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A new species of *Hydraena* (Coleoptera: Hydraenidae) of the *H. evanescens* complex from Sardinia*

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Abstract

A morphological analysis was performed in order to clarify the taxonomic scenario within the *Hydraena evanescens* complex (Coleoptera: Hydraenidae: Hydraeninae), including species associated with fast running waters in mountain areas of Corsica and Sardinia. The analysis was mainly focused on the specific distinction and formal description of a new species, *H. rosannae* **sp. nov.**, from the Sulcis-Iglesiente region (SW Sardinia), morphologically distinctly separated from both the nearly parapatric *H. tyrrhena* Binaghi, 1961 (central and northern Sardinia) and the allopatric *H. evanescens* Rey, 1884 (Corsica). Two hypothetical palaeogeographical scenarios explaining the specific differentiation of the three species are briefly discussed.

Key words: Moss beetles, *Hydraena*, *Haenydra* lineage, new species, Corso-Sardinia, palaeogeography

Introduction

Hydraena Kugelann (*s. l.*) is the largest genus within the family Hydraenidae, including some 700 species worldwide (Jäch *et al*. 2000; Beutel *et al*. 2003). The large W-Palaearctic subgenus *Haenydra* Rey, 1886 was the object of a series of recent discussions, aimed at considering this group either as a quite distinct separate genus or subgenus (Jäch 1988, 1992; Angelini *et al.* 1995; Audisio & De Biase 1995; Ferro & Audisio 2006) or as a simple "lineage" of related species without any generic or even subgeneric value (Jäch *et al*. 2000, 2006; Beutel *et al*. 2003). We intend to discuss the taxonomic position of this assemblage elsewhere, based upon a series of relevant apomorphic characters well supported also by molecular data (Ferro & Audisio 2006; Ribera *et al*. unpublished; Audisio *et al*. unpublished). Here we only recall that *Haenydra* is certainly a monophyletic clade, including just over 80 species distributed from southern Spain westwards at least to northern and western Iran eastwards (Bilton & Jäch 1998; Jäch *et al.* 2006).

During a recent (2008) field trip in Sardinia organized by the CNBFVR (Centro Nazionale per lo Studio e la Conservazione della Biodiversità Forestale "Bosco Fontana", Verona, Italy) in the Sulcis-Iglesiente region, we discovered a new species of *Hydraena* (*Haenydra* lineage) closely related to but specifically distinct from *H. tyrrhena* Binaghi, 1961, the only representative of this group hitherto known from Sardinia. *H. tyrrhena* was recently raised from subspecific to specific rank and separated from the Corsican *H. evanescens* (Rey, 1884) (Binaghi 1961; Audisio & De Biase 1995), due mainly to important differences in the shape of the aedeagus.

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The present paper is thus mainly focused on the specific distinction and formal description of the above-mentioned new species, *H. rosannae* **sp. nov.**, from the Sulcis-Iglesiente region (SW Sardinia).

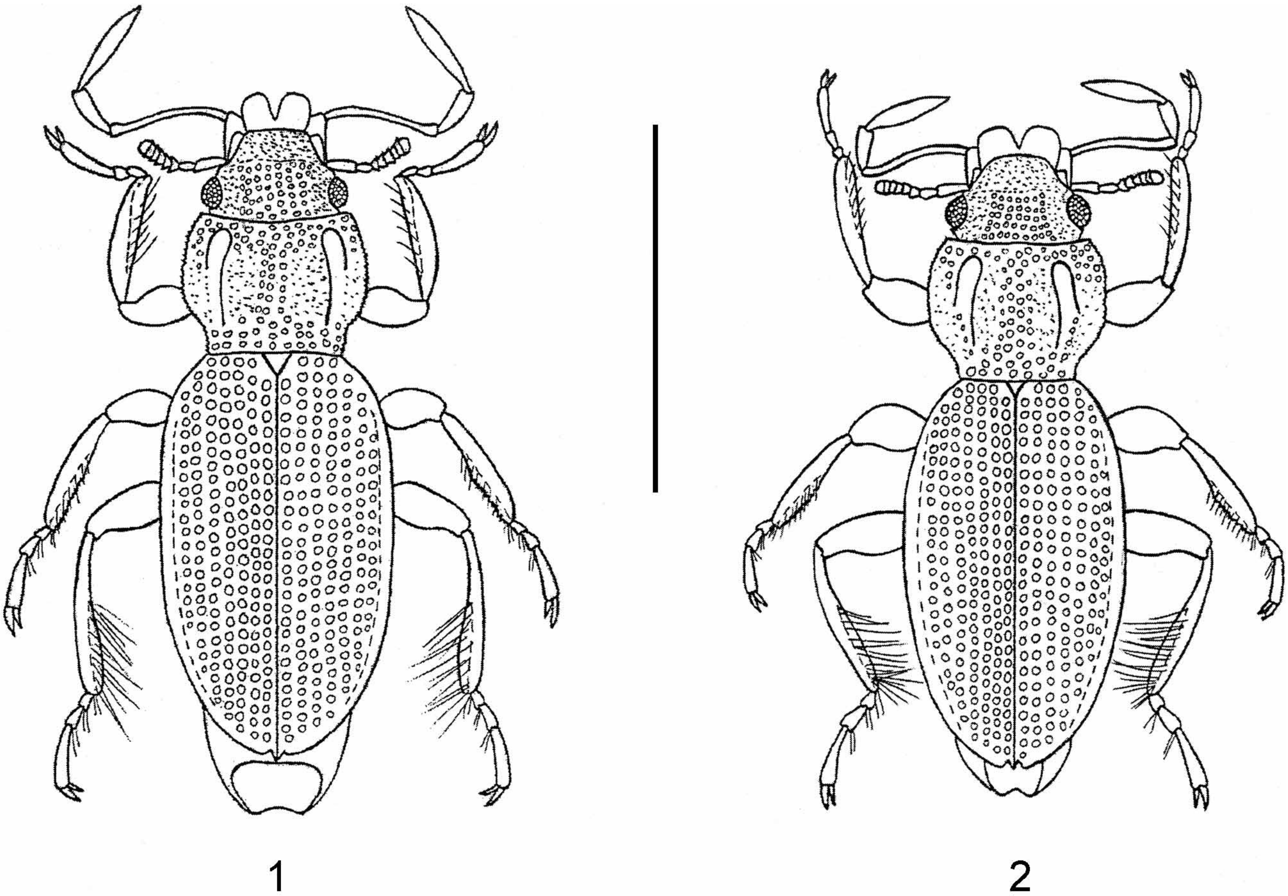
Abbreviations

CAR	P. Audisio collection, Sapienza University of Rome, Italy
CDL	J.A. Díaz collection, University of Lugo, Spain
CDM	J.A. Delgado collection, University of Murcia, Spain

The *Hydraena evanescens* species-complex

The here morphologically defined *Hydraena evanescens* complex comprises three European species (including *H. rosannae* sp. nov. described below) sharing the following combination of characters:

- Body size small (1.8–2.2 mm), long and thin, uniformly reddish to yellowish (Figs 1–2), with elytra long, only narrowly flattened at sides.
- Pronotum moderately transverse, about 1.15–1.18 times as wide as long (Figs 1–2).
- Mid and posterior tibiae in males without teeth or distinct thorns, posterior tibiae in males only moderately dilated in their distal half (Figs 1–2).
- Male genitalia with a rather small and short aedeagus, dilated in the middle in lateral view, with a very small and relatively simple distal mobile piece (Figs 3–8), a very short and hardly visible flagellum, and with only a couple of small, almost obliterated pre-distal setae on the main piece.



FIGURES 1–2. Male habitus of *Hydraena* spp. **1.** *Hydraena rosannae* sp. nov. (paratype, Sardinia, Villacidro, Cannisoni River). **2.** *Hydraena tyrrhena* Binaghi (Sardinia, Aratu River, near Desulo). Scale bar: 1 mm.

List of included species

1 ***Hydraena evanescens*** Rey, 1884
Hydraena evanescens Rey, 1884: 270.

2 ***Hydraena tyrrhena*** Binaghi, 1961
Hydraena evanescens ssp. *tyrrhena* Binaghi, 1961: 75.

3 ***Hydraena rosannae*** Audisio, Trizzino & De Biase **sp. nov.**

Hydraena rosannae Audisio, Trizzino & De Biase, sp. nov.

(Figs 1, 7–8, 11)

Diagnosis. Small-sized (length 1.94–2.21 mm), elongate orange species with yellowish to orange legs and antennae; pronotum 0.62–0.81 times width of combined maximum elytral width (Fig. 1). Similar to the widespread Sardinian *H. tyrrhena* Binaghi, 1961 and to the Corsican *H. evanescens* Rey, 1884, recently re-described by Audisio and De Biase (1995), but with a much less deep emargination on dorsal profile of aedeagus (in lateral view), slightly more inflated apical portion of male hind tibiae, and slightly sinuose and dilated middle portion of male front tibiae (Fig. 1).

Type material. Holotype ♂: Italy, Sardinia (Medio Campidano province), above Villacidro, Cannisoni River, 390 m a.s.l., 39.24.37.28 N, 8.38.27.39 E, 19.V.2008, M. Trizzino, P. Audisio, G. Nardi & M.Bardiani leg. (CAR).

Paratypes: same data as holotype, 2 ♂♂, 3 ♀♀ (CAR, CDL, CDM).

Description. Male [measurements refer to holotype]. Length (apex of labrum – apex of pygidium) 2.21 mm; breadth (at elytral widest point) 0.70 mm, pronotal breadth 0.57 mm. Elongate, scarcely convex (Fig. 1), orange with shiny reflections. Legs, antennae and lateral edges of pronotum yellowish to pale orange.

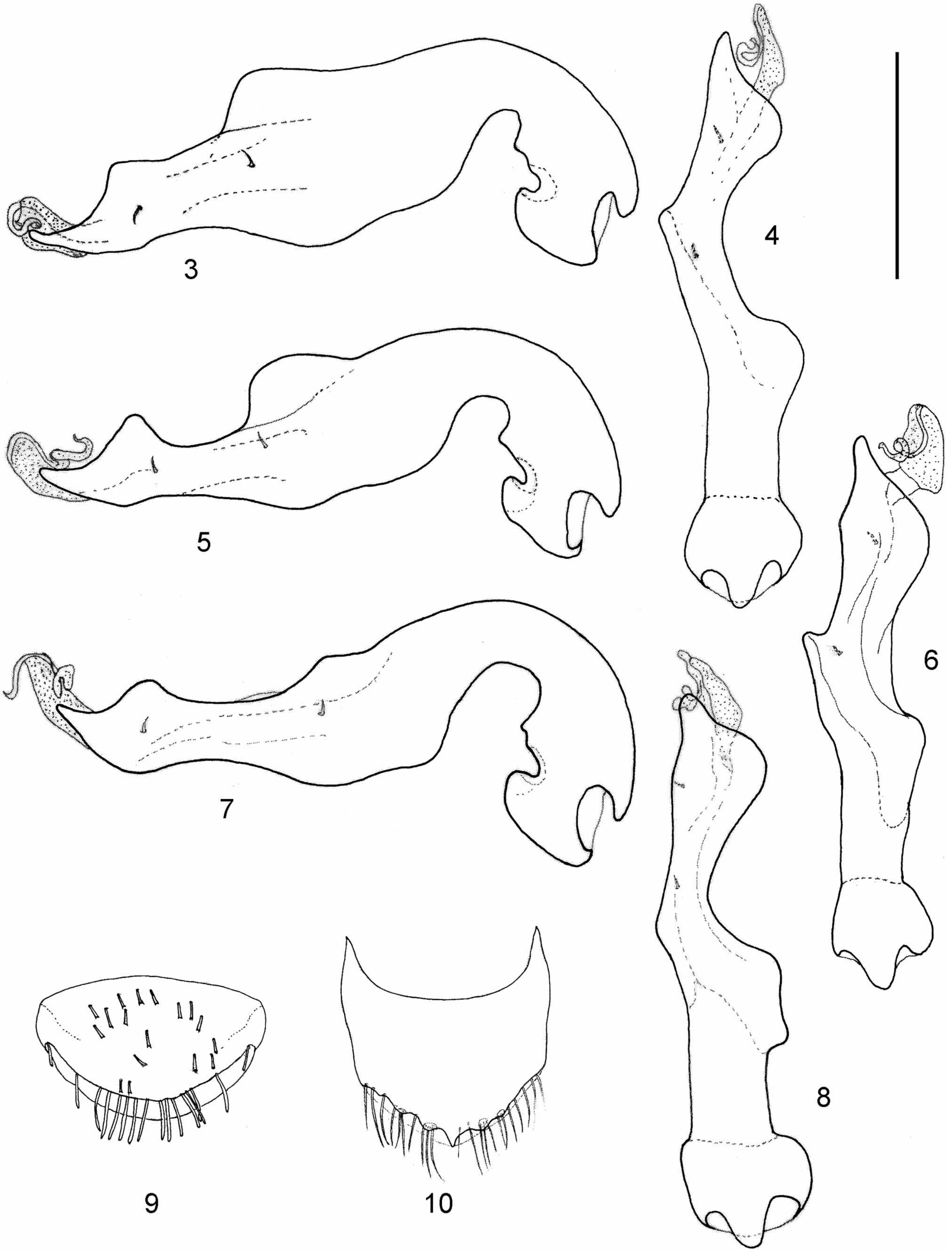
Labrum with deep, V-shaped notch anteriorly; margins very slightly upturned. Fronto-clypeal suture almost straight. Middle of frons moderately densely punctate, interstices shining; lateral portions of frons densely and rugosely punctate, punctures and interstices microreticulate; paraocular grooves shallow. Eyes moderately large, protruding, with more than 20 facets visible in dorsal view. Maxillary palpi very long, about twice as long as distance between eyes. Antennae small, of normal shape for members of the *Haenydra* lineage (Fig. 1).

Pronotum nearly exagonal, about 1.15 times wider than long; anterior margin slightly concave; anterior angles slightly obtuse; lateral margin moderately produced at middle, strongly convergent at anterior angle, sinuately convergent at posterior angle; lateral rim minutely crenulate; disc moderately convex, sparsely to moderately densely punctate, more densely punctate near anterior and posterior margins, smooth and punctate between punctures, foveae hardly perceptible; anterior and posterior sublateral foveae well impressed, elongate; lateral portion of pronotum evenly deflexed, sparsely punctate (Fig. 1).

Elytra elongate, nearly 1.8 times as long as their combined width, slightly and regularly arcuate at sides, apically produced and only very weakly declivitous; moderately declivitous laterally; with seven rows of punctures between suture and shoulder; strial punctures moderately large, distinctly impressed and forming regular lines moderately deeply impressed in middle of each elytron; punctures rather densely arranged within lines; intervals and interstices almost flat and glabrous or superficially microreticulate; intervals slightly wider than one puncture diameter; explanate margin and pseudepipleura relatively narrow and long, not reaching apex (Fig. 1).

Pygidium in male as in Fig. 1.

Mentum and submentum microreticulate. Transverse genal ridges not very prominent, glabrous.



FIGURES 3–10. 3–8. Aedeagus of *Hydraena* spp. in lateral and dorsal view. **3–4.** *Hydraena evanescens* Rey (Corsica, Vizzavona). **5–6.** *Hydraena tyrrhena* Binaghi (Sardinia, Aratu River, near Desulo). **7–8.** *Hydraena rosannae* sp. nov. (paratype, Sardinia, Villacidro, Cannisoni River). **9–10.** Female of *Hydraena rosannae* sp. nov. (paratype, Sardinia, Villacidro, Cannisoni River). **9.** Last abdominal tergite. **10.** Last abdominal sternite. Scale bar: 0.2 mm.

Prosternum with median keel. Mesoventrite with a pair of sublateral distinct glabrous streaks; very deeply impressed between disc and posterior process. Metaventral disc shallowly impressed between well developed, posteriorly divergent plaques.

First ventrite without glabrous areas behind metacoxal sockets; abdominal sternites III–VI more or less entirely covered with hydrofuge pubescence; abdominal sternites VII and VIII largely glabrous.

Aedeagus (Figs 7–8): main piece (length ca. 472 µm) oriented as in Figs 7–8, with only two small, short, and hardly distinct setae on left side, apparently without setae on right side; distinctly bisinuous in apical half (dorsal view); with subtruncate projection before the middle (dorsal view), and with proximal obtuse projection on dorsal side of apical fifth; apical third short and thick (lateral view), apex acute; dorsal outline (lateral view) with a very wide and shallow arcuate emargination at distal third; prebasal tooth (lateral view) not very prominent.

Phallobase more or less symmetrical (in dorsal view). Distal mobile lobe small, elongate, composed of two parts: an elongate piece and a very thin and short flagellum.

Secondary sexual characters. Male elytral apices convergent posteriorly, slightly conjointly rounded (Fig. 1); in female only slightly more acuminately convergent (with small sutural notch). Male femora slightly more strongly built. Male protibiae slightly but distinctly dilated and hardly curved along their inner edge. Male mesotibia not dilated subapically, with a row of short spines and 11–12 minute denticles along their inner edge. Male metatibia slightly but distinctly dilated in distal half, with fringe of very long hairs along their inner edge.

Female. Last abdominal tergite and sternite as in Figs 9–10.

Variability. Length variable between 1.94 and 2.21 mm.

Distribution. Known with certainty only from the Sulcis-Iglesiente area around Villacidro (Medio Campidano province), SW Sardinia.

Biological notes. The type specimens were collected under stones in a stream with relatively fast-running water, on a granodioritic substrate, at nearly 400 m a.s.l.

Etymology. This species is named after Mrs Rosanna Calabrò (M.T.'s wife).

Key to the *Hydraena evanescens* species-complex

1 (2) Male anterior tibiae more robust and with slightly more curved inner edges (Fig. 1). Male posterior tibiae slightly more distinctly dilated in their distal half (Fig. 1). Dorsal outline of aedeagal main piece (in lateral view) with a very wide and much shallower arcuate emargination in distal third (Fig. 7), and with only a weak angulate projection slightly distad to the middle. Middle portion of aedeagal main piece (in lateral view) thinner, 0.21 times as thick as length of aedeagal main piece (Fig. 7). Distributed in SW Sardinia.. ***H. rosannae*** Audisio, Trizzino & De Biase, sp. nov.

2 (1) Male anterior tibiae weaker and with nearly straight inner edges (Fig. 2). Male posterior tibiae slightly more weakly dilated in their distal half (Fig. 2). Dorsal outline of aedeagal main piece (in lateral view) with a deeper and widely U-shaped emargination in distal third (Figs 3, 5), and with a marked gibbose projection slightly distad to the middle. Middle portion of aedeagal main piece (in lateral view) thicker, 0.25–0.32 times as thick as length of aedeagal main piece (Figs 3, 5). Distributed in Corsica or in central and northern Sardinia............................. **3**

3 (4) Middle portion of aedeagal main piece (in lateral view) thicker, 0.31–0.32 times as thick as length of aedeagal main piece (Fig. 3); dorsal outline with shallower and more widely U-shaped emargination at distal third. Distributed in Corsica .... ***H. evanescens*** Rey, 1884

4 (3) Middle portion of aedeagal main piece (in lateral view) thinner, 0.25–0.26 times as thick as length of aedeagal main piece (Fig. 5); dorsal outline with deeper and more narrowly U-shaped emargination at distal third. Distributed in central and northern Sardinia.. ***H. tyrrhena*** Binaghi, 1961

Discussion

The phylogenetic relationships of members of the *Hydraena evanescens* complex are still rather obscure.

They clearly represent part of an ancient stem within the *Haenydra* lineage, showing morphological similarity (but no certain phylogenetic relationships) only with the rare western Iberian endemic *H. lusitana* (Berthélemy *in* Berthélemy & Whitton De Terra, 1977), but likely having some weakly defined relationships also with the relict and extremely rare *H. carniolica* Pretner, 1970 from NE Italy and Slovenia (Ferro & Audisio 2006). Also members of the *H. truncata* Rey, 1885 and *H. producta* (Mulsant & Rey, 1852) species groups from southern Europe (Audisio & De Biase 1995) could be weakly related. The marked morphological differentiation characterizing members of the *H. evanescens* complex should suggest that their common ancestor probably stayed isolated in the Corso-Sardinian microplate before its counter-clockwise rotation, started some 27–30 mya from its original position close to the present-day Mediterranean coastal areas of NE Spain and S France, included in the ancient Iberian Plate (Alvarez 1972, 1974; Cherchi & Montadert 1982; Sbordoni *et al*. 1990; La Greca 1990; Caccone *et al*. 1994; Cimmaruta *et al*. 1998; Oliverio *et al*. 2000; Ketmaier *et al*. 2003; Lanza *et al*. 2008). However, cues from preliminary molecular data on members of the *Haenydra* lineage (Ribera, personal communication 2008) seem to be more compatible with a relatively more recent differentiation of the whole lineage in southern Europe. On the other hand, differential morphological characters seem to suggest that *H. rosannae* separated earlier from the pair [*Hydraena evanescens* + *H. tyrrhena*], while preliminary molecular data on members of the *H. evanescens* complex (Ribera, Trizzino & Audisio, unpublished data) indicate that *H. rosannae* separated, in fact, only more recently from *H. tyrrhena*. As observed in different groups of vertebrates and invertebrates (Nascetti *et al*. 1996; Cimmaruta *et al*. 1998; Ketmaier *et al*. 2003; Lanza *et al*. 2006, 2008), the Sulcis-Iglesiente area has proved to represent a relevant sub-region of secondary local differentiation, due to a long isolation from the rest of Sardinia after the Messinian age (Early Pliocene, some 5.2–4.0 mya) caused by a marine transgression which transformed the Sulcis-Iglesiente region into a smaller island (Cherchi & Montadert 1982; Boccaletti *et al*. 1990). An alternative interpretation of this insularity condition refers to an even pre-Miocenic origin of the so-called "Iglesias zone block" (Sulcis-Iglesiente block) from an isolated microplate originated from the Alboran Plate (La Greca 1990), but we obviously exclude a causal relation between the speciation of *H. tyrrhena* and the last mentioned ancient palaeogeographic event. About the cladogenetic event which separated the pair [*Hydraena evanescens* + *H. tyrrhena*], even though short contacts between southern Corsica and northern Sardinia may have occurred until very recent times (Late Pleistocene), the separation of these islands from each other was almost certainly complete by 9 mya (Alvarez 1972, 1974; Cherchi & Montadert 1982; Caccone *et al*. 1994; Carranza *et al*. 2008). With the above depicted palaeogeographic scenarios, we can hypothesize that at least two evolutionary and cladogenetic sequences better fit the combined set of available morphological and molecular data:

1. admitting a relatively ancient (30–35 mya) origin for the whole *Haenydra* lineage, the common ancestor of *H. rosannae* sp. nov., *H. tyrrhena*, and *H. evanescens* was present in mountain areas of the NE portion of the Iberian Plate and, some 27–30 mya, migrated following the Corso-Sardinian microplate during its counter-clockwise rotation. The cladogenetic event separating the pair [*Hydraena evanescens* + *H. tyrrhena*] in Corsica and Sardinia, respectively, likely originated some 8–9 mya, as discussed above. Under these circumstances, the cladogenetic event later separating *H. rosannae* sp. nov. from *H. tyrrhena* probably occurred only after the Messinian age (late Miocene-early Pliocene, some 5.2–4.0 mya), due to the above-mentioned secondary long isolation of the Sulcis-Iglesiente, separated into a smaller island from the rest of Sardinia, when the geographic range of a more continuously distributed Sardinian ancestor became fragmented because of sea introgression.
2. excluding a causal relation between the split of the *H. evanescens* clade from its continental sister taxon and the initial phases of the detachment of the Corso–Sardinian microplate from the mainland, and at the same time admitting a much more recent (about 5–6 mya) origin for the whole *Haenydra* lineage, the common ancestor of *H. rosannae* sp. nov., *H. tyrrhena* and *H. evanescens* was probably present in mountain areas of the emerged north-western portion of peninsular Italy. From there, due to Messinian (5.6–5.3 mya) contacts of Tuscany with NE Corsica and limited land connections between Corsica and

northern Sardinia, the species rapidly colonized the Corso-Sardinian system (for a similar evolutionary framework recently hypothesized in a group of land snails, see Ketmaier *et al*. (2006)). These time estimates coincide with the very last phase of detachment and rotation of the Corso-Sardinian microplate (from 5 to 3 mya). Under this scenario, the specific differentiation between *H. tyrrhena* and *H. evanescens* occurred only in more recent times, likely during the earlier Plio-Pleistocene ice cycles (some 2.3–1.5 mya) (Van Couvering 1997). The cladogenetic event finally separating *H. rosannae* sp. nov. and *H. tyrrhena* probably occurred during the Middle Pleistocene, some 0.5–1.0 mya.

The available morphological clues do not univocally support one of the two above-depicted biogeographic scenarios. However, a molecular paper based on comparison of mitochondrial and nuclear genes of the involved taxa is in preparation (Ribera, Trizzino & Audisio, unpublished data). The aims of this paper are twofold: to give more insights into the phylogenetic and zoogeographic relationships among members of the *Hydraena evanescens* complex, and to calibrate a molecular clock supporting a preliminary dating of the main steps of the *Hydraena* s.l. and *Haenydra* evolution in northern Mediterranean areas. However, our preliminary data outline values of genetic distance for the COI gene (computed as simple *p* values and corrected for multiple hits using the Tamura & Nei parameter model: *TN93*; Tamura and Nei (1993)) near to 3% between *H. evanescens* and the pair [*H. tyrrhena* + *H. rosannae* sp. nov.], and near to 1% between *H. tyrrhena* and *H. rosannae* sp. nov. Thus, the evolutionary rate could be calibrated pointing towards a particularly slow value (0.3–0.5% of genetic differentiation/my) in the first palaeogeographic scenario depicted, or towards a much faster value (1.5–2.0 % of genetic differentiation/my) in the second one. The mean values of evolutionary rate scored for the COI gene in other groups of Coleoptera (e.g., Stireman *et al*. 2005; Audisio *et al.* 2009) seem to better support the latter hypothesis (1.5–2.0%). However, the palaeogeographic history of Sardinia and Corsica, and the high level of morphological differentiation of the whole complex from any other relatives within the *Haenydra* lineage, certainly better support the cladogenetic events hypothesized in the first of the above options.

Moreover, it should be stressed that peculiarly low rates of molecular evolution, comparable to those postulated by our first palaeogeographic scenario, have been recently observed in other groups of Corso-Sardinian freshwater invertebrates (e.g., in the Plecoptera: Fochetti 1994; Fochetti *et al.* 2004, 2009).

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