Description of *Berkanella selouensis* gen. et sp.n., a new subterranean snail from Morocco and redescription of *Islamia tifertiensis* Glöer, Mabrouki et Taybi, 2020 (Gastropoda: Hydrobiidae)

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ABSTRACT: Recent studies on freshwater gastropods of the family Hydrobiidae from Morocco have led to a number of discoveries of new taxa. New field studies in the oriental region of Morocco have led to the discovery of living specimens of *Islamia tifertiensis* Glöer, Mabrouki, et Taybi, 2020, previously described only on the basis of empty shells. The study of the new fresh material led to the discovery of a new genus of valvatiform stygobionts, its redescription and assignment to a new genus as *Berkanella tifertiensis* gen. et comb.n. In addition, another stygobiont species belonging to the same new genus was discovered, i.e. *Berkanella selouensis* sp.n. described and illustrated here.
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KEY WORDS: hydrobiid snails; Triffa aquifer; stygobiont snail; new genus; freshwater gastropods; endemism; North Africa; groundwater.

Описание *Berkanella selouensis* gen. et sp.n., нового подземного брюхоногого моллюска из Марокко и переописание *Islamia tifertiensis* Glöer, Mabrouki et Taybi, 2020 (Gastropoda: Hydrobiidae)

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РЕЗЮМЕ: Недавние исследования пресноводных брюхоногих моллюсков семейства Hydrobiidae Марокко привели к открытию многих новых таксонов. Новые полевые

исследования в восточной части Марокко привели к обнаружению живых экземпляров *Islamia tifertiensis* Glöer, Mabrouki, et Taybi, 2020, вида, ранее описанного по пустым раковинам. Изучение нового свежего материала привело к открытию нового рода вальватиформных стигобионтов и переописанию вида как *Berkanella tifertiensis* gen. et comb.n. Также дано иллюстрированное описание второго стигобионтного вида того же рода, *Berkanella selouensis* sp.n.

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КЛЮЧЕВЫЕ СЛОВА: моллюски-гидробииды; водоносный слой Триффа; стигобионтные моллюски; новый род; пресноводные брюхоногие моллюски; эндемизм; Северная Африка; грунтовые воды.

Introduction

Freshwater molluscs, and in particular gastropods, are among the most abundant non-arthropod invertebrates in freshwater habitats worldwide, where they play important ecological roles (Sánchez *et al*., 2023), primarily by controlling water quality and nutrient balance through filter feeding and algae grazing, and to a lesser extent as a food source for predators, including a number of vertebrate species (Oscoz *et al*., 2014). These single-shelled molluscs can live in a variety of natural freshwater habitats (e.g. springs, streams, rivers, lakes), including aquifers, where some species, known as stygobionts, are adapted to live in caves and underground environments and form major components of stygobiotic communities worldwide (Kebapçi, 2013; Prié, 2019). Most stygobionts often have a pigmentless body and almost complete eye atrophy, they are minute (the shell width is usually between 1 and 2 mm). Often overlooked due to their small size, they are considered one of the most understudied groups of freshwater gastropods in the world (Gladstone *et al*., 2021; Glöer, 2022).

Morocco's geographical position makes it a country of particular interest for faunistic studies and nature conservation. Located at the crossroads of Europe and Africa, the country is bounded to the north by the Strait of Gibraltar and the Mediterranean Sea, and to the west by the Atlantic Ocean; the Moroccan coastline extends over 3500 km. In addition, Morocco has many geographical barriers, such as the Atlas Mountains (e.g. Jbel Toubkal, the highest mountain in North Africa), which divides the northern part of the country into two bioclimatic regions (Mabrouki *et al*., 2019a, b; Marrone *et al*., 2020; Taybi *et al*., 2020), all these conditions support high diversity ecosystems shaped by both the Mediterranean and the Saharan climate types (Abdul Malak *et al*., 2010). Morocco's freshwater ecosystem is one of the most diverse in the North African region, including groundwater, which is an important part of the country's freshwater heritage due to its geological formation, i.e. sedimentary basins with water tables and captive aquifers, karstic limestone massifs with large springs, etc. Morocco has about fifty superficial aquifers and thirty semi-deep to deep aquifers (Bahir, Mennani, 2002).

Despite its geographical position and the extraordinary diversity of its subterranean ecosystems, Morocco has been poorly studied, particularly with regard to its stygobiont molluscan fauna, including minute snails. Recent research in north-eastern Morocco has led to the discovery of a new genus of stygobionts in the family Hydrobiidae. In addition, we found living specimens of *Islamia tifertiensis* Glöer *et al*., 2020, which allows us to redescribe this taxon and place it in the new genus described here.

Material and methods

Field surveys were conducted between 2014 and 2023, in which several localities were prospected in north-eastern Morocco (Fig. 1). Stygobiont molluscs were collected from wells by means of a phreatobiological net, through filtering subterranean water by passing it through a nylon net and sieving mud and sediment. The samples were fixed in 75% ethanol. The dissections and measurements of the genital organs and the shells were carried out using a stereo

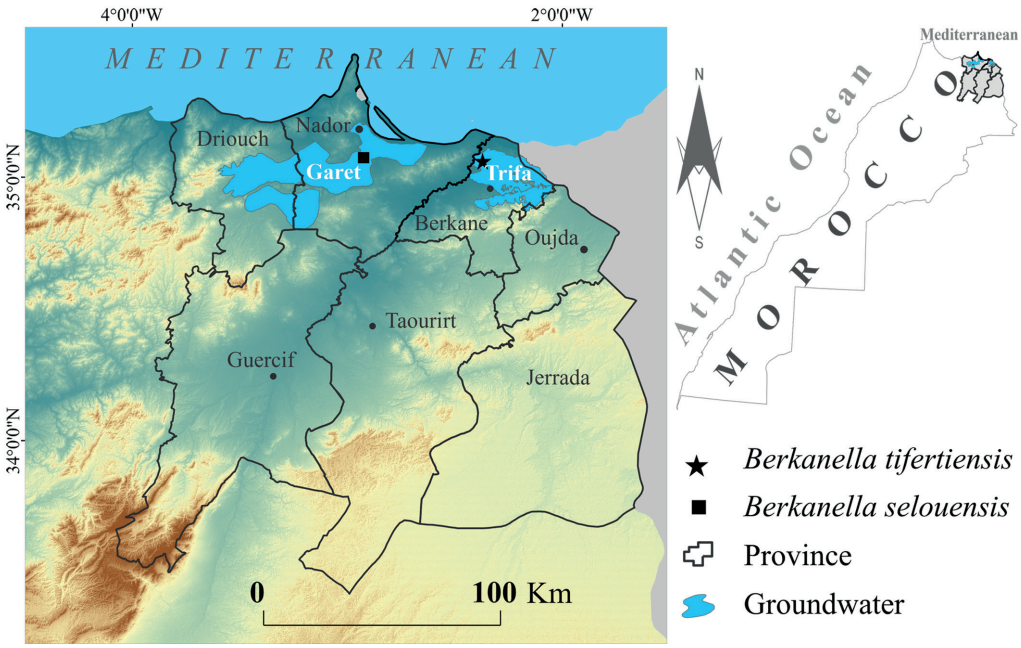

Fig. 1. Provinces of north-eastern Morocco, and the type localities of the new genus and species.
Рис. 1. Провинции северо-восточного Марокко и типовые местонахождения нового рода и вида.

microscope (Leica M205C) with a digital camera (Leica DMC5400). The type material is stored partly in the Zoological Museum Hamburg (ZMH), partly in the collection of the first author.

Results

Phylum Mollusca Cuvier, 1795
Class Gastropoda Cuvier, 1795
Superorder Caenogastropoda Cox, 1960
Superfamily Truncatelloidea Gray, 1840
Family Hydrobiidae Stimpson, 1865

Berkanella **gen.n.**
Figs 2–4.

TYPE SPECIES: *Islamia tifertiensis* Glöer *et al*., 2020 (see below).

DIAGNOSIS: The new genus is characterised by the following characters: the minute valvatiform transparent shell (when fresh), the colourless body and atrophy of eye spots (adapted to a subterranean or stygobiotic mode of life), the penis has a knob at the left side near the basis, at the distal end tapered.

DIFFERENTIAL DIAGNOSIS: *Berkanella* gen.n. may be confused with the only three genera of stygobionts and valvatiformes known to occur in North Africa, namely: *Rifia* Ghamizi, 2020, which has a bifurcated penis; the recently described *Maroccohoratia* Ghamizi et Falniowski, 2024 which has a proportionally minute penis, bent and triangular in shape, with a broad and slightly marked swelling distally on its right side, and finally *Maroccoaganiella* Ghamizi et Falniowski, 2024 which has a broad and straight penis flat and massive, with a broad and not prominent outgrowth distally on its right side. The "outgrowths" in the genera of Ghamizi *et al*. (2024) should be better named as "swelling". *Berkanella* gen.n. is the only stygobiont and valvatiform hydrobiid having a penis with a knob at the left side near the basis and the tapered distal end. While the other stygobiont genera i.e. *Heideella* Backhuys et Boeters, 1974; *Atebbania* Ghamizi *et al.*, 1999 and the recently described *Mahrazia* Mabrouki *et al.*, 2022 have elongated conical shells. The penis morphology of *Berkanella* gen.n. is a unique characteristic for the stygobiont and valvatiform microsnails, not known among any other hydrobiid genera. This feature justifies the description of a new genus, as it is acknowledged that hydrobiid genera can be identified by the shell shape in combination with the penis morphology (Radoman, 1983; Szarowska, 2006; Glöer, 2022). The other valvatiform genera of North Africa are crenobiont gastropods living in surface waters, have eyespots and pigmented bodies. The new genus resembles the recently described crenobiont *Ainiella* Taybi, Glöer et Mabrouki 2022. However, the latter has larger shells, pigmented bodies and the largest eyespots among the

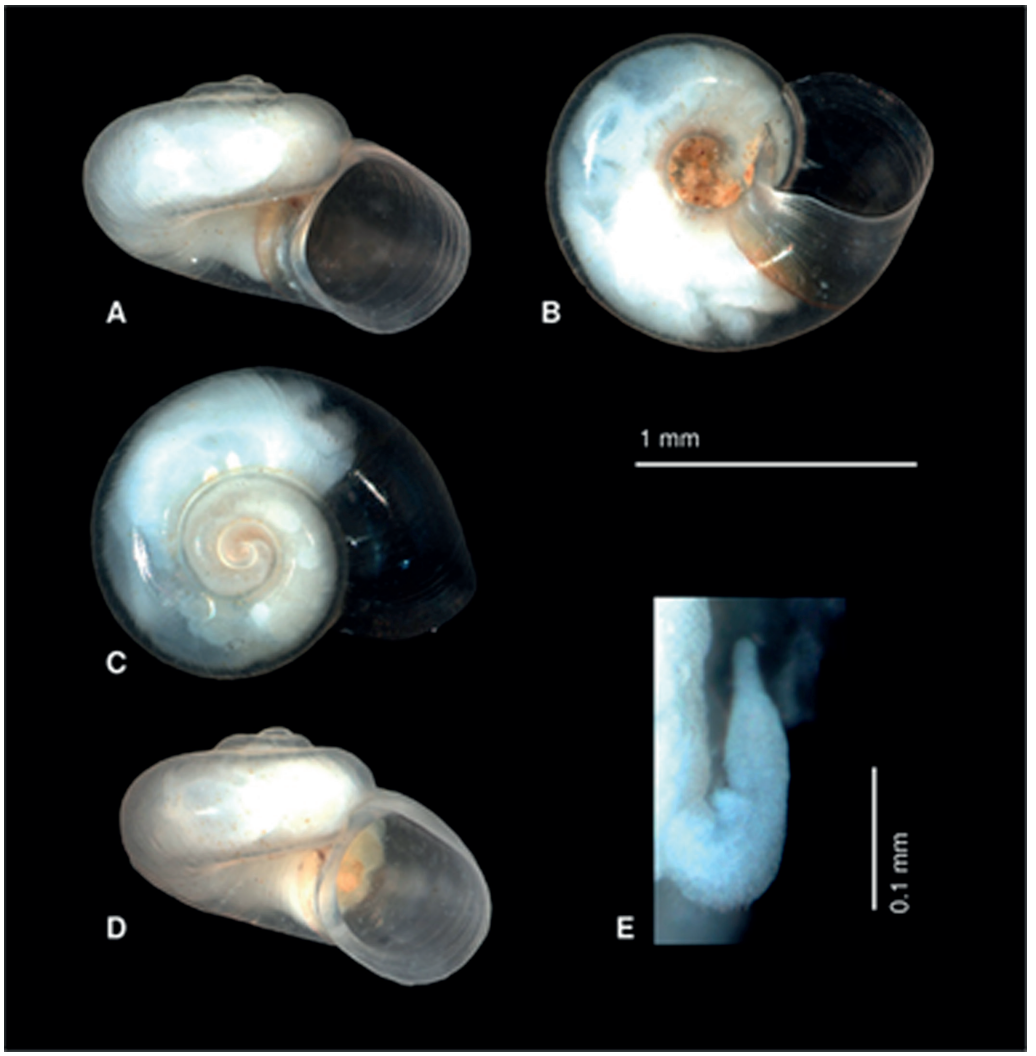

Fig. 2. Paratype of *Berkanella tifertiensis*. A–D — different views of the shell, E — penis.
Рис. 2. Паратип *Berkanella tifertiensis*. A–D — различные виды раковины, E — пенис.

valvatiform hydrobiid microsnails of North Africa. Whilst *Berkanella* gen.n. is an obligate stygobiont.

DERIVATIO NOMINIS. The new genus was named after Berkane province, where it was first found the first time.

The new genus contains two species, one of them is described below as new for science.

Berkanella tifertiensis (Glöer *et al*., 2020) **comb.n.**

Islamia tifertiensis Glöer, Mabrouki et Taybi, 2020: Glöer *et al*., 2020: 3–4; fig. 2.

MATERIAL EXAMINED. **Holotype**. Empty shell deposited in the collection of the Zoological Museum Hamburg (ZMH 140648). **Paratypes**. Three empty shells from the type locality deposited in the collection of the Zoological Museum Hamburg (ZMH 140649) and three ethanol-fixed specimens kept in the personal collection of Glöer and 10 ethanol-fixed specimens in the personal collection of Mabrouki and Taybi (Figs 2–4).

TYPE LOCALITY. Tiffert spring, Berkane province (the oriental region of Morocco), adjacent to the Moulouya River (2′16.800″N, 2°25′36.000″W), located inside the SBEI (Site of Biological and Ecological Interest) of the Moulouya, listed also as a Ramsar site. The live specimens (topotypes) were collected on 20 March, 2023.

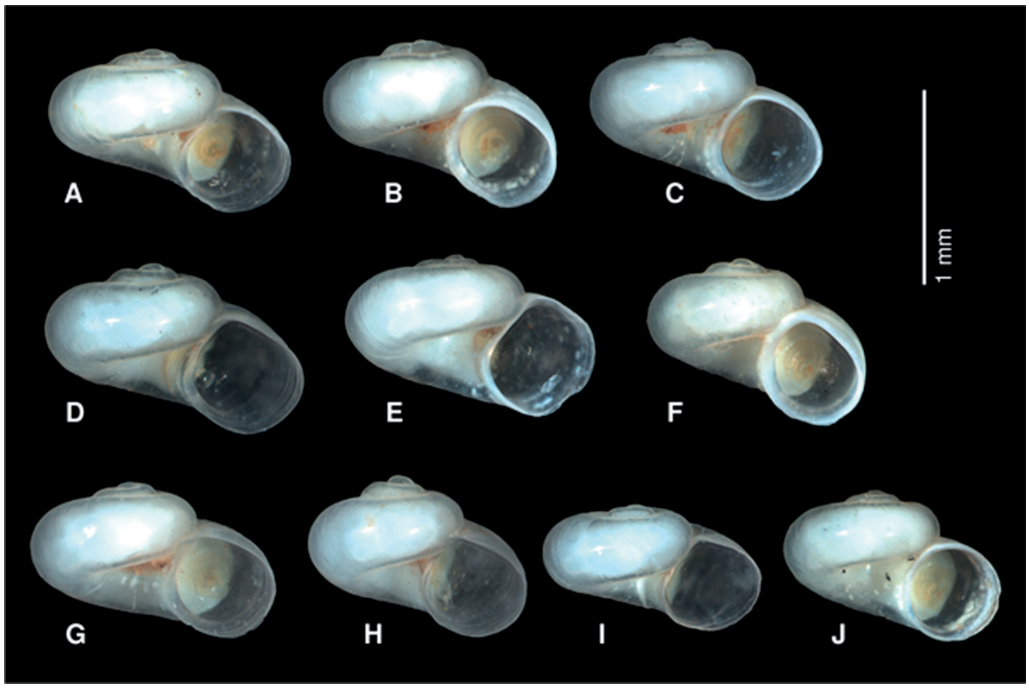

Fig. 3. A–J — topotypes of *Berkanella tifertiensis* comb.n. (Glöer *et al.*, 2020).
Рис. 3. A–J — типотипы *Berkanella tifertiensis* comb.n. (Glöer *et al.*, 2020).

DESCRIPTION:

CONCHOLOGICAL FEATURES. The translucent and colourless shell has 3 fast-growing glossy whorls with a slightly striated surface (Fig. 2A–D). Shell surface smooth, with growth lines that are slightly visible. The small spire is slightly raised up; the body whorl is prominent. The aperture is rather rhomboidal (or almost quadrangular) and prosocline (leaning forwards relative to the direction of growth), the peristome is situated at the bottom in umbilical view. The shell is 0.92–0.96 mm high and 1.31–1.42 mm broad. Shell measurements are presented in Table 1.

OPERCULUM. The corneous operculum is smooth and very thin, pale yellow.

SOFT PARTS. The species is eyeless and colourless, body translucent when alive (Fig. 4), white when preserved, pigment-less; cephalic tentacles very long and thin (no pallial tentacle), without eyes. The penis has a knob at the left side near the basis and the distal part is tapered (Fig. 2E).

REMARKS. This species has originally been places in the genus *Islamia* because we had only empty shells and were unable to study its anatomy (Glöer *et al*., 2020). The *Islamia* species of Mo-

Table 1. Shell measurements (in mm; N = 10; the measurement accuracy is 0.01) of *Berkanella tifertiensis* comb.n. (Glöer *et al*., 2020).
Таблица 1. Промеры раковин (в мм; N = 10; точность измерения 0,01) *Berkanella tifertiensis* comb.n. (Glöer *et al*., 2020).

Shell measurements	Minimum	Maximum	Mean	Standard deviation
Shell height	0.66	0.92	0.836	0.13
Aperture height	0.39	0.55	0.495	0.08
Spire height	0.27	0.37	0.341	0.05
Shell width	1.15	1.37	1.236	0.11
Aperture width	0.52	0.63	0.57	0.05

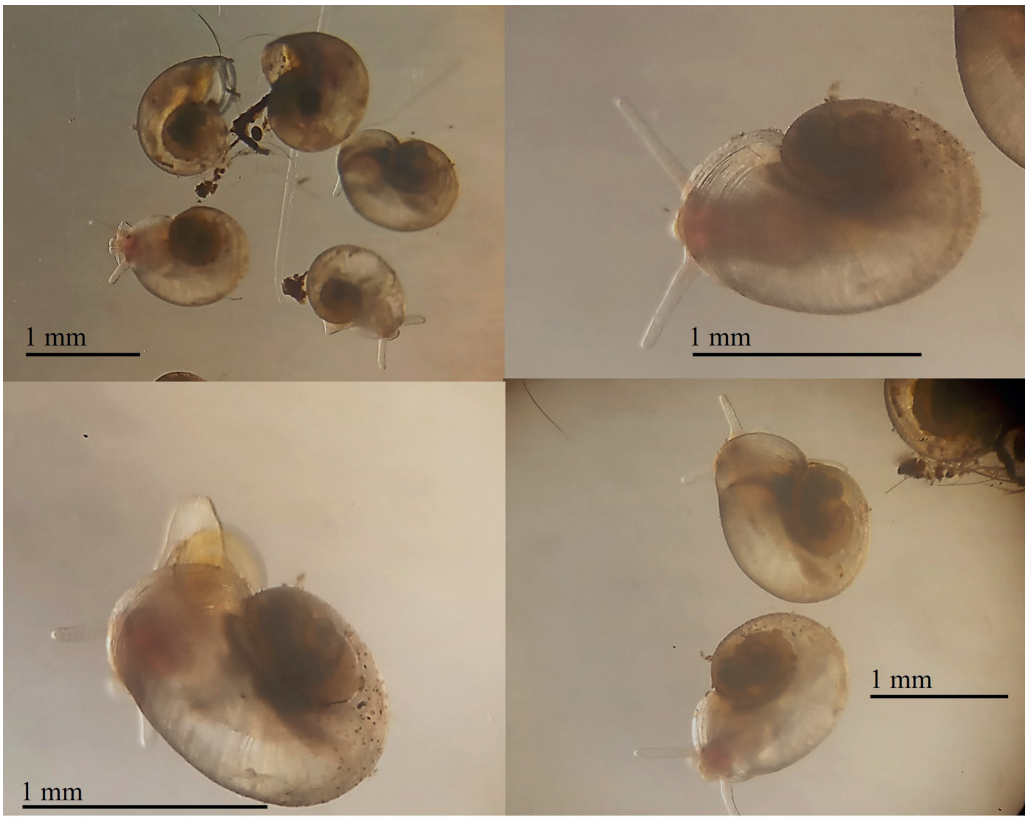

Fig. 4. Habitus of live specimens of *Berkanella tifertiensis* comb.n.
Рис. 4. Внешний вид живых экземпляров *Berkanella tifertiensis* comb.n.

rocco were described only based on shell criteria and assigned provisionally to this genus without knowledge of its anatomy, pending the discovery of males. In *Islamia*, the penis is bilobed and the bursa copulatrix is absent.

GEOGRAPHIC RANGE. This new genus and species is known only from eastern Morocco (Fig. 1). It's type locality, which is a spring located in the plain of Triffa, is bounded to the east by Oued Kiss (Algeria), to the north by the Mediterranean Sea, to the west by Oued Moulouya and to the south by the Beni-Snassen ranges. It covers an area of 61,000 ha and is one of the most fertile and productive areas in eastern Morocco (Yahya *et al*., 2017). The plain of Triffa (Eastern Morocco) has great socio-economic importance in the region; the local economy is based specially on agriculture, which consumes the total water use. Indeed, the plain is characterized by two aquifers: a free one of secondary and quaternary formations; and a confined aquifer of the Liassic formation (El Mandour *et al*., 1998).

Berkanella selouensis **sp.n.**
Figs 5–6.

MATERIAL EXAMINED. **Holotype**. Ethanol-fixed specimen (Fig. 5A, B, D), shell is 1.42 mm high and 1.31 mm wide, deposited in the collection of the Zoological Museum Hamburg (ZMH 141508). **Paratypes**. Two paratypes deposited in the collection of the Zoological Museum Hamburg (ZMH 141509), ethanol-fixed (Figs. 5C, 6). In addition, 10 ethanol-fixed specimens are kept in the personal collections of Mabrouki and Taybi.

TYPE LOCALITY. A well located inside the Multidisciplinary Faculty of Nador, Selouan, Nador province, the oriental region of Morocco (35°03′56.2″N 2°54′42.4″W) belongs to the watershed of the Marchica lagoon, the latter classified as SBEI (Site of Biological and Ecological Interest) and a Ramsar site. The groundwater of the region belongs to the aquifer of Garet. Collected on 20 March, 2023.

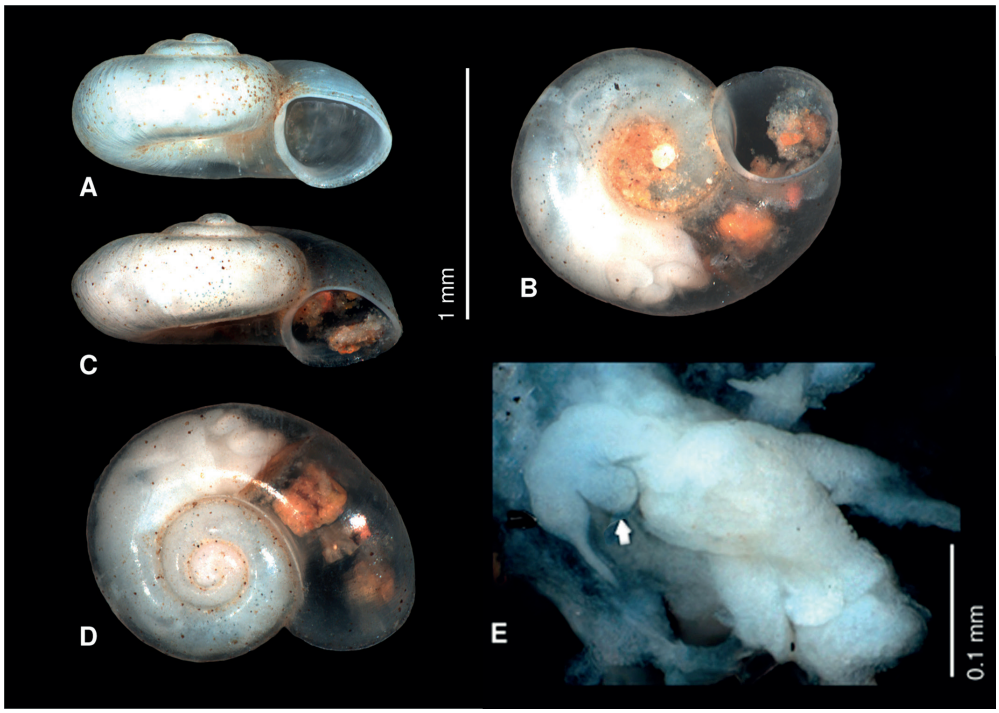

Fig. 5. *Berkanella selouensis* sp.n. A, B, D — holotype, C — paratype, E — penis (arrow).
Рис. 5. *Berkanella selouensis* sp.n. A, B, D — голотип, C — паратип, E — пенис (стрелочка).

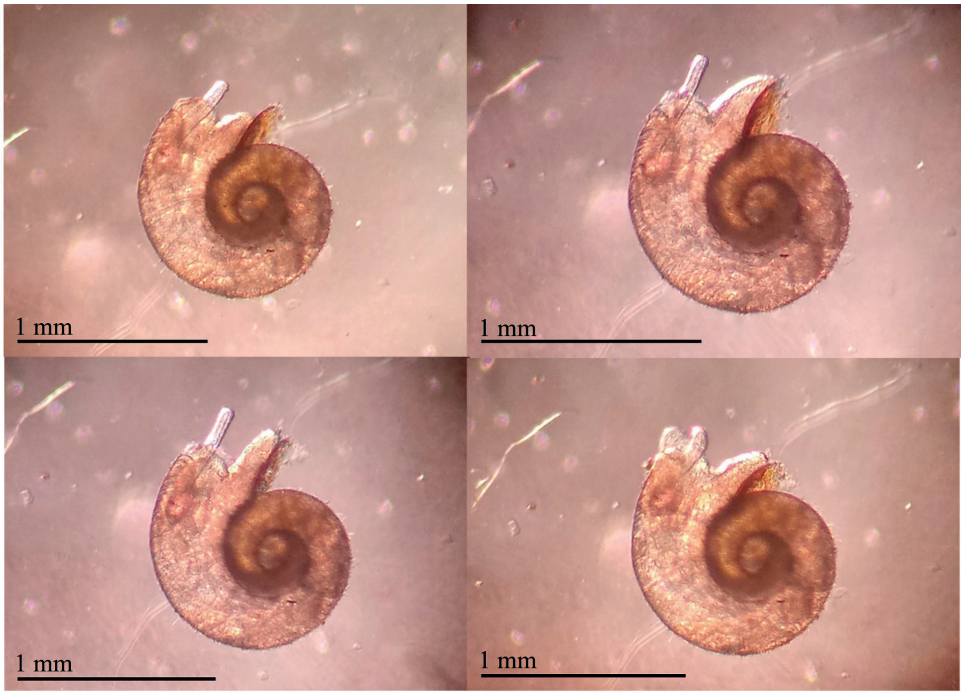

Fig. 6. Habitus of live specimen of *Berkanella selouensis* sp.n.
Рис. 6. Внешний вид живого экземпляра *Berkanella selouensis* sp.n.

Table 2. Shell measurements (in mm; N = 10; the measurement accuracy is 0.01) of *Berkanella selouensis* sp.n.
Таблица 2. Промеры раковин (в мм; N = 10; точность измерения 0,01) *Berkanella selouensis* sp.n.

Shell measurements	Minimum	Maximum	Mean	Standard deviation
Shell height	0.51	0.66	0.59	0.06
Aperture height	0.29	0.38	0.33	0.04
Spire height	0.22	0.28	0.25	0.03
Shell width	1.17	1.29	1.23	0.05
Aperture width	0.38	0.42	0.4	0.02

DESCRIPTION:

CONCHOLOGICAL FEATURES. The translucent, glossy and colourless shell has 3 fast-growing glossy whorls with a smooth surface, nearly planispiral and thin-walled. Shell growth lines are hardly visible (Fig. 5A–D). The small spire is slightly raised up; the body whorl is prominent. The aperture is prosocline and rounded, the peristome is not sinuated at the bottom from umbilical view. The umbilicus wide, with the earlier whorls visible inside. The shell is 0.63 mm high and 1.35 mm broad. Shell measurements are presented in Table 2.

OPERCULUM. The very thin corneous operculum is pale yellow.

SOFT PARTS. The species is eyeless and colourless (Fig. 6), cephalic tentacles very long and thin (no pallial tentacle); the penis has a large knob at the left side near the basis and the distal part is tapered (Fig. 5E).

DIFFERENTIATING CHARACTERS. The new species differs from *Berkanella tifertiensis* (Glöer *et al*., 2020) comb.n. by a lower shell, almost planispiral, the smooth shell surface, the non-sinuated peristome and the rounded aperture. In addition, the penis in *Berkanella selouensis* sp.n. is larger, widened at the basis and tapered at the distal end with a long pointed penis tip, and the knob is larger too.

DERIVATIO NOMINIS. The specific epithet refers to the city of Selouane, where the new species was found. It is located in the northeast, in the province of Nador, in the eastern Rif and the oriental region of Morocco.

GEOGRAPHIC RANGE. This new species is known only from the type locality and groundwater from a well located in north-eastern Morocco (Fig. 1). The Garet-Bouareg aquifer consists of a free aquifer, which extends continuously and generally under the two plains of Garet and Bouareg. This aquifer extends over an area of 570 km^2 (ADS, 2005). The overall quality of waters in this aquifer is poor due to the high mineralization of the waters (high salinity) and the high levels of nitrates. This is due to the geological nature of the formations from this aquifer and intensive agricultural use.

NOMENCLATURAL ACTS: This work and the nomenclatural acts it contains have been registered in ZooBank. The ZooBank Life Science Identifiers (LSID) for this publication are:

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Discussion

Our results raise the known taxonomic richness of the family Hydrobiidae *sensu stricto* in Morocco to 24 genera (Mabrouki *et al*., 2022a, 2023; Taybi *et al*., 2022a, b, 2023a, b; Ghamizi *et al*., 2024), and the stygobiont hydrobiids to nine species and seven genera. They typically exhibit highly restricted distributions and considered local endemics (except for *Rifia yacoubii* Ghamizi, 2020 which is widespread in the phreatic waters in the southern border of the Rif region, in the upstream of the Moulouya, Sebou and Loukkos basins, according to Ghamizi (2020)). The new genus and two species described here are currently known only from their type localities in north-eastern Morocco. The recently described *Maroccohoratia bouregregensis* Ghamizi et Falniowski, 2024 and *Maroccoarganiella touarguii* Ghamizi et Falniowski, 2024 are restricted to their type localities in the Bouregreg Basin (NW Morocco) (Ghamizi *et al*., 2024). *Mahrazia benlemlihi* Mabrouki, Taybi et Glöer, 2022 is endemic to Sais aquifer, known from a single locality (Mabrouki *et al*., 2022b). *Heideella andreae* Backhuys et Boeters, 1974 is distributed in southern-central Morocco and the Marrakech vicinity, and *H. makhfamanensis* Bodon, Ghamizi et Giusti, 1999 is endemic to the hyporheic

waters of Oued Makhfamane in the centre of the Haouz plain (central Morocco). *Atebbania bernasconii* Ghamizi, Bodon, Boulal et Giusti, 1999 seems restricted to the subterranean waters of the Tiznit plain (Glöer, 2022). Additionally, the two stygobiont Moitessieriidae species cf. *Iglica seyadi* Backhyus et Boeters, 1974 and cf. *Iglica soussensis* Ghamizi et Boulal, 2017 (Ghamizi, 2020) are known only from their type localities, respectively at Oued Noun and Ait Msia village in the Souss plain, area of Agadir (Backhuys, Boeters, 1974; MolluscaBase, 2021).

Although Morocco's freshwater ecosystem is one of the most diverse in the North African region, where the most diverse mollusc fauna seems to live in the aquifers and karst ecosystems, the equilibrium of Morocco's underground environments is generally considered to be fragile (Van Damme *et al.,* 2010). Subterranean waters in Morocco are currently facing many challenges, including the ongoing drought and its negative impact on water resources and aquifers, as well as disturbances caused by human activities, as evidenced by pollution indicators in karst springs and wells (Akdim, 2015; Yahya *et al.,* 2017). Given their high endemism and diversity in the freshwater ecosystems of Morocco, including the underground waters and the karst system, and the fact that freshwater snails are currently highly threatened by anthropogenic disturbances, there is an urgent need to prioritise species discoveries and conservation actions. Ongoing exploration of Morocco's vast subterranean environments will undoubtedly increase the already considerable number of stygobiont hydrobiids.

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Compliance with ethical standards

CONFLICTS OF INTEREST: The authors declare that they have no conflicts of interest.

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