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Hydrodroma angelieri (Acari, Hydrachnidia: Hydrodromidae) a new water mite species from Corsica based on morphological and DNA barcode evidence

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Original research

ABSTRACT

In the present study we used morphological data and DNA barcodes to describe a new species, *Hydrodroma angelieri* **sp. nov.** from Corsica, France. A high genetic distance of $17.3 \pm 0.017\%$ K2P from its molecularly most closely related European congener, *H. despiciens* (Müller, 1776), supports *H. angelieri* **sp. nov.** as a distinct species. Morphologically the new species can be identified on the basis of relatively small leg claws, the presence of only one swimming seta on II-L-5 and 4-6 swimming setae on the anterior surface of IV-L-5. An updated key for the European species of *Hydrodroma* is provided.

Keywords water mites; new species; taxonomy; species delimitation; France

Zoobank <http://zoobank.org/5B105F82-EF77-4C18-B9DC-DF4B51123A54>

Introduction

The family Hydrodromidae K. Viets, 1936 comprises of two genera, *Oxopsis* Nordenskiöld, 1905, known from a single specimen collected in Sudan (see Smit 2020) and the widely distributed *Hydrodroma* Koch, 1837, recorded from all continents except Antarctica. The representatives of the latter genus are often abundant both in lentic and lotic habitats. Important characters in hydrodromids include i) idiosoma integument completely soft, lacking muscle attachment sclerites, ii) the uppermost layer of the integument is characterized by dense papillosity, with papillae that differ in shape and which are species specific, iii) genital flaps bearing numerous small acetabula arranged in several rows along the medial edge; iv) legs rather uniform with interspecific differences in the absolute and relative size of claws (larger in stream dwelling species), and in number and arrangement of long, fine swimming setae; v) morphology of mouth-parts, with P-4 bearing a long and pointed dorsodistal extension reaching the tip of the slender and elongated P-5 (Gerecke 2017).

Currently, 31 species of the family Hydrodromidae are known worldwide (Zhi-Qiang *et al.* 2011; Pešić *et al.* 2021a, b), five of which are present in Europe, i.e. *Hydrodroma despiciens* (Müller, 1776), *Hydrodroma pilosa* Besseling, 1940, *H. torrenticola* (Walter, 1908), *H. reinhardi* Pešić, 2002, and *H. cf. rheophila* Cook, 1967. The latter species, originally described from India (Cook 1963), is known in Europe only from the Greek island of Lesbos (Pešić *et al.* 2010). Most of these species such as *H. pilosa*, *H. reinhardi* and *H. torrenticola* have a Western Palearctic distribution. *Hydrodroma despiciens* was considered cosmopolitan (see Di Sabatino *et al.* 2010). Nevertheless, studies on extra-European populations of *Hydrodroma*, such as

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those on Australian populations (Pešić and Smit 2007a, b, 2011) have revealed the presence of several clearly distinct autochthonous species. Recently, Więcek *et al.* (2020) applied an integrative approach based on the DNA barcode of the mitochondrial cytochrome *c* oxidase subunit I (COI) gene sequence and morphology to delineate the status of some *Hydrodroma* species from North America and Europe.

In this paper we used morphological data and COI barcodes to describe one new species of the genus *Hydrodroma* from Corsica.

Material and methods

Water mites were collected by hand netting, sorted live in the field, and immediately preserved in 96% ethanol for the purpose of the molecular analyses. After DNA extraction, the holotype specimen was dissected and slide mounted in Faure's medium. Holotype and paratype of the new species are deposited in Naturalis Biodiversity Center in Leiden (RMNH).

All measurements are in μm . Morphological nomenclature follows Gerecke *et al.* (2016). The genital plates and number of acetabula were measured on both sides, and for and therefore their dimensions were given as a range. The following abbreviations are used: Ac = acetabula; Cx-I = first coxae; dL = dorsal length; H = height; I-L-4-6 = fourth-sixth segments of first leg; L = length; P-1-P-5 = palp segment 1-5; RMNH = Naturalis Biodiversity Center, Leiden; W = width.

DNA barcode analyses

Molecular analyses were conducted at the Canadian Centre for DNA Barcoding (Guelph, Ontario, Canada; CCDB; <http://ccdb.ca/>). In CCDB the specimens were sequenced for the barcode region of COI using standard invertebrate DNA extraction (Ivanova *et al.* 2007), amplification (Ivanova and Grainger 2007a) and sequencing protocols (Ivanova and Grainger 2007b). The DNA extracts were archived in -80°C freezers at the Centre for Biodiversity Genomics (CBG; biodiversitygenomics.net), while the specimen vouchers were returned to the first author for morphological examination. In CCDB the chromatograms were assembled into consensus sequences for each specimen and uploaded to the barcode of life database (BOLD; <https://www.boldsystems.org/>). The sample identifiers in BOLD are given for each barcoded specimen.

Sequence comparisons were performed using MUSCLE alignment (Edgar 2004). Intra- and interspecific genetic distances were calculated based on the Kimura 2-parameter model (K2P; Kimura 1980), using MEGAX (Kumar *et al.* 2018) software. MEGAX software was used to calculate Neighbour-Joining (NJ) trees based on K2P distances (standard for barcoding studies) and pairwise deletion of missing data. The support for tree branches was calculated by the non-parametric bootstrap method (Felsenstein 1985) with 1000 replicates.

Results and discussion

Species delimitation using DNA-barcodes

The final alignment for species delimitation using COI sequence data included 11 *Hydrodroma* specimens listed in Table 2 and one outgroup, *Panisopsis thori* (Walter, 1907) (BOLD DCBDJ086-21, Voucher code CCDB 38392 H02) from Germany to root the tree. The final alignment consisted of 658 nucleotide positions. The NJ tree is presented in Figure 3.

The sequences retrieved from two specimens of *H. angelieri* **sp. nov.** from Corsica appeared as a sister clade of the clade formed by *H. despiciens* and *H. pilosa* (Figure 3). The average K2P genetic distance between *H. angelieri* **sp. nov.** from Corsica and *H. despiciens* from the Netherlands was estimated $17.3 \pm 0.017\%$ (Table 3). The mean genetic distance between congeneric COI sequence groups recovered in the molecular analysis ranged from

13.1±0.015 % between *H. despiciens* and *H. pilosa*, to 22.2±0.021 % between *H. torrenticola* and *H. pilosa* (Table 3). The intraspecific distance of *H. despiciens* was 1% whereas *H. angelieri* sp. nov. showed no intraspecific variation.

Systematics

Family Hydrodromidae K. Viets, 1936

Diagnosis — Di Sabatino *et al.* 2010: 8.

Genus *Hydrodroma* Koch, 1837

Diagnosis — Di Sabatino *et al.* 2010: 9.

Hydrodroma angelieri Pešić & Smit sp. nov.

Zoobank: C279C2A2-E5E5-4C4D-8751-69B75F9BB0DD

Figs. 1A-F, 2C

Material examined — Holotype ♀ (RMHN.ACA.P.67573), France, Corsica, Tributary of Ruisseau de Canne, 14 Apr. 2015, leg. Smit (sequenced [DCCDB058-21], dissected and slide mounted [CCDB38233 E10]). Paratype: 1 ♀, same place and data as holotype (sequenced [DCCDB057-21]; preserved in Koenike fluid [CCDB38233 E09], RMNH.ACA.4508).

Diagnosis. Female (male unknown) — Idiosoma large (idiosoma L > 1500, genital plates L > 200 µm); integument papillae uniform, apically rounded. Genital plates with 69–80 pairs of Ac in at most 5 longitudinal rows. Legs with relatively short claws (L 42–47, ratio claw L/segment 5 L 11–14 %). Leg setae numbers: II-L-posterior 1; III-L-4 posterior 8; III-L-5 posterior 6–7; IV-L-4 anterior 10, posterior 9; IV-L-5 anterior 5–6, posterior 5–6.

Description — Female — Integument papillae distally rounded. Cx-I+II medially separated by a fine membranous line, with a row of long fine setae at medial margins of Cx-I, and posterior margins of Cx-II, -III, and -IV; a few most medial setae on Cx-I inserted on projections. Genital flaps with rounded lateral and concave medial margins. Excretory pore sclerotized. Leg claws without claw blade, with a dorsal clawlet. P-2 with pectinate mediobasal setae; P-4 with a long, pointed dorsobasal extension reaching tip of the slender and elongated P-5.

Measurements (holotype; in parentheses some measurements of the paratype specimen, n = 1): Idiosoma L 1615 (1550), W 1560 (1280). Coxal field L 731 (694); Cx-III W 994 (850); L Cx-I+II 375 (356); Cx-III+IV 400 (375); coxal setae numbers: Cx-I, 29–31 (24); Cx-II, 24 (21); Cx-III, 22 (21); Cx-IV 19 (20). Genital plate L 273 (244), on each plate Ac number 80 (69), with 45 setae, which in the anterior part are solid and flat, in the posterior part hollow. Egg maximum diameter 141–150, n = 3 (147, n = 2).

Gnathosoma (Fig. 1F) vL 322; chelicera (Fig. 1E) total L 392, L basal segment 320, claw 80, L ratio basal segment/claw 4.0. Palp (Figs. 1D–E) total L 561, dL/H, dL/H ratio: P-1, 52/56, 0.92; P-2, 103/70, 1.47; P-3, 55/75, 0.73; P-4, 241/57, 4.2; P-5, 110/23, 4.8; L ratio P-2/P-4, 0.43. dL I-L: 84, 122, 147, 244, 322, 272; ratio claw L/segment 5 L 13.9%. dL II-L-2-6: 153, 194, 331, 394, 322; ratio claw L/segment 5 L 11.9%. dL III-L-2-6: 166, 203, 327, 394, 344; ratio claw L/segment 5 L 11.2%. dL IV-L: 134, 209, 303, 448, 469, 409; ratio claw L/segment 5 L 11.1%.

Male — unknown.

Etymology — Named after the French acarologist Eugène Angelier in appreciation of his outstanding contribution to the study of water mite diversity of Corsica.

Discussion — Based on COI data the new species from Corsica seems to be most closely related to *Hydrodroma despiciens* (Müller, 1776) and *H. pilosa* Besseling, 1940. All three species are characterized by relatively small leg claws (L ratio claw/segment 5 < 14 %). Presence of only one short swimming seta on II-L-5 (II-L-5 posterior with 8–10 swimming setae in *H. pilosa*), makes the new species more similar to *Hydrodroma despiciens*, a species

Figure 1 *Hydrodroma angelieri* sp. nov., holotype ♀, Tributary of Ruisseau de Canne, France: A – integument papillae; B – coxal field; C – genital field; D – palp, lateral view; E – palp, medial view; F – gnathosoma; G – chelicera. Scale bars = 100 µm.

Figure 2 Terminal segment of IV-Leg. A – *Hydrodroma reinhardi*, ♂, Cijevna River, Montenegro; B – *H. despiciens* ♀, Moromiš pond, Montenegro; C – *H. angelieri* **sp. nov.**, holotype ♀, Tributary of Rau de Canne, France; D – *H. pilosa*, ♂, Markova bara pool, Montenegro. Scale bar = 100 µm.

widely distributed in standing waters in Europe (Di Sabatino *et al.* 2010). The new species from Corsica can be distinguished from *H. despiciens* by the presence of anterior swimming setae from IV-L-5. The high genetic distance between the new species and *H. despiciens* (COI 17.3 ± 0.017 K2P%) suggests a long independent history of the new species.

Two other species, *H. torrenticola* and *H. reinhardi*, both reported from Corsica (see Angelier 1959; Santucci 1971 and Pešić 2002, respectively) differ from the new species among others in the morphology of legs with rather large claws (L ratio claw/segment 5 > 14%; see Figure 2A for comparison). *Hydrodroma torrenticola*, a species similar to *H. angelieri* **sp. nov.** in the presence of swimming setae on anterior IV-L-5, differs also in having bluntly pointed papillae and anterior face of IV-L-5 bearing 3-4 swimming setae; *H. reinhardi* differs in the

Figure 3 Neighbor-joining tree based on studied *Hydrodroma* COI sequences.

absence of swimming setae from anterior IV-L-5 and a generally smaller measurements of idiosoma and gnathosoma (Pešić 2002; Gerecke 2017).

Distribution — France (Corsica).

Table 1 Number of swimming setae for *Hydrodroma angelieri* sp. nov.

	Holotype ♀	Paratype ♀
II-L-5 posterior	1	1
III-L-4 posterior	8	8
III-L-5 posterior	7	6
IV-L-4 anterior	10	8-10
IV-L-4 posterior	9	8
IV-L-5 anterior	6	5-6
IV-L-5 posterior	5	6

Key to the European species of *Hydrodroma* Koch, 1837

- 1 Swimming setation strongly reduced (one short seta each on II-L-5, III-L-4/5, and IV-L-4/5).
..... *Hydrodroma* cf. *rheophila* (In Europe reported only from the Greek island of Lesbos)
— Legs with more numerous swimming setae, at least on IV-L-4/5 located in rows 2
- 2(1) II-L-5 with more than four swimming setae, leg claws relatively small (L ratio claw/segment 5, 7-12 %; after Gerecke 2017); integument papillae acutely pointed; genital flaps with 6-8 Ac lying along an imaginary transverse line crossing at maximum width....
..... *Hydrodroma pilosa*
— II-L-5 with one swimming seta or without swimming setae; integument papillae various but not acutely pointed; genital flaps with 4-6 Ac lying along an imaginary transverse line crossing at maximum width; leg claws various 3
- 3(2) IV-L-5 anteriorly without swimming setae 4
— IV-L-5 anteriorly with swimming setae 5
- 4(3) Number of swimming setae: III-L-4 posterior > 9, IV-L-4 anterior > 9; leg claws relatively small (L ratio claw/segment 5, 11-18 %; after Gerecke 2017).....*Hydrodroma despiciens*
— Number of swimming setae: III-L-4 posterior 2-4, IV-L-4 anterior 2-6; leg claws relatively large (L ratio claw/segment 5, 15-16 %; after Gerecke 2017).....*Hydrodroma reinhardi*
- 5(3) IV-L-5 anterior 2-4 swimming setae; leg claws relatively large (L ratio claw/segment 5, 11-18 %; after Gerecke 2017); integument papillae bluntly pointed
..... *Hydrodroma torrenticola*
— IV-L-5 anterior 5-6 swimming setae; leg claws relatively small (L ratio claw/segment 5, 11-14 %); integument papillae distally rounded *Hydrodroma angelieri* **sp. nov.**

Table 2 List of *Hydrodroma* specimens used in this study.

Locality (country, name)	Lat/Long	BOLD Acc. Nos	Voucher code
<i>Hydrodroma angelieri</i> sp. nov.			
France, Corsica, tributary of Ruisseau de Canne	42.38307° N, 8.69903° E	DCCDB057-21	CCDB38233 E09
France, Corsica, tributary of Ruisseau de Canne	42.38307° N, 8.69903° E	DCCDB058-21	CCDB38233 E10
<i>Hydrodroma despiciens</i> (Müller, 1776)			
the Netherlands, Gelderland, Tongerense heide	52.34095° N, 5.90389° E	NLACA210-15	RMNH.ACA.473
the Netherlands, Gelderland, Tongerense heide	52.34095° N, 5.90389° E	NLACA212-15	RMNH.ACA.475
the Netherlands, Gelderland, Tongerense heide	52.34095° N, 5.90389° E	NLACA211-15	RMNH.ACA.474
the Netherlands, Limburg, Epen: Pool Klitserbeek valley	50.78250° N, 5.92873° E	NLACA477-15	RMNH.ACA.919
the Netherlands, Limburg, Epen: Pool Klitserbeek valley	50.78250° N, 5.92873° E	NLACA478-15	RMNH.ACA.920
the Netherlands, Overijssel, Weerribben, ditch	52.80024° N, 5.93571° E	NLACA244-15	RMNH.ACA.512
<i>Hydrodroma pilosa</i> Besseling, 1940			
the Netherlands, Alkmaar, Oudorperpolder, ditch	52.63911° N, 4.76657° E	NLACA145-15	RMNH.ACA.383
<i>Hydrodroma reinhardi</i> Pešić, 2002			
Montenegro, Podgorica, Cijevna river	42.4057° N, 19.3569° E	DNCBD076-20	CCDB-3867-G04
<i>Hydrodroma torrenticola</i> (Walter, 1908)			
Montenegro, Bar, Međurječka river	42.0363° N, 19.2179° E	DNCBD054-20	CCDB-3867-E06

Table 3 Estimates of genetic distance (K2P) of the mtCOI gene fragment between studied *Hydrodroma* spp. Standard error estimates are shown above the diagonal.

Species	1	2	3	4	5
1. <i>Hydrodroma pilosa</i>		0.015	0.021	0.018	0.019
2. <i>Hydrodroma despiciens</i>	0.131		0.02	0.019	0.017
3. <i>Hydrodroma torrenticola</i>	0.222	0.197		0.02	0.021
4. <i>Hydrodroma reinhardi</i>	0.171	0.196	0.193		0.02
5. <i>Hydrodroma angelieri</i> sp. nov.	0.187	0.173	0.209	0.204	

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