

SHORT COMMUNICATIONS

КРАТКИЕ СООБЩЕНИЯ

THE FIRST RECORD OF THE NORTH AMERICAN FRESHWATER LIMPET
FERRISSIA CALIFORNICA (MOLLUSCA, GASTROPODA) IN MOROCCOYouness Mabrouki¹ , Peter Glöer² , Abdelkhaleq F. Taybi³ ¹Sidi Mohamed Ben Abdellah University, Morocco

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Invasive species are a major threat to global biodiversity. One of the most effective invaders among freshwater snails is the North American ancyline gastropod *Ferrissia californica* (= *fragilis*). A new population of this species has been found in Lake Zerrouka (Northern Morocco), a Protected Area, which is also a site of ecological and biological interest (known as SIBE). Thus, this record expands the known distribution range of this invasive species in the Mediterranean area. Despite the fact it is located in only one out of more than 150 localities sampled by us, ongoing investigations could soon reveal more finds of the species in Morocco. Lake Zerrouka is known for recently described endemic snail species, i.e. *Ifrania zerroukansis* and *Gyraulus marocana*. Therefore, the monitoring of the presence and expansion of *F. californica* within invaded areas, as well as studies improving the knowledge on its biology and ecology is an urgent need.

Key words: alien ancyline, aquarium trade, invasive species, Lake Zerrouka, new arrival, non-native Planorbidae, Protected Area

Introduction

Invasions by non-native species are significant threats to the global biodiversity and ecosystem functioning worldwide (Taylor et al., 2006; Gonzalez et al., 2008). They threaten the survival of autochthonous species, populations, and communities through hybridisation, competition, parasitism, predation, and the structural changes they cause to the colonised habitats (Simberloff et al., 2013; Marrone & Naselli-Flores, 2015). Freshwater environments being particularly vulnerable to this phenomenon are considered the most invaded and threatened ecosystem worldwide, with proportionally more invaders than terrestrial ecosystems (Vitousek et al., 1997; Pyšek et al., 2010; Strayer, 2010). Moreover, the negative impacts of invaders on native species appear to be more frequent in freshwater ecosystems than in marine ones (Ricciardi & Kipp, 2008; Ricciardi & MacIsaac, 2011). In addition, aquatic invasive species are frequently involved in economic damages and can affect the human health (Pimentel et al., 2005; Keller et al., 2011).

Within the class of Gastropoda, many species have been considered as invasive in freshwater ecosystems, such as the New Zealand mudsnail *Potamopyrgus antipodarum* (J.E. Gray, 1843), the

apple snail *Pomacea canaliculata* (Lamarck, 1828) (Estebenet & Martín, 2002; Karatayev et al., 2009), and the American limpet *Ferrissia californica* (Rowell, 1863). The native range of *F. californica* lies in North America, where it is widespread throughout the United States up to southern Canada. During several decades, it has widely invaded Europe, Asia, South America, Africa and Oceania (Brown, 1965; Lacerda et al., 2015; Vecchioni et al., 2017; Vinarski & Palatov, 2018; Coote et al., 2018; Glöer, 2019). In the neighbouring countries of North Africa, *Ferrissia californica* has been recorded in Tunisia (Khalloufi & Boumaiza, 2007) and recently in Algeria (Glöer & Ramdini, 2019).

The aim of this paper was to provide the first record of *F. californica* from Morocco, in Lake Zerrouka, a Protected Area, also recognised as a site of ecological and biological interest, located in the Middle Atlas Mountains, a geographical barrier known as a habitat of endemic molluscs.

Material and Methods

Sampling area

In order to promote knowledge on the malacofauna of Morocco, several field expeditions have

been conducted since 2014 in the northern part of Morocco, with a focus on Protected Areas, especially on great geographical barriers as the Middle Atlas Mountains. More than 150 localities have been investigated and most of these sampling sites were visited at least three times.

The Zerrouka Lake is a Protected Area located in the province of Ifrane in the heart of the Middle Atlas at an altitude of 1613 m a.s.l., considered a site of Biological and Ecological Interest (SIBE) (https://ma.chm-cbd.net/manag_cons/esp_prot/sibe_ma/sibe_cont_hum/plan-d-eau-zerrouka-i-h16/sibe_h16) by the Moroccan government. This area is an integral part of the Oued Tizguite Wetland, of which the River Zerrouka is a tributary, classified as a Ramsar Site from 22.05.2019 (for more details, see Mabrouki et al., 2022).

Fieldwork and laboratory processing

The samples of benthic fauna (including gastropods) were collected by a kick net and clamps during 2014–2022. The samples have been fixed in 75% ethanol. Photographs were made with a Leica M205C Microscope with a digital camera Leica DMC5400. The voucher specimens are deposited in the authors’ collections. Conductivity, pH, and dissolved oxygen were measured *in situ* with a multiparametric measuring device (WTW, Multi-Line P4). The other parameters (ammonium and biological oxygen demand) were measured in the laboratory. The distribution map of *F. californica* in the West Palearctic was performed according to Glöer (2019).

Results

The first Moroccan records of the North American freshwater limpet *Ferrissia californica* is a sample including about twenty individuals collected in Lake Zerrouka (33.5437157° N, 05.095078° W) in 14.02.2020, 24.10.2021, and 06.03.2022 (Fig 1, Fig. 2). The site is situated in the River Sebou basin near the city of Ifran. The

analysis of the physicochemical parameters of the water, such as ammonium and biological oxygen demand, revealed a good environmental quality of the habitat (Table 1), according to the Moroccan surface water guidelines of good to excellent quality (MSWG).

The individuals of *Ferrissia californica* were found attached to the submerged aquatic vegetation present in Lake Zerrouka. It consists of *Myriophyllum spicatum* L., *Ranunculus aquatilis* L., *Persicaria amphibia* (L.) Delarbre, *Potamogeton* spp., *Elodea* sp., and *Ceratophyllum* sp., sometimes attached to submerged parts of *Typha latifolia* L. The bottom substrate consists of sand, slit and mud. The density of *F. californica* ranged between 5–7 individuals per 0.5 m².

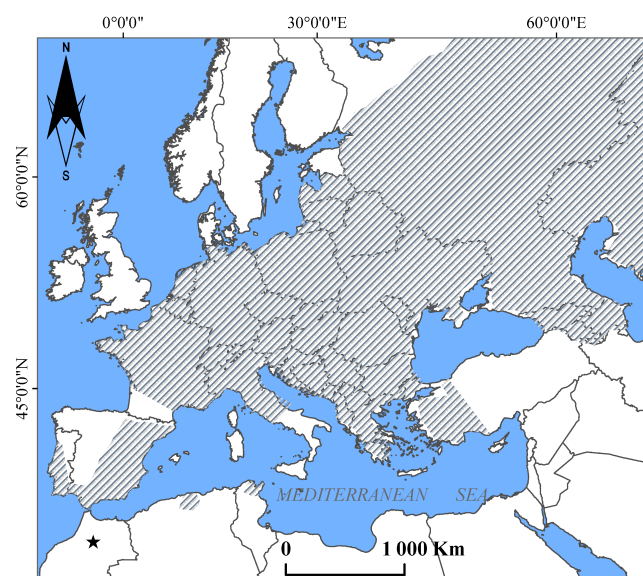


Fig. 1. The updated distribution of *F. californica* in the West Palearctic with a new record (black star) in Lake Zerrouka (Morocco).

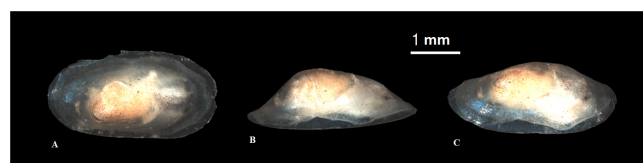


Fig. 2. Fixed specimens of *Ferrissia californica* found in Lake Zerrouka (Morocco). Designations: A – dorsal view, B – lateral right view, C – lateral left view.

Table 1. The mean and limit values of Moroccan surface water guidelines of good to excellent quality, minimum and maximum values of the physical and chemical water parameters measured at the sampling locality (Lake Zerrouka, Morocco)

Parameter	pH	Conductivity, mg/l	Dissolved oxygen, mg/l	Ammonium, mg/l	BOD ₅ , mg/l
M	7.5	150	10	0.05	1.5
MSWG	6.5–8.5	100–1300	> 7–5	< 0.1–0.5	< 3–5
min	7.0	125	9.5	0.03	1
max	8.0	170	10.5	0.1	3

Note: M – mean, MSWG – Moroccan surface water guidelines of good quality, min – minimum value, max – Maximum value, BOD₅ – Biological oxygen demand.

Discussion

Freshwater molluscs disperse over short or long distances, various vectors, such as current of streams and rivers during floods, birds and animals or boats and ships, in addition to aquarium trades (Alexandrowicz, 2003). The invasion pathways of *F. californica* in Morocco are unknown. However, it has been verified that the aquarium trade is the main responsible for the establishment of this invasive species into non-native areas (Boettger, 1949; Tokinova, 2012; Vecchioni et al., 2017). Ornamental aquarium pet trade starts to become a leading pathway for the introduction of aquatic invasive species in Morocco (Mabrouki et al., 2020; Taybi et al., 2020a, 2021, 2023). Perhaps, aquarists from the surrounding cities (i.e. Ifran) are behind this introduction of *F. californica* in Morocco, too.

The species seems to require good water quality such as the water of Lake Zerrouka (Barakat et al., 2016; Taybi et al., 2020b). The number of the collected *F. californica* individuals was relatively low in this first study. This suggests that the invasion could be at its initial stage, as also observed for introduction of *Physa acuta* (Draparnaud, 1805) in Ilha Grande (Miyahira et al., 2021). It is expected that the species range will increase exponentially across Morocco as has happened in Europe (Glöer, 2019).

Migratory water birds, abundant in Lake Zerrouka (personal observations), like members of families Anatidae and Rallidae have also been suggested as a potential invasion vector for *F. californica* (Raposeiro et al., 2011). Waterfowl may be the main vectors for inland spread in Morocco and North Africa, since many routes of bird migration between Europe and Africa cross the Iberian Peninsula and Morocco (Pérez-Tris & Santos, 2004; Alonso et al., 2019), as it might have happened with *Potamopyrgus antipodarum*, which is also present in Morocco (Taybi et al., 2021). Lake Zerrouka is a nesting site for several aquatic birds including members of Anatidae (*Anas ferina* Linnaeus, 1758, *A. fuligula* Linnaeus, 1758, and *A. nyroca* Guldénstad, 1770) and Rallidae (*Fulica cristata* Gmelin, 1789, *F. atra* Linnaeus, 1758) (Chillasse et al., 2001).

Ferrissia californica has now a near-cosmopolitan distribution owing to multiple capacities of this snail. It is a eurybiontic species and is capable of adaptation to tolerating a wide range of various habitat types (Dillon & Herman, 2009). The high abundance of *F. californica* has been discovered recently, living even in parts of the cave habitats differing by light regime. This indicates that the species has established a stable underground population able to reproduce (Vinarski & Palatov, 2018). Once arriving in new environments, the success

key for establishment of this hermaphroditic gastropod might be the capacity for self-fertilisation (Raposeiro et al., 2011; Vecchioni et al., 2017) in addition to its small body size and the ability to live in stagnant water (Walther et al., 2006).

No clear data are currently available on the possible impact of *F. californica* on native molluscan communities, and especially those, which have similar ecological niches, such as the autochthonous *Ancylus* sp., with which the species often co-exists in the invaded areas (Marrone et al., 2011). In addition to the newly discovered *F. californica*, Lake Zerrouka is a home for endemic freshwater snails, which been recently described, namely *Gyraulus marocana* Mabrouki, Glöer & Taybi 2022 (Planorbidae), and *Ifrania zerroukansis* Glöer, Mabrouki & Taybi 2020 (Hydrobiidae) known only from their type locality (Glöer et al., 2020; Mabrouki et al., 2022).

Conclusions

This paper reports the first finding of an acclimated population of *F. californica* in Morocco. The species seems to be at the initial stage invasion, by requiring good quality of water such as that in the invaded area of Lake Zerrouka. Despite the fact it is located in only one out of more than 150 localities sampled by the authors, the on-going investigations can soon reveal more finds of this species in the country and on the rest of the continent.

The trade of exotic species appears as a major source favouring the invasion in Moroccan freshwater habitats by non-native species. Strict law enforcement policies and procedures must be established in the trade of aquatic species as a preventive measure to preserve the native biodiversity.

Being located in the Middle Atlas Mountains, which is a geographical barrier, known as a habitat of endemic molluscs, Lake Zerrouka has a major importance for conservation of the autochthonous aquatic biodiversity. This requires urgent actions to prevent its unique biota from potential alteration and to prevent extinctions of native species. The realisation of careful monitoring programmes throughout the invasive range of *F. californica* is thus advisable.

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ПЕРВАЯ НАХОДКА СЕВЕРОАМЕРИКАНСКОГО ПРЕСНОВОДНОГО БЛЮДЕЧКА *FERRISSIA CALIFORNICA* (MOLLUSCA, GASTROPODA) В МАРОККО

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Инвазионные виды представляют серьезную угрозу глобальному биоразнообразию. Среди пресноводных улиток одним из наиболее активных инвайдеров является североамериканский вид анцилин *Ferrissia californica* (= *fragilis*). Новая популяция этого вида была обнаружена в оз. Зерроука (север Марокко), на особо охраняемой природной территории, которая также является областью экологического и биологического интереса (известной как SIBE). Таким образом, эта находка расширяет известный ареал этого инвазионного вида в Средиземноморье. Несмотря на то, что находка сделана только в одном из более чем 150 изученных авторами локалитетов, текущие исследования могут вскоре выявить больше находок этого вида в Марокко. Для оз. Зерроука известны описанные эндемичные виды улиток, *Ifrania zerroukansis* и *Gyraulus marocana*. Поэтому мониторинг распространения *F. californica* в пределах инвазионного ареала, а также исследования, пополняющие знания о биологии и экологии вида являются насущной необходимостью.

Ключевые слова: инвазионный вид, новый занос, озеро Зерроука, особо охраняемая природная территория, торговля аквариумными организмами, чужеземная анцилина, чужеземные Planorbidae