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The water mite species *Hygrobates norvegicus* (Thor, 1897) (Acari, Hydrachnidia, Hygrobatidae) – a redescription

REINHARD GERECKE & ELISABETH STUR

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Hygrobates norvegicus (Thor, 1897), the type species of the subgenus *Rivobates* Thor, 1897 is redescribed, based on the syntypes harboured at the Museum of Natural History in Oslo and fresh material recently collected from various parts of Norway. The species is defined considering its morphological variability range and molecular data (CO1 sequences), bibliographical data published during the past 125 years are discussed. The synonymy of *Hygrobates polyporus* Piersig, 1898 with *H. norvegicus* is confirmed and *H. norvegicus imminutus* Maglio, 1909 is regarded a nomen dubium. .

Key words: Acari, Hydrachnidia, Hygrobatidae, *Hygrobates norvegicus*, redescription.

Reinhard Gerecke, University of Tübingen, Faculty of Science, Department of Evolution and Ecology, DE-72074 Tübingen, Germany and Arachnologie, Senckenberg Forschungsinstitut, Mertonstr. 17-21, DE-60325 Frankfurt, Germany. E-mail: reinhard.gerecke@uni-tuebingen.de

Elisabeth Stur, Department of Natural History, NTNU University Museum, Norwegian University of Science and Technology, NO-7491 Trondheim, Norway. E-mail: elisabeth.stur@ntnu.no

Introduction

Sig Thor (1897) introduced the genus name *Rivobates* after his detection of the first multiacetabulate hygrobatid in a forest stream in Central Norway. Short after its description, *Rivobates* was proposed to be a synonym of *Hygrobates* by Piersig (1899). In 1926, Karl Viets reintroduced *Rivobates* as a subgenus of *Hygrobates*. After Faradonbeh et al. (2015) moved *Hygrobates quanaticola* Schwoerbel & Sepasgozarian, 1976, a species described under the genus name *Decabates*, to *Rivobates*, twelve representatives of the subgenus are now known from the palearctic (K.O.Viets 1987, Gerecke & Di Sabatino 2013, Pešić 2015). Without much debate, multiacetabulate hygrobatids found in Europe were over many decades attributed to the typus subgeneris, *Hygrobates norvegicus*, with published records from most Limnofauna regions (2-10, 12, 14-16, 18, 20-24, K.O.Viets 1978). Our aim is to give a detailed redefinition of that species to allow a better understanding of its identity and geographical distribution.

Material and methods

The mites investigated in this study were collected by hand netting in springs and small forest streams as part of NTNU University Museum projects (Artsprosjektet 2019, 2022) and preserved in 96% ethanol.

From four specimens selected for molecular analysis (DNA barcoding) one of each pair of legs were removed before further treatment and shipped to the Canadian Centre for DNA Barcoding (CCDB) at the University of Guelph

in collaboration with the Norwegian Barcode of Life Network. Protocols and original trace-files are accessible through the dataset DS-HYGRONOR in BOLD. DNA extraction followed standard protocols for insect tissues at CCDB, PCR and bi-directional Sanger sequencing using the C_LepFolF and C_LepFolR primer cocktail (Hernández Triana et al. 2014). The DNA barcodes, Barcode Index Numbers (BINs), GenBank accessions and associated meta-data are available through the public dataset DS-HYGRONOR (dx.doi.org/10.5883/DS-HYGRONOR) in the Barcode of Life Data Systems (BOLD) (Ratnasingham & Hebert 2007).

Specimens selected for morphological studies were steeped in concentrated acidic acid for at least 48 hours and then dissected and slide-mounted in Hoyers fluid as described elsewhere (Gerecke et al. 2016). The morphological nomenclature follows Gerecke et al. (2016). All measurements are given in µm. If not stated otherwise, length of appendage segments is given as dorsal length.

Systematics

Family Hygrobatidae
Genus *Hygrobates* Koch, 1837
Subgenus *Rivobates* Thor, 1897
Type species *Rivobates norvegicus* Thor, 1897, by original designation.

***Hygrobates norvegicus* Thor, 1897**
[original label text in squared brackets]

No holotype defined. **Type locality**: "Skovbækken mellem Kjemsjø og Storsjø" 1♂2♀♀.

There are two tubes with *Rivobates norvegicus* from the type locality collected by Sig Thor deposited at the Museum of Natural History, Oslo (NHM-UiO). These three specimens are evidently the syntypes on which the first description was based. It is interesting that these specimens were not dissected.

Syntypes: NORWAY, Innlandet, Stor-Elvdal and Rendalen municipalities, forest brook between Storsjø and Koppang, 21.VII.1896, leg. Sig Thor, 1♂1♀ [Koppang Skovbak mell. Storsjø y Koppang]; NORWAY, Innlandet, Stor-Elvdal and Rendalen municipalities, forest brook between Kjemsjø and Koppang, 21.VII.1896, leg. Sig Thor, 1♀ [Skogbek mell. Kjemsjø y Koppang Osterdalen].

Further material in NHM-UiO identified by Sig Thor as *Rivobates norvegicus*: Two tubes with specimens from the type locality, obviously collected after publication of original description: NORWAY, Innlandet, Stor-Elvdal municipality, forest brook near Kjemsjø, 19.VIII.1897, 1♂1♀ [Skovbæk ved Kjemsjø]; NORWAY, Innlandet, Stor-Elvdal municipality, forest brook north Kjemsjø, 19.VIII.1897, 1♂ [Skovbæk nor Kjemsjø Koppang i Osterdalen]. More specimens from the Thor collection at UiO: NORWAY, Troms, Balsfjord municipality, leg. Sig Thor, 4.VIII.1900, 3♀♀ [Mysbek (til Josefsv.) i fjeldet ov. Storstein nor Balsfjord Sig Thor]; NORWAY, Troms, Tromsø municipality, Vågelva, leg. Sig Thor, 9.VII.1900, 1♀ [Vaagelv Skjervø Tromsø S.T.]; NORWAY, Buskerud, Norefjell, leg. Sig Thor, 17.VIII.1908, 3♀♀ [Badeknoel v. Fjelskvil, Norefjell Sig Thor]. Two tubes coll. E. Strand [all?] with specimens identified as *Rivobates norvegicus*: NORWAY, Nordland, Hattfjelldal municipality, possibly Dalhaugan north of Eslvatnet, 15.VII.1899, 2♀♀ [Dalbakken Dalen nor Elgsvand y Hartfjeld Nordland]; NORWAY, Nordland, Hattfjelldal municipality, possibly Dalhaugan north of Eslvatnet, 15.VII.1899, 1♂1♀ [Dalbakken Dalen nor Elgsvand Embr. Strand] (retro: "Dalbakken v. Hatfjelddalen 99 Strand").

Other material examined from the NTNU University Museum (NTNU-VM): NORWAY, Agder, Flekkefjord municipality, Ytre Hølen, inlet stream, 58.32531˚N, 6.66087˚E, 3 m a.s.l. 23.VIII.2019, leg. Gaute Kjærstad & Reinhard Gerecke, 1♂ (NTNU-VM 227752, BOLD: HYDCA333, slide), 3♂♂6♀♀ (NTNU-VM 227753, tube); Hapte at Sirnes, Haptetjønna, 58.40386˚N, 6.65008˚E, 109 m a.s.l. 24.VIII.2019, leg. Gaute Kjærstad & Reinhard Gerecke, 1♂ (NTNU-VM 227754, BOLD: HYDCA317, slide), 3♂♂1♀ (NTNU-VM 227755, slide), 1♂ (NTNU-VM 228731, slide); Kristiansand municipality, inlet stream to Drangsvannene, in the forest, east to the boating association, 58.16133˚N, 8.09201˚E, 1 m a.s.l. 27.VIII.2019, leg. Gaute Kjærstad &

Reinhard Gerecke, 1♀ (NTNU-VM 227756, slide); Nordland, Vefsn municipality, spring in Bjørnådalen, 65.819822˚N, 13.248943˚E, 25 m a.s.l. 23.VII.2022, leg. Gaute Kjærstad 1♀ (NTNU-VM 228728, tube); stream at Mosheim, at Vefsnvegen, 65.80537˚N, 13.25126˚E, 30 m a.s.l. 23.VII.2022, leg. Gaute Kjærstad 1♀ (NTNU-VM 228729, tube); Trøndelag, Melhus municipality, spring near Damtjønna, 63.134804˚N, 10.132812˚E, 340 m a.s.l. 30.V.2022, leg. Gaute Kjærstad & Reinhard Gerecke, 1♀ (NTNU-VM 228713, BOLD: HYDCA611, slide), 1♀ (NTNU-VM 228714, tube); Røros municipality, Sølendet nature reserve, spring brook A, 62.68991˚N, 11.84141˚E, 753 m a.s.l., 12.VII.2022, leg. Gaute Kjærstad & Torbjørn Ekrem, 11♀♀ (NTNU-VM 228722, tube); spring brook B, 62.68883˚N, 11.83171˚E, 781 m a.s.l., 12.VII.2022, leg. Gaute Kjærstad & Torbjørn Ekrem, 3♂♂1♀ (NTNU-VM 228723, tube), 2♂♂2♀♀ (NTNU-VM 228724, NTNU-VM 228725, NTNU-VM 228726, NTNU-VM 228727, slide); Snåsa municipality, Muusdalan nature reserve, stream in Muusdalan, 64.217081˚N, 12.567766˚E, 425 m a.s.l., 10.VIII.2022, leg. Gaute Kjærstad & Karstein Hårsaker, 1♂ (NTNU-VM 228730, tube); Viken, Asker municipality, stream near Padderudvannet, 59.825342˚N, 10.367996˚E, 210 m a.s.l. 7.VI.2022, leg. Gaute Kjærstad & Reinhard Gerecke, 1♀1 deutonymph (NTNU-VM 228716, tube); Drammen municipality, spring near Ormetjern, 59.72110˚N, 10.08497˚E, 348 m a.s.l. 4.VI.2022, leg. Gaute Kjærstad & Reinhard Gerecke, 2♂♂5♀♀ (NTNU-VM 228715, tube); Lunner municipality, inlet stream Østre Småtjernet, 60.262494˚N, 10.625828˚E, 473 m a.s.l. 8.VI.2022, leg. Gaute Kjærstad & Reinhard Gerecke, 4♀♀ (NTNU-VM 228717, tube), 2♂♂2♀♀ (NTNU-VM 228718, NTNU-VM 228719, NTNU-VM 228720, NTNU-VM 228721, slide).

BINs in BOLD are BOLD:ACH7323 and BOLD:AEC4178.

Diagnosis. Colour inconspicuous, greyish brown. Genital field with 30-51 Ac (on one side 15–28, numbers of the two sides may differ by up to 5). Palp: P-2 distoventral extension little prominent, strong denticles restricted to the area of the tip and distal surface; P-3 ventral margin slightly convex, strong denticles covering distal 2/3 of ventral surface; P-4 ventral margin nearly straight, with two ventral setae close to each other in distal half of segment; P-5 slender, with four claw-like apical setae. Chelicera basal segment with a pointed dorsal extension in distal part. Male genital field wider than long (L/W 0.74-0.90), with a blunt, slightly projecting anteromedial tip, lateral margins equally rounded, posteromedial margin with a shallow indentation or (rarely) straight. Female genital plates laterally equally rounded, medially straight, L about 70 % (in juveniles up to 90 %) gonopore L.

Description (Figures 1–2). *Both sexes*: Colour of idiosoma and appendages greyish to brown, excretory organ visible as a whitish, anteriorly bifurcated dorsal marking. Integument smooth. Posteromedial margin of plate Cx-I+II, as well as medial margin of plate Cx-III+IV equally rounded; legs without swimming setae.

Males: Idiosoma L/W 760-1060/620-920; coxal field L 430-460, Cx-II W 375-440, Cx-I+II mL 300-340, posterior apodeme W 125-160; genital plate L/W 205-225/250-285, median L 190-215, gonopore L 100-115, Ac n right/left 15-25/15-24, max Ac diameter 40-45; ejaculatory complex L 200-240, distal arms W 200-220, proximal chamber W 65-90. Chelicera L 270-290, basal segment/claw ratio 2.35-3.15, L/H ratio 1.72-2.64; palp total L 455-473, segments L (L/H ratio, relative L): P-1, 30-43 (0.83-1.19, 6.6-9.3%); P-2, 110-125 (1.33-1.53, 24.1-27.4%); P-3, 85-95 (1.25-1.58, 18.5-20.9%); P-4, 150-165 (3.72-4.57, 33.0-35.6%); P-5, 48-55 (2.36-3.06, 10.4-12.1%); P-4 ventral setae dist 4-15; L ratio P-2/P-3, 1.18-1.46; P-2/P-4, 0.68-0.78; P-3/P-4, 0.53-0.63. Leg setation: See Fig. 2; segment measurements (in parentheses, L/H ratio): I-leg-1, 65-80 (1.3-1.6); I-leg-2, 85-105 (1.6-1.9); I-leg-3, 125-140 (2.3-2.8); I-leg-4, 170-180 (3.0-4.5); I-leg-5, 170-190 (4.2-4.8); I-leg-6, 150-165 (3.7-4.1) - I-leg-6 L max 170-200, claw L 38-45. IV-leg-1, 140-160 (2.0-2.4); IV-leg-2, 140-150 (2.6-3.0); IV-leg-3, 205-230 (4.1-4.6); IV-leg-4, 270-320 (5.6-6.8); IV-leg-5, 270-310 (6.7-7.8); IV-leg-6 L 210-240 (5.5-6.7), IV-leg-6 L max 240-275; claw L 40-48 (18-20% IV-L-6 L); L ratio IV-leg-4/5, 0.93-1.03;

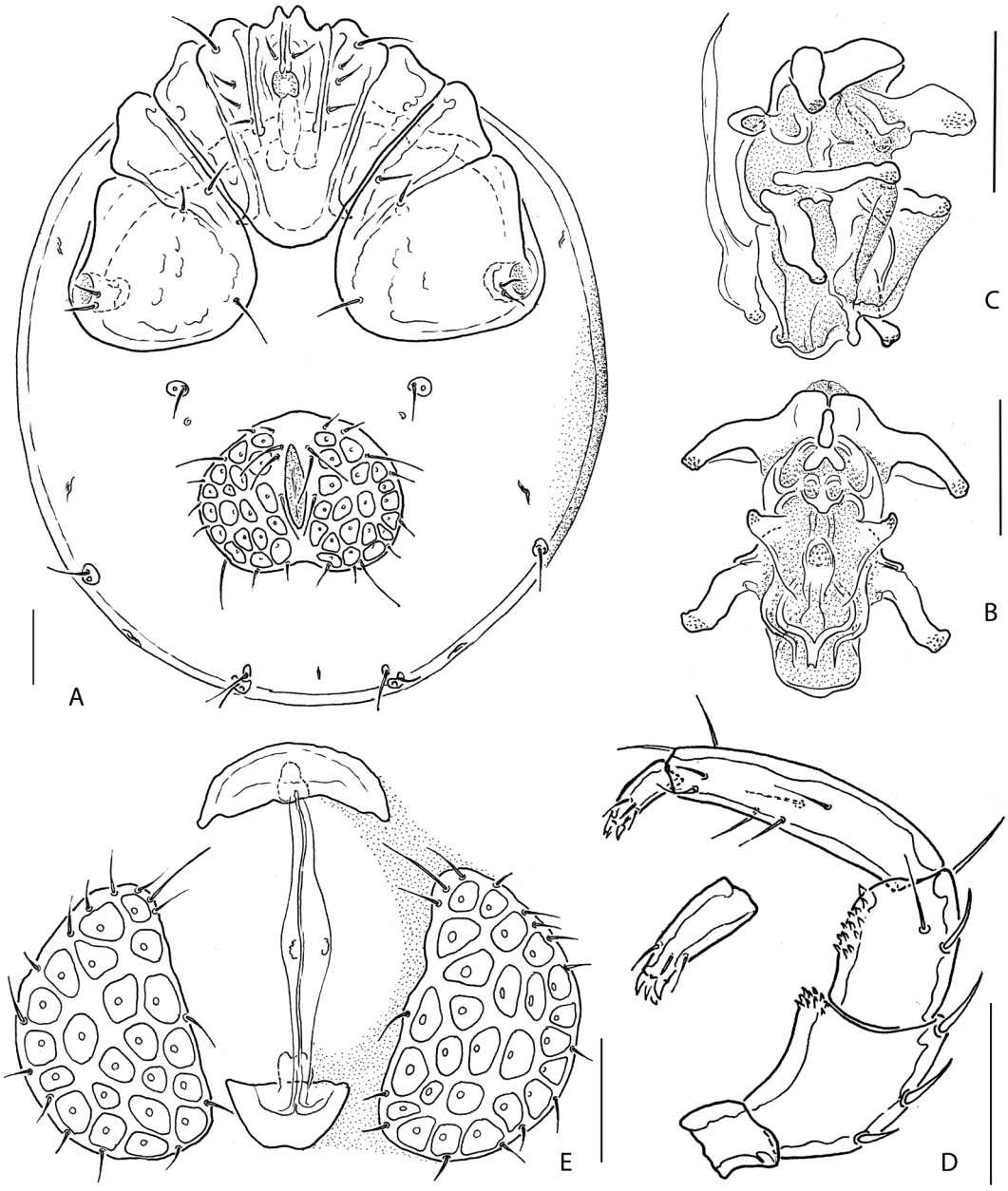

FIGURE 1. *Hygrobates norvegicus* Thor, 1897. **A–D**. male. **A**. Venter. **B–C**. Ejaculatory complex (**B**. Anterior. **C**. Lateral view). **D**. Palp (detail: P-5). **E**. Female genital field. Scale bars: 100 µm.

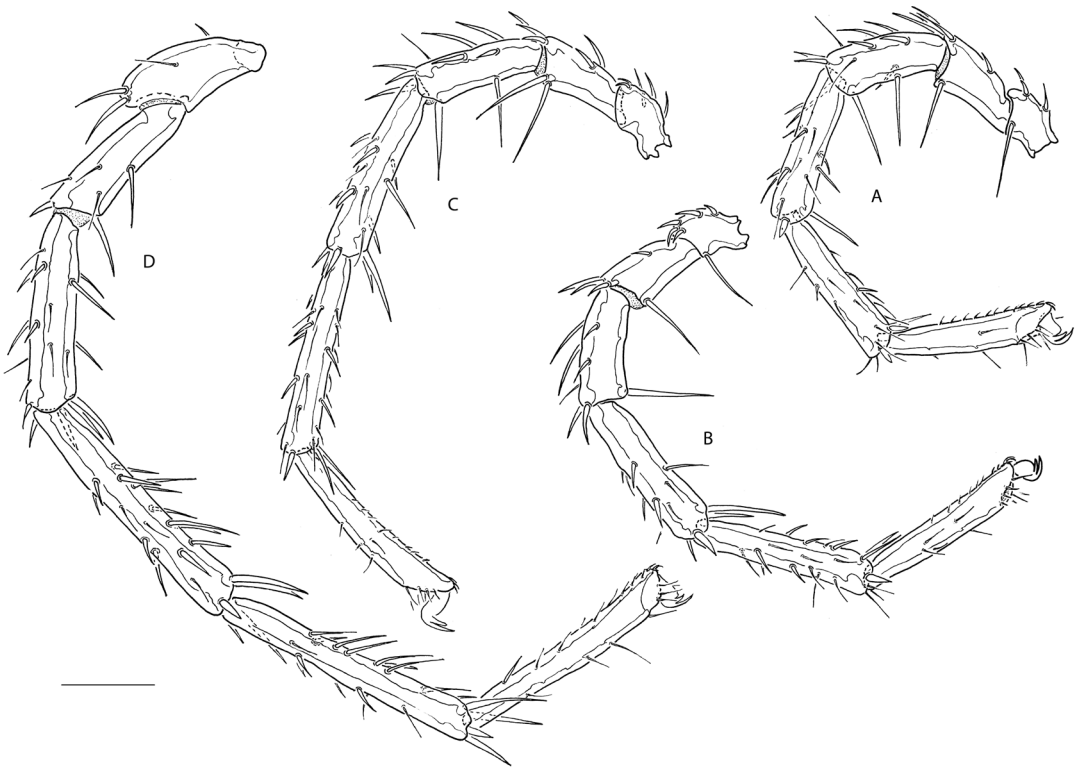

FIGURE 2. *Hygrobates norvegicus* Thor, 1897, male. **A**. I-leg. **B**. II-leg. **C**. III-leg. **D**. IV-leg. Scale bar: 100 µm.

IV-leg-4/6, 1.23-1.40; IV-leg-5/6, 1.29-1.43.

Females: Idiosoma L/W 780-1120/570-870; coxal field L 470-500, Cx-II W 410-480, Cx-I+II mL 310-375, Cx-I+II apodeme W 120-180; genital plate L/W 180-220/105-138, gonopore L 200-310, praegenitale W 120-190, postgenitale W 70-105, Ac n right/left 17-28/17-23; max. Ac diameter 38-45; eggs max. n 3, diameter 190-320. Chelicera L 285-340, basal segment/claw ratio 2.44-2.88, L/H ratio 2.28-2.56; palp total L 502-540, segments L (L/H ratio, relative L): P-1, 40-48 (0.9-1.2, 7.9%-9.1%); P-2, 130-143 (1.3-1.5, 25.7%-26.7%); P-3, 95-105 (1.3-1.5, 18.8%-20.0%); P-4, 175-192 (4.0-4.5, 33.8%-35.6%); P-5, 55-60 (2.5-2.8, 10.3%-11.4%); P-4 ventral setae dist 4-15; L ratio P-2/P-3, 1.29-1.42; P-2/P-4, 0.74-0.77; P-3/P-4, 0.53-0.59. Leg segment measurements (in parentheses, L/H ratio): I-leg-1, 75-86 (1.33-1.62); I-leg-2, 90-110 (1.58-1.91); I-leg-3, 135-150 (2.50-2.70); I-leg-4, 180-200 (3.80-4.22); I-leg-5, 190-215 (4.17-4.75); I-leg-6, 160-175 (3.95-4.38), I-leg-6 L max 200-220, claw L 40-45. IV-leg-1, 150-170 (2.0-2.2); IV-leg-2, 150-170 (2.5-3.0); IV-leg-3, 225-250 (4.3-5.2); IV-leg-4, 290-330 (5.8-6.5); IV-leg-5, 305-340 (7.0-8.3); IV-leg-6, 230-290 (6.1-7.3) - IV-leg-6 L max 260-300, claw L 40-50 (14-21% IV-leg-6 L); L ratio IV-leg-4/5, 0.95-1.00; IV-leg-4/6, 1.10-1.32; IV-leg-5/6, 1.14-1.33.

Discussion

Hygrobates norvegicus was introduced to science under the name of a new genus, *Rivobates* Thor, 1897, from a forest brook in the Gudbrandsdalen area in Norway. The original description of this first known polyacetabulate hygrobatid from Europe is poor in details and with extremely sketchy figures. One year later, a further polyacetabulate representative of the family, *Hygrobates polyporus* Piersig, 1998, was reported from a spring in Saxony, Germany (Piersig 1898, figures in Piersig 1896–1899). There, Piersig

stated that *Rivobates* should be treated as a junior synonym of *Hygrobates*. He considered the presence of a distoventral projection of P-2 as a diagnostic feature of *H. polyporus*. – In *H. norvegicus* the distoventral margin of this segment was described as "just slightly protruding, without a projection proper" (Thor 1897, without figures) - In a reply to Piersig (1898), Thor (1899) stated that there was no difference in palp shape between *H. norvegicus* and *H. polyporus* and proposed the latter as a junior synonym of *Rivobates norvegicus*. However, Piersig (1901) continued to treat the two taxa as separate species within the genus *Hygrobates*, based on the difference in palp morphology described above. No type material of *H. polyporus* has been defined and no specimens authorized by Piersig have remained in scientific collections. Comparing our redescription with morphological details and figures in Piersig (1896-1899) implies that Thor's (1899) synonymization with *H. norvegicus* was correct. Since then, only one further name was introduced for a *H. norvegicus*-like population from the Italian Alps, *H. norvegicus imminutus* Maglio, 1909. There the character states considered as diagnostic for the "forma" *H. norvegicus imminutus* were a relatively small idiosoma size (but given measurements fall within the range of the Norwegian material), a narrow interspace between Cx-I+II and Cx-III+IV, and a comparatively weak denticulation of P-3 (not documented in a figure). As no specimens representing the population in question are conservated in the collection Maglio at Verbania Pallanza (unpublished list by courtesy of Daniele Benfatti 1994), *H. norvegicus imminutus* must be considered an uncertain taxon. Rina Monti (1910), giving details about the variability in palp shape of *H. norvegicus* populations in the Italian Alps, mentions the name of *H. n. imminutus*, but does not make use of it.

Taxonomic labels in his collection and the use of his original name in a later publication (Thor 1914) document that Thor did not accept the synonymization of *Rivobates* with *Hygrobates*, in contrast to all other contemporary specialists. A proposal of K. Viets (1926) to treat *Rivobates* as a subgenus of *Hygrobates* was accepted by most authors up to the present. Similarly, until recently, the taxonomic state of *Hygrobates* (*Rivobates*) *norvegicus* was considered well defined. Figures of adults were published by numerous authors, but in general without describing and discussing morphological details: figures in accordance with the description given here were published by K.Viets (1928, identic in K.Viets 1936, K.Viets 1956, and Szalay 1964), Sokolow (1940), Gledhill (1960), Popp (1960), Hopkins (1961), Lundblad (1962), Motaş & Botea (1962), and Láska (1966). However, two specimens from Poland and France depicted under the name of *H. norvegicus* differ from the Scandinavian populations described here: a male from the Podlaskie Voivodeship (Demel 1922) who has a distinctly indented, not projecting anterior margin of the genital field, and a female from the Haut-Rhin province (Hubault 1927) who has acetabular plates with distinctly concave medial margins. As a curiosity, Szalay (1956) depicted a gynandromorphic specimen from a spring at Tiszabogdány (SW Ukraine); Bader (1969) provided a figure of the morphology of the intestinal system. Populations from Southern Italy (Calabria, Sicily) attributed to *H. norvegicus* by Gerecke (1991) were later described as *H. helocrenicus* Gerecke & Di Sabatino, 2013.

Specimens figured by Bader (1975) under the name of *Hygrobates norvegicus* show relatively larger and more robust genital fields with higher numbers of Ac (> 30), in males with a relatively shorter gonopore (L about 50% genital field), in females with genital plates having rounded anterior margins. These differences suggest that more than one species might be hidden behind the name of *H. norvegicus*. In all published papers, no details on morphology and setation of legs were given, except for statements about the absence of swimming setae. These appendages are here figured for the first time and could provide additional information for taxon discrimination within the subgenus *Rivobates*.

Walter (1922) described for the first time the larval stage, based on specimens reared from populations attributed to *H. norvegicus* living in the sanatory spring at Davos, and Martin (2003) redescribed the larval stage after specimens obtained from springs in the Berchtesgaden Alps. Both authors did not provide morphological

data about the parental adults. Karl Viets (1923) published, in addition to a drawing of a larva, first figures of the deutonymphal stage, based on populations from Northern Germany. Lundblad (1927) provided drawings of an egg clutch and a protonymph, reared from a population found in a spring in Sweden. Like Walter (1922), also the two latter authors did not provide adult morphology descriptions of their populations.

Based on the analysis of molecular data, Blattner et al. (2019) reported the presence of two distinct clades ("*Hygrobates* cf. *norvegicus* A/B") morphologically attributed to *Hygrobates norvegicus*. Morphological and molecular analysis of our material shows that "*Hygrobates* cf. *norvegicus* A" sensu Blattner et al. 2019 (BIN, BOLD:ACH7323) is genetically identic with *Hygrobates norvegicus* (Thor, 1897) as it is defined here. Our data suggest that in Norway only representatives of this typical clade are present (in addition to a second, closely related BIN, BOLD:AEC4178). "*Hygrobates* cf. *norvegicus* B" sensu Blattner et al. 2019 (BIN, BOLD:ADV5105) represents obviously an undescribed species, at present recorded from Alpine areas of Germany and Switzerland. To this species might refer the above mentioned, morphologically different specimens reported by Bader (1979) from the Swiss National Park.

Data in BOLD show a rather wide distribution of *Hygrobates norvegicus* in Central and Eastern Europe (records from Germany, The Netherlands, Poland, Russia and Montenegro).

Several genera of non-biting midges (Diptera, Chironomidae) from the subfamilies Orthocladiinae and Chironomidae are reported as hosts for the parasitic larvae of *Hygrobates norvegicus* (Martin & Stur 2006, Martin et al. 2010). Dealing with two different molecular clades named *H. norvegicus* the question arises if representatives of these two clades have the same host spectrum or can also be separated by having a different host preference. As a start, we collected and sequenced a *H. norvegicus* s. str. larva (BOLD specimen id HYDCA770, voucher lost) from the abdomen of *Brillia bifida* (Orthocladiinae). The record is visible in the dataset DS-HYGRONOR (dx.doi.org/10.5883/DS-HYGRONOR).

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