

# NEW DATA AND RECORDS OF THE GENUS *THEODOXUS* IN MOROCCO (GASTROPODA: NERITIDAE)

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**Mabrouki, Y., Taybi, A. F. & Glöer, P.: New data and records of the genus *Theodoxus* in Morocco (Gastropoda: Neritidae). Nat. Croat., Vol. 32, No. 1, 143-148, 2023, Zagreb.**

In this paper, we present new data on the distribution of *Theodoxus* spp. in Morocco, providing new records of three known species, in addition to a record of an unknown species resembling the extinct *T. valentinus* (Graells, 1846) recorded only from Spain, where it is endemic to the Valencia region. Identification key and photos of the species are also presented.

**Key words:** checklist, conservation, identification, North Africa, endemism

**Mabrouki, Y., Taybi, A. F. & Glöer, P.: Novi podaci i nalazi za rod *Theodoxus* u Maroku (Gastropoda: Neritidae). Nat. Croat., Vol. 32, No. 1, 143-148, 2023, Zagreb.**

U ovom radu donosimo nove podatke o rasprostranjenosti vrsta iz roda *Theodoxus* spp. u Maroku, uz nalaze tri poznate vrste te dodatno nalaz nepoznate vrste koja sliči izumrloj vrsti *T. valentinus* (Graells, 1846) zabilježenoj samo za Španjolsku, gdje je bila endem regije Valencije. Predstavljen je i ključ za determinaciju i fotografije vrsta.

**Ključne riječi:** popis, zaštita, determinacija, sjeverna Afrika, endemizam

## INTRODUCTION

Neritidae Rafinesque, 1815 is a Gastropoda family commonly known as Nerites. The shell in this family is small and flattened, hemispherical, fast-growing, thick and sturdy with a calcareous D-shaped operculum. The last whorl covers the whole shell and presents a variable pattern; sometimes the whole shell is evenly black; up to 12 mm (TACHET *et al.*, 2010). The main identification criteria are the shell characters and operculum shape, and the polymorphism of shell coloration and pattern is very common in some species (TAN & CLEMENTS, 2008; GLÖER, 2019).

Nerites can occur in marine, brackish, and freshwater ecosystems. They are herbivores that usually inhabit the middle to upper intertidal zones and are known to be gregarious. Freshwater Neritidae can live both in lentic and lotic waters and are common in rivers, canals, springs and lakes, on rocks or other hard substrates (Oscoz *et al.*, 2011). The genus *Theodoxus* Montfort, 1810 is a genus of the family Neritidae that is a common component of the aquatic malacofauna of the western Palearctic (GLÖER, 2019; SANDS *et al.*, 2020). The genus requires good environmental conditions which is very

useful for ecologists since *Theodoxus* species can be used as indicators of aquatic habitat quality (PÉREZ-QUINTERO, 2007; ROTHMEIER *et al.*, 2022).

The genus *Theodoxus* was previously represented in Morocco by only the three following species: *Theodoxus fluviatilis* (Linnaeus, 1758), *T. marteli* (Pallary, 1918) and *T. numidicus* (Récluz, 1841). In this paper, we present new data on the distribution of *Theodoxus* spp. known to occur in Morocco, in addition, we provide the first record of a *Theodoxus* sp., the shell of which is similar to *T. valentinus* (Graells, 1846) known only from Spain, endemic to the Valencia region.

## Material and Methods

In order to advance knowledge on the freshwater molluscs of Morocco, several field expeditions were conducted between 2019 and 2022 in the northern part of the country, focusing on the Middle Atlas, Sebou and the Moulouya River basins. More than 100 localities were investigated, most of these sampling sites being visited at least three times (see also TAYBI *et al.*, 2017; MABROUKI *et al.*, 2020 for more details on the localities). Samples of benthic fauna including molluscs were collected using kick nets, entomological forceps or by hand.

The dissections and measurements of the genital organs and the shells were carried out using a stereo microscope (ZEISS); the photographs were made with a digital camera system (Leica R8). The map was made using ArcGIS software. Voucher specimens were deposited in the collections of the authors. Identifications were made following GLÖER (2019).

## Results

### *Theodoxus fluviatilis* (Linnaeus, 1758) (Fig. 1a)

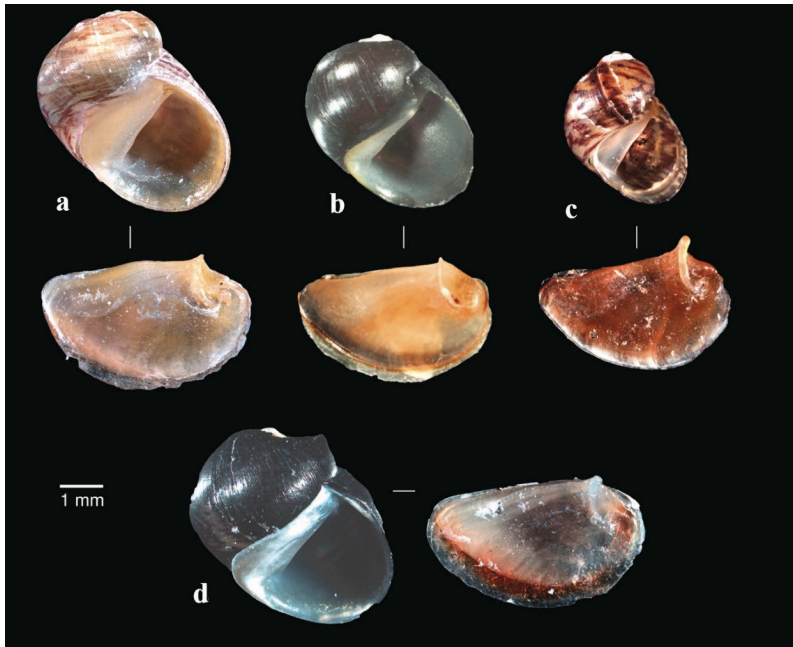
**Sampling site.** Guercif 33°57'33" N 3°30'52.8" W (07/09/2020); Aval Safsaf 34°54'27.53" N 2°38'8.86" W (19/06/2019); Oued Beht 33°49'21.7"N 5°55'38.6"W (15/07/2019); Ain Chkef 33°58'05.0"N 5°01'22.4"W (06/12/2019); Ain Smen spring 33°57'56.5"N 5°01'18.5"W (06/12/2019); Oued Bourkaiz 33°55'21.8"N 5°05'20.2"W (09/12/2020); Zaouiat Sidi Ben Aïssa, spring 1, 33°55'12.4"N 4°40'20.7"W (07/03/21); Zaouiat Sidi Ben Aïssa, spring 2, 33°53'07.0"N 4°41'24.9"W (24/10/21); Skoura 33°30'58.2"N 4°32'17.9"W (01/08/2021); Oued Inaouen 34°13'20.4"N 4°54'27.9"W (02/08/2021).

**Comments.** The range of this species is the largest of *Theodoxus* in the Palearctic (MARKOVIĆ *et al.*, 2014; GLÖER, 2019; ZETTLER *et al.*, 2004). *Theodoxus fluviatilis* is the most common and widespread *Theodoxus* species in Morocco (Fig. 2) (TOUABAY *et al.*, 2002; TAYBI *et al.*, 2017). It can be found in most of the springs with running waters with high levels of calcium, living on hard substrates and very close to the surface. In the Moulouya River basin the populations of *T. fluviatilis* can tolerate a certain amount of salinity and they prefer well oxygenated waters (BERRAHOUI *et al.*, 2001; TAYBI, 2016).

### *Theodoxus marteli* (Pallary, 1918) (Fig. 1b)

**Sampling site.** Tgafait, 34°14'10.6"N 2°24'30.3"W (26/03/22).

**Comments.** *Theodoxus marteli* is a Maghrebian endemic species known only from Morocco and Algeria (GLÖER, 2019), listed as "Vulnerable" according to the IUCN Red List of Threatened Species (IUCN, 2022). During the sampling period, the species was



**Fig. 1.** The *Theodoxus* spp. of Morocco. a: shell and operculum of *T. fluviatilis*. b: shell and operculum of *T. marteli*. c: shell and operculum of *Theodoxus* sp. d: shell and operculum of *T. numidicus*.

collected at a place named Tgafait, belonging to the Moulouya River basin (Fig. 2). Future investigations will probably increase its known distribution range.

#### *Theodoxus* sp. (Graells, 1846) (Fig. 1c)

**Sampling site.** Ain Sidi Bouali, Lakliaa, 33°46'24.3"N 4°42'22.9"W (09/04/22); Ain Regrag spring 33°46'39.8"N 4°43'54.5"W (09/04/22).

**Comments.** The shell looks a little similar to the shell of *Theodoxus valentinus* (Graells, 1846), a species endemic to Spain but which is currently considered an extinct species known only from a single spring (Venta del Conde, Valencia) (MARTINEZ-ORTÍ & OSCA, 2023). However, the operculum in *Theodoxus* sp. from the Middle Atlas of Morocco has a longer apophysis, different from that of *T. valentinus*. Future anatomical and molecular studies could probably assign it to a new species.

#### *Theodoxus numidicus* (Récluz, 1841) (Fig. 1d)

**Sampling site.** Aïn Bourzeg 34°46'41.0"N 2°09'12.0"W (16/06/2019).

**Comments.** Listed as "Vulnerable" according to the IUCN Red List of Threatened Species (IUCN, 2022). This is also a Maghrebian endemic species restricted to Morocco and Algeria (TAYBI *et al.*, 2017; GLÖER, 2019). It is rare throughout its range of distribution in Morocco, where the species is very stenotopic and is found only in springs (MABROUKI *et al.*, 2019a). During the sampling period, the species was collected at a place named Aïn Bourzeg, belonging to the Isly River basin (Fig. 2).

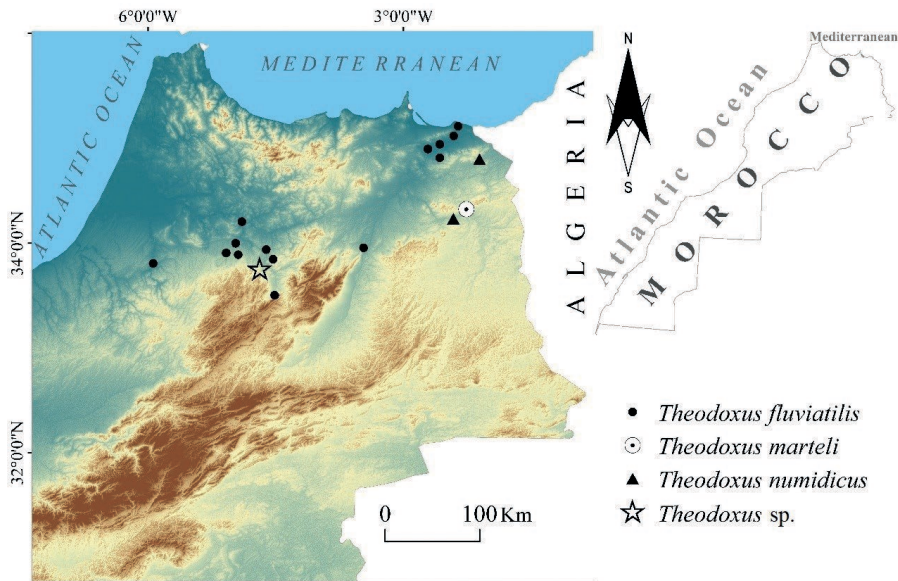


Fig. 2. The verified records of *Theodoxus* spp. of Morocco

**Identification key of *Theodoxus* spp. of Morocco**

- 1. Operculum lacking a pseudo-apophysis .....2
  - Operculum with pseudo-apophysis.....3
- 2. Apophysis strong, no apophysis shield exists ..... *T. numidicus*
  - Apophysis medium thick, apophysis shield exists..... *T. fluviatilis*
- 3. Pseudo-apophysis diagonal from apophysis or apophysis-shield to the right adductor .....4
  - Pseudo-apophysis horizontal does not reach the border, shell elongated ..... *Theodoxus* sp.
- 4. Diagonal pseudo-apophysis not very strong, curved to the right ..... *T. marteli*

**DISCUSSION**

Our findings raise the known biodiversity of the *Theodoxus* genus in Morocco to four potential species. *Theodoxus fluviatilis*, widely distributed in the Palearctic, is found in a wide range in the northern part of Morocco, the Maghrebian *T. numidicus* and *T. marteli* are known only from Morocco and Algeria from few localities. And finally, *Theodoxus* sp. from the Middle Atlas, resembling the extinct Spanish endemic *T. valentinus* (MARTÍNEZ-ORTÍ & OSCA, 2023) in the shape of its shell. Indeed, as a result of geographical position, sister species and the Ibero-Moroccan chorotype are strongly represented in the animal biodiversity of Morocco, especially in the freshwater invertebrate fauna (including molluscs), which is highly related to Iberian fauna (MABROUKI *et al.*, 2017; MABROUKI *et al.*, 2019b, c; MABROUKI *et al.*, 2020; TAYBI *et al.*, 2018; TAYBI *et al.*, 2019). Until 5.3 million years ago, together with Spain, the north of Morocco formed the Betico-Rifian massif, Spain

and Morocco sharing fauna not present in the other countries (DOADRIO, 1994; KRIJGSMAN *et al.*, 1999a, b; TAYBI *et al.*, 2020; BOULAASSAFER *et al.*, 2021).

For conservation purposes, it is very important to carry out a management plan for the endemic *Theodoxus* species of Morocco, which includes knowing the phylogenetic relationships between them and with other species of the genus and their taxonomic position, as well as to expand knowledge of their bio-ecology, which is an urgent need. Indeed, the freshwater biodiversity of Morocco in general is facing multiple anthropogenic threats, summed up in habitat loss because of the agricultural intensification, solid and liquid pollution, excessive water pumping... etc. Even worse, invasive species including freshwater molluscs are being detected in Morocco (MABROUKI *et al.*, 2022; MABROUKI *et al.*, 2023; TAYBI *et al.*, 2021; TAYBI *et al.*, 2023a, b). In addition to the protection of areas hosting endemic species, the local population needs to be informed of the importance of the endemism that characterizes Moroccan biodiversity, get involved in its conservation, and sensitized to the threats of habitat degradation and invasive species to local environments.

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