–12h), *Agapetus yasminae* Oláh & B. Samraoui, sp. nov. Holotype: 12e = sternite VI with spine-like ventral process, 12f=genitalia in left lateral view, 12g = left gonopod in ventral view, 12h = phallic organ in left lateral view.

Diagnosis. This new species is closely related to *Agapetus numidicus* Vaillant, 1954, but differs in the fine phenomics of the genitalia. In particular, the lateral profile of the spine-like ventral process of the sternite VI is long, almost straight, and slightly broadened in the middle, rather than exhibiting a simple digitiform shape. In addition, the bilobed ventral arm of the aedeagus has a clavate appearance rather than simply narrowing slightly anteriorly. In addition, the gonopod of this new species is straight with a tapering, almost pointed apex, as opposed to the upwardly curved shape with a blunt apex found in *Agapetus numidicus*.

Description. Small, almost black animal. Forewing length just over 3 mm. General body and colour character states almost identical with *Agapetus numidicus*.

Male genitalia. Segment IX subquadrangular in lateral view forms complete fused ring-like structure with ventral suture or sulcus, remnant of pleuron and sternite fusion. Segment X less pigmented, except broad basoventral more sclerotized strengthening structure. Cerci lacking. Paraproct difficult to discern, but present as sclerotized lateral vertical plate supporting phallic organ. Gonopod narrowing apicad with pointed apex in lateral profile; in ventral view with three mesal teeth and with single basal tooth. Phallic organ comprised of phallobase, endotheca, aedeagus and paramere; bilobed ventral arm of aedeagus clavate gradually narrowing anterad.

Etymology. Species is named in honour of the first author's daughter, Yasmina.

Uenoidae Iwata, 1927

Thremmatinae Martynov, 1935

Thremma africanum Malicky & Lounaci, 1987 stat. nov.

(Figures 13a–13i)

Thremma sardoum africanum Malicky & Lounaci, 1987:12." Die algerischen Exemplare sind von den

sardischen und korsischen kaum zu unterscheiden, aber sie haben ventral am 7. abdominal Segment einen dichten Kamm aus ungefähr 7 Stacheln, die distal geknöpft und halb so lang wie das Segment sind. Bei den Tieren von Sardinien und Korzika befindet sich dort nur ein kurzer Stachel, der auch fehlen kann." Holotypus ♂: Algerien, Tizi-Ouzou, obere Bachregion des Oued Aissi, 26.V.1986, Lounaci leg., coll. Malicky. Mehrere Paratypen vom gleichen Ort mit verschiedenen Daten in den Sammlungen Malicky und Lounaci."

Type material. Holotype: Algeria, Tizi-Ouzou, upper stream region of O. Aissi, 1084 26.V.1986, Lounaci leg. (1 male, CHM).

Material examined. ALGERIA: Mount Edough, O. Agab, 26.iv.2021, leg. Boudjéma Samraoui (1 male, OPC).

Remarks. Malicky and Lounaci found no differences in the general or genital structures between the Sardinian, Corsican, and Algerian specimen of *Thremma sardoum* Costa, 1884, except for the presence of a well-produced and heavily sclerotized comb structure on the ventrum of segment VII in the Algerian specimens, which is lacking or variably vestigial in the Sardinian and Corsican specimens.

Applying the principles and procedures of fine phenomics, we have recognised significant differences in character states between specimens available for comparative examination from Algeria and Corsica. We have identified two character states that are reliable and stable for differentiating species within the *Thremma* genus. *(1)* The first trait is the ventral profile/contour/horizon of the fused gonopods and basal plate of gonopods. This highly serrated structure appears to have a key function in sexual integration and is a non-neutral adaptive speciation trait, sometimes referred to as a "magic trait" (Servedio *et al*. 2011). *(2)* The second trait is the lateral profile of the phallic organ. The highly sclerotized phallotheca with its apicoventral lip probably has a stimulatory function during copulation and is another non-neutral speciation trait. Based on both of these speciation traits, the specimen from Algeria differs from all the other species in the genus. The ventral profile of the serrated mesal ridge of the fused gonopods is entirely different in shape compared to all other species. In comparison to *Thremma sardoum,* the Algerian specimen has a longer mesal process and an angled lateral corner, rather than a rounded one. The apicoventral lip of the phallotheca in the Algerian specimen is very short, unlike the long one seen in the Corsican specimen. Furthermore, the lateral shape of the phallotheca and the basoventral lip of the phallotheca, which provides the attachment surface to the basal plate of the fused gonopod, are also different in shape and not as prominently produced. Based on the theories of phylogenetic species concept, which suggest excluding subspecies and races from scientific classification (Oláh & Johanson 2008), and considering these pronounced divergences, we propose elevating the subspecies status of *Thremma sardoum africanum* Malicky & Lounaci, 1987 to species rank as *Thremma africanum* Malicky & Lounaci, 1987 stat. nov.

Lepidoptomatidae Ulmer, 1903

***Lepidostoma kumanskii* (Malicky, 1982)**

Material examined. ALGERIA: Mount Edough, O. Agab, 1.vii.2021, leg Boudjéma Samraoui (1 male, OPC), Mount Edough, O. Agab, 11.vii.2021, leg Boudjéma Samraoui (1 male, OPC), Mount Edough, O.Agab, 5.vi.2021, leg Boudjéma Samraoui (2 males, OPC).

Remark. This is a new addition to the caddisfly fauna of Algeria.

Goeridae Ulmer, 1903

***Silonella aurata* (Hagen, 864)**

Material examined. ALGERIA: Mount Edough, O. Agab, 1.xi.2021, leg Boudjéma Samraoui (1 male, OPC), Mount Edough, O. Agab, 26.iv.2021, leg Boudjéma Samraoui (2 males, 2 females; OPC).

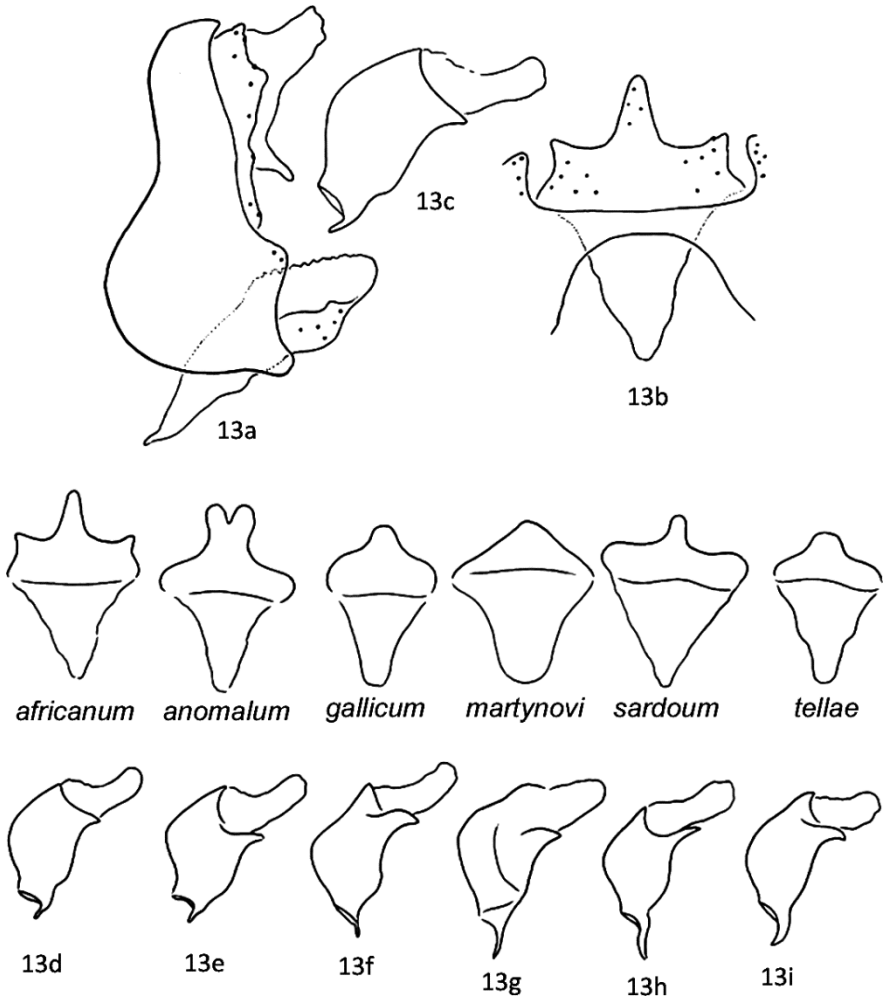

Figure 13. Genitalia of *Thremma* spp. 13a–13i, *Thremma africanum* Malicky & Lounaci, 1987: 13a = genitalia in left lateral view, 13b = fused gonopod and basal plate of gonopod in ventral view, 13c = phallic organ in left lateral view. 13d–13i, Speciation traits of the fused gonopod and basal plate of gonopod in ventral view and of the phallic organ in left lateral view of the six *Thremma* species. 13d = *Thremma africanum* Malicky & Lounaci, 1987; 13e = *Thremma anomalum* McLachlan, 1876; 13f = *Thremma gallicum* McLachlan, 1880; 13g = *Thremma martynovi* Malicky, 1976 13h = *Thremma sardoum* Costa, 1884; 13i = *Thremma tellae* Gonzalez, 1978.

Remark. This species has a relatively long flight period.

Limnephilidae Kolenati, 1848

Mesophylax McLachlan, 1882

Mesophylax McLachlan, 1882:157. "Very closely allied to *Stenophylax* typically; differs especially in the spur of the anterior tibiae of ♂ being so much reduced as to be microscopic, whereas the corresponding spur in the ♀ is long; hence the spur-formula is *quasi* 1,3,4 and 1,3,4 ♀." Type of this genus is *Stenophylax aspersus*, Rambur."

Remarks. It should be noted that in McLachlan's taxonomy, the spur formula was once considered an important character state for delimiting genera within the order Trichoptera, especially in the family Limnephilidae. However, it later became clear that this character state is highly variable and not reliable. In Schmid's taxonomy (1955), the architecture of the genital structure became essential for delimiting genera within the

family Limnephilidae. Malicky's revision of the taxonomy of the genus *Mesophylax* (1998) included extensive research on a large sample but reached rather pessimistic conclusions regarding reliable character states for delineating taxa.

In our studies on parameres as a species trait (Oláh *et al.* 2014, 2015, 2017), we found that the hooked shape of parameres serves as an adaptive, non-neutral structure that is highly reliable for distinguishing closely related sibling species within the genus *Mesophylax*.

Mesophylax aspersus (Rambur, 1842)

Material examined. ALGERIA, Pont Ain Makhlouf, 1.ii.2023, leg Boudjéma Samraoui (male, OPC).

Remark. Mesophylax aspersus (Rambur, 1842) represents a sibling species characterized by short gonopods, in contrast to the species represented by *Mesophylax impunctatus*, which has elongate and slender gonopods.

Mesophylax hoggarensis Malicky, 1998 stat. nov.

Mesophylax aspersus hoggarensis Malicky, 1998:135–136. "Die Tiere aus dem Hoggar-Gebirge stimmen weitgehend mit den typischen *aspersus* überein, haben aber konstant die Spornformel 022 (♂) 4nd 122 (♀). Holotypus ♂: Gueltas Imeleoulaouene, 16 km NE Tamanrasset."

Type material: Holotype: ALGERIA: Gueltas Imeleoulaouene, 16 km NE Tamananrasset, 22° 53'N, 5°38'E, 1400 m, 5.IV.1984, leg Aspöck, Rausch, Hölzel & Ohm (1 male, CHM).

Material examined. ALGERIA: Mount Edough, O. Agab, 1.xi.2021, leg Boudjéma Samraoui (1 male, OPC), Cheniour, 15.iv.2023, leg Boudjéma Samraoui (1 female, OPC), Cheniour, 30.iv.2023, leg Boudjéma Samraoui (2 females, OPC), Cheniour, 1.iv.2023, leg Boudjéma Samraoui (1 male, OPC).

Remarks. The specimens from Mount Edough have a tibial spur formula of 022, similar to *Mesophylax sardous* Moretti & Gianotti, 1981, and not 034 as observed in *Mesophylax aspersus.* The lateral shape of gonopods and paramere is identical to the specimens from the Ahaggar Mountains. The divergences in the genital structure, along with the principles of phylogenetic species concept (Burbrink *et al*. 2022), suggests elevating the subspecies *Mesophylax aspersus hoggarensis* Malicky, 1998 to the species rank as *Mesophylax hoggarensis* Malicky, 1998, stat. nov.

Beraeidae Wallengren, 1891

Beraea auresi Vaillant, 1953

Material examined. ALGERIA: Mount Edough, O. Agab, 11.vii.2021, leg Boudjéma Samraoui (2 males, OPC).

Remark. This record expands considerably the range of this Algerian endemic species.

Leptoceridae Leach, 1815

Adicella syriaca Ulmer, 1907

Material examined. ALGERIA: Mount Edough, O. Agab, 18.viii.2021, leg Boudjéma Samraoui (1 male, OPC).

Remark. This is a new addition to the caddisfly fauna of Algeria.

Athripsodes ygramul Malicky & Lounaci, 1987

Material examined. ALGERIA: Mount Edough, O. Agab, 19.vi.2021, leg Boudjéma Samraoui (2 males, OPC).

Remark. This record expands considerably the range of this Algerian endemic species.

DISCUSSION

This study represents a significant advance in the field of Algerian caddisfly taxonomy, providing convincing morphological evidence for the existence of 15 new species belonging to the genera *Hydropsyche* and *Agapetus*. The newly

identified species from the genus *Hydropsyche* include *Hydropsyche cherfa, H. makhloufa, H. seybousa, H. algirica*, *H. dbabcha*, H. *farrahae*, *H. guitna*, *H. chenioura, H. edougha*, *H. louara*, *H. vinconi*, *H. linae,* and *H. nardjissae*. In addition, two new species were discovered in the genus *Agapetus*: *Agapetus cheniour* and *A. yasminae*. This research also suggested elevating three subspecies to species rank: *Wormaldia numidica*, *Mesophylax hoggarensis*, and *Thremma Africanum*. It is noteworthy that these three species are Maghrebian endemics, with the first one occurring exclusively in Algeria. In addition to the study of the genus *Hydropsyche*, a new species, *H. tenerifa* sp. nov., was described from the Canary Islands. Taken together, these results greatly improve our understanding of caddisfly diversity in North Africa (Table 2).

In addition, this study has provided valuable insights into the distribution patterns of caddisflies in Algeria and has greatly increased our knowledge in this field. The discovery of previously unrecorded species such as *Lype reducta*, *Lepidostoma kumanskii*, and *Adicella syriaca* contributes to our understanding of caddisfly diversity and distribution in Algeria. In particular, *L. kumanskii*, a Maghrebian endemic, had previously been documented only once in Tunisia (Malicky & Lounaci 1987), making this the first record of its occurrence in Algeria. *Lype reducta* and *Adicella syriaca* were also recorded in Algeria for the first time in this study.

Mount Edough, more specifically O. Agab, proved to be the site with the highest species richness, hosting a remarkable number of 12 caddisfly species. In comparison, Cheniour, a tributary of the Seybouse River, had a species richness of 5. The presence of numerous endemic species at Mount Edough, the El Kala region, the Seybouse River, and other parts of the Maghreb region underscores the extraordinary evolutionary history and ecological importance of freshwater ecosystems in this area. These habitats, located primarily at mid-elevations of 400–800 meters, are critical to protecting diverse caddisfly populations and maintaining ecological integrity in this freshwater hotspot.

Furthermore, the taxonomic advances made in this study have shed more light on the genus *Hydropsyche* in the Maghreb. Indeed, this study highlights the remarkable diversity of the genus *Hydropsyche* in northeastern Algeria with the discovery of 13 new species. In particular, the Seybouse River stands out as the catchment with the greatest *Hydropsyche* species richness, where eight new *Hydropsyche* species were identified. Following closely behind is the El Kala region, where four new *Hydropsyche* species were documented. A previous study focusing on larvae had already identified the Seybouse River as a notable hotspot for *Hydropsyche* species (Samraoui *et al*. 2020). To further our understanding, future studies that include both larvae and adults would be immensely valuable.

The trichopteran net-spinning family Hydropsychidae, which includes the genus *Hydropsyche*, displays impressive ecological diversity (Rutherford *et al*. 1986, Gordon & Wallace 1975). The genus *Hydropsyche*, which comprises a group of caddisflies known for their sensitivity to environmental conditions, plays a critical role in assessing the health of aquatic ecosystems (Stuijfzand *et al*. 1999, Pirvu & Pacioglu 2012, Awrahman *et al*. 2016). Understanding the taxonomy and ecology of *Hydropsyche* larvae is critical for effective water quality monitoring, as they contribute significantly to macroinvertebrate populations in aquatic environments (Ruiz García & Ferreras-Romero 2008, Statzner *et al*. 2010). These larvae colonize different lotic habitats and have different ecological requirements, although there may be some intraspecific variability and adaptations (Boon 1984). Furthermore, it is noteworthy that a single habitat may harbor multiple species of *Hydropsyche* (Fuller & MacKay 1980), highlighting the need for accurate identification. By improving our understanding of *Hydropsyche* taxonomy in the Maghreb, this study provides a valuable basis for investigating the ecological responses of these species to environmental

Table 2. Checklist of recorded adult caddisflies with their regional distribution and flight period.

Family	Species	Localities	Flight period
Philopotamidae			
	Wormaldia numidica Vaillant 1974 stat.nov.	O. Agab; Tizagban (Collo)	June, December
Psychomyiidae			
	Lype reducta (Hagen 1868)	O. Agab	April, June
Hydropsychidae			
	Cheumatopsyche lepida (Pictet 1834)	Nouazi	June
	Hydropsyche cherfa Oláh & B. Samraoui sp. nov.	Pont Aïn Makhlouf	July
	Hydropsyche makhloufa Oláh & B. Samraoui sp. nov.	Pont Aïn Makhlouf	March
	Hydropsyche seybousa Oláh & B. Samraoui sp. nov.	Boukamouza	February
	Hydropsyche algirica Oláh & B. Samraoui sp. nov.	O. Agab; Pont Aïn Makhlouf	February, March, May
	Hydropsyche dbabcha Oláh & B. Samraoui sp. nov.	Dbabcha	May
	Hydropsyche farrahae Oláh & B. Samraoui sp. nov.	Dbabcha	July-September
	Hydropsyche guitna Oláh & B. Samraoui sp. nov.	Guitna	May
	Hydropsyche tenerifa Oláh sp. nov.	Tenerife, Canary Islands	July
	Hydropsyche chenioura Oláh & B. Samraoui sp. nov.	Cheniour	February, May, July
	Hydropsyche edougha Oláh & B. Samraoui sp. nov.	O. Agab	June, July
	Hydropsyche louara Oláh & B. Samraoui sp. nov.	Louar inf	May
	Hydropsyche vinconi Oláh & B. Samraoui sp. nov.	Cheniour	April, May
	Hydropsychae linae Oláh & B. Samraoui sp. nov.	Nouazi	July
	Hydropsyche nardjissae Oláh & B. Samraoui sp. nov.	Nouazi	May-July
Rhyacophilidae			
	Rhyacophila munda McLachlan 1862	Louar sup	February
Glossosomatidae			
	Agapetus ferrerasi Oláh & B. Samraoui sp. nov.	Cheniour	September
	Agapetus numidicus Vaillant 1954	Cheniour	All-year round
	Agapetus yasminae Oláh & B. Samraoui sp. nov.	O. Agab	June
Uenoidae			
	Thremma africanum Malicky & Lounaci 1987 stat. nov.	O. Agab	April
Lepidostomatidae			
	Lepidostoma kumanskii (Malicky 1982)	O. Agab	June, July
Goeridae			
	Silonella aurata (Hagen 1864)	O. Agab	April, November
Limnephilidae			
	Mesophylax aspersus (Rambur 1842)	Pont Aïn Makhlouf	February
	Mesophylax hoggarensis Malicky 1998 stat. nov.	O. Agab, Cheniour	April, November
Beraeidae			
	Beraea auresi Vaillant 1953	O. Agab	July
Leptoceridae			
	Adicella syriaca Ulmer 1907	O. Agab	August
	Athripsodes ygramul Malicky & Lounaci 1987	O. Agab	June

change and serves as a basis for future monitoring and conservation efforts.

While identification of *Hydropsyche* larvae plays a critical role in water quality assessment, especially considering how sensitive certain species are to pollution, comprehensive identifycation keys for Hydropsychidae in the Maghreb region are currently lacking. Despite the dominance of western Palearctic elements in the *Hydropsyche* fauna of the Maghreb, existing European identification keys for *Hydropsyche* larvae (Bournaud *et al*. 1982, Zamora-Muñoz *et al*. 1995, Múrria *et al*. 2010, Karaouzas 2018) are of limited practical use because of the many endemic species in the Maghreb. A major obstacle to the development of a comprehensive key to Maghrebian *Hydropsyche* larvae is the lack of taxonomic progress of this poorly studied caddisfly genus in the region (Dakki 1978, Allaya 2003,

Bonada *et al*. 2008). To address this critical gap, two recent publications focused on the taxonomy of *Hydropsyche* species in western Algeria and partially addressed this pressing need (Bemmoussat-Dekkak 2021a, 2021c). These advances in identification tools improve our ability to accurately assess water quality and monitor the status of aquatic ecosystems in the Maghreb, contributing to effective conservation and management measures.

Our understanding of the genus *Agapetus* in Algeria has benefited greatly from the seminal work of Vaillant (1954). Vaillant's research brought to light the existence of two previously unknown species of *Agapetus*: *A. numidicus* and A. *fuscus*. In addition, he also collected a third species, *A. incertulus* McLachlan, 1884. Building on Vaillant's fundamental contributions, our study expands the *Agapetus* checklist by introducing two new species: *A. ferrerasi* and *A. yasminae,* both endemic to Algeria. While *A. numidicus* has considerable local abundance, its syntopic counterpart, *A. ferrerasi* sp. nov., appears to be comparatively rare.

Thremma africanum was previously identified by Malicky & Lounaci (1987) as a subspecies of *Thremma sardoum* Costa, 1884. With the recent reassessment of *T. africanum* as a distinct species, the genus *Thremma*, which is distributed around the Mediterranean, now includes six species, three of them microendemic to specific zoogeographic areas (González *et al*. 1989). These include *T. tellae* González, 1978 in the Cantabrian Mountains of Spain, *T. sardoum* in Corsica, France, and Sicily, Italy, and *T. africanum* in the eastern Maghreb. Similar to its European relatives *T. gallicum* McLachlan, 1880 and *T. anomalum* McLachlan, 1876 (Kehl 2005, Živić *et al*. 2013, Macher *et al*. 2015), *T. africanum* is also patchy in its range. It has been recorded in the Djurdjura Mountains and on Mount Edough, both located in northern Algeria, and in a single stream in northwestern Tunisia (Malicky & Lounaci 1987, Allaya *et al*. 2003, this study). These Maghrebian mountains serve as refugia for *T. africanum* and other aquatic insects (Samraoui & Alfarhan 2015, Boucenna *et al*. 2023).

The identification of new records, including *Wormaldia numidica*, *Thremma africanum*, *Mesophylax hoggariensis*, *Cheumatopsyche lepida*, *Rhyacophila munda*, *Agapetus numidicus*, *Silonella aurata*, *Beraea auresi*, and *Athripsodes ygramul* contributes to our knowledge of the distribution patterns of caddisflies in Algeria. This information is important for mapping their geographic ranges, identifying potential hotspots for species conservation, and developing effective management strategies. The presence of Algerian endemics such as *Beraea auresi* Vaillant, 1953 and *Athripsodes ygramul* Malicky & Lounaci, 1987 in northeastern Algeria for example, is an important finding in this regard, highlighting the need for further studies on their distribution and ecological requirements.

The results of this study highlight the importance of the Maghreb region as a hotspot of biodiversity and a center of endemism. These results are consistent with recent research on several taxa, including fishes, amphibians, and aquatic insects, demonstrating the presence of endemic species in Algeria (Boucenna *et al*. 2023). They also confirm previous results showing faunal and floristic similarities between the Kroumiria region on the Algerian-Tunisian border and Mount Edough (Samraoui & Alfarhan 2015). The cumulative evidence highlights the urgent need for local authorities and managers to mitigate the taxonomic impediment such as lack of expertise, funds, and environmental education (Giangrande 2003), establish monitoring programs, and develop conservation measures that specifically target freshwater biodiversity.

By prioritizing and protecting these habitats, we not only value caddisfly conservation but also preserve the intricate web of ecological interactions they support. Aquatic insects, with their various life stages and ecological functions, play an important role in maintaining the balance and health of freshwater ecosystems (Corbet 1999,

Sartori & Brittain 2015 Morse *et al*. 2019). In addition, the mid-elevation range of 400–800 meters is a critical zone for biodiversity conservation because it hosts a number of Palearctic relict species (Samraoui & Alfarhan 2015) and an exceptional diversity of freshwater fauna (Samraoui *et al*. 2021a, 2021b, 2021c, Boucenna *et al*. 2023). Implementation of measures such as habitat restoration, sustainable land management, and targeted conservation initiatives will be critical. By recognizing the importance of these unique habitats and taking proactive conservation measures, we can ensure the continued existence of this unique Maghrebian freshwater hotspot.

CONCLUSIONS

In summary, the taxonomic advances and new distributional records presented in this study contribute significantly to our understanding of Algerian caddisflies. The description of new endemic species as well as the discovery of new records demonstrate the importance of conserving and managing the freshwater biodiversity of the Maghreb. By filling knowledge gaps and providing insights into the taxonomy, distribution, and conservation of Algerian caddisflies, this research sets the stage for future studies and conservation initiatives aimed at preserving these valuable aquatic ecosystems.

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