Distribution of the alien Tubificid worm *Branchiura sowerbyi* (Beddard, 1892) in Morocco

A. F. Taybi, Y. Mabrouki, T. van Haaren

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Abstract

Distribution of the alien Tubificid worm Branchiura sowerbyi *(Beddard, 1892) in Morocco.* The tubificid worm *Branchiura sowerbyi* Beddard, 1892 is one of the most successful invasive freshwater oligochaetes worldwide. In the Maghreb region, this species was known only from two localities in Morocco and from one locality in Libya. This paper presents novel information about the current distribution and presence of this invasive species in Morocco, and provides guidance on further areas of research regarding invasive oligochaetes in North African.

Key words: Alien species, Red worm, Progressive dispersal, New records, North Africa

Resumen

Distribución del gusano tubifícido Branchiura sowerbyi *(Beddard, 1892) en Marruecos.* El gusano tubifícido Branchiura sowerbyi Beddard, 1892 es uno de los oligoquetos de agua dulce invasores con mayor éxito en todo el mundo. En la región del Magreb, esta especie se conocía únicamente en dos localidades de Marruecos y una de Libia. Este artículo ofrece nueva información sobre la distribución actual y la presencia de esta especie invasora en Marruecos y orienta sobre nuevas áreas de investigación de los oligoquetos invasores norteafricanos.

Palabras clave: Especie exótica, Lombriz acuática, Dispersión progresiva, Nuevos registros, Norte de África

Resum

Distribució del cuc tubifícid Branchiura sowerbyi *(Beddard, 1892) al Marroc.* El cuc tubifícid Branchiura sowerbyi Beddard, 1892 és un dels oligoquets d'aigua dolça invasors amb més èxit arreu del món. A la regió del Magrib, aquesta espècie només era coneguda en dues localitats del Marroc i una de Líbia. Aquest article ofereix nova informació sobre la distribució actual i la presència d'aquesta espècie invasora al Marroc i orienta sobre noves àrees de recerca dels oligoquets invasors nord–africans.

Paraules clau: Espècie exòtica, Cuc d'aigua, Dispersió progressiva, Nous registres, Nord d'Àfrica

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Abdelkhaleq Fouzi Taybi, Applied Biology and Biotechnology Research Team, Multidisciplinary Faculty of Nador, Mohammed First University, Morocco.– Youness Mabrouki, Laboratory of Biotechnology, Conservation and Valorization of Natural Resources, Faculty of Sciences, Sidi Mohamed Ben Abdellah University, Dhar El Mehraz, Fes, Morocco.– Ton Van Haaren, Eurofins AquaSense, H. J. E. Wenckebachweg 120, 1114 AD Amsterdam–Duivendrecht.

Corresponing author: A. F. Taybi. E–mail: a.taybi@ump.ac.ma

ORCID ID: A. F. Taybi 0000-0001-9652-5407; Y. Mabrouki: 0000-0002-7336-8717;
T. van Haaren: 0000-0001-5119-1714

Introduction

Alien species are among the main threats to global biodiversity and are recognized as the second leading cause of extinctions around the world (Njiru et al., 2005; Pimentel et al., 2005). In addition, alien and invasive species can reduce genetic diversity of autochthonous biodiversity and biotic homogenization through a variety of mechanisms and interactions (Canonico et al., 2005; Fenoglio et al., 2016). Freshwater ecosystems are the most invaded and threatened ecosystems worldwide, with proportionally more invaders than terrestrial habitats, in part because of habitat alteration and degradation (Rahel, 2002; Alcaraz et al., 2005). Among invertebrates, exotic and invasive species can belong to various branches and classes. A good example of the success biological invasion in phylum Annelida is the tubificid worm *Branchiura sowerbyi* Beddard, 1892, which is one of the most successful alien freshwater oligochaetes worldwide.

Branchiura sowerbyi is a large red worm. It is easily identified and can be differentiated from other tubificid species by the presence of gills. It has a pair of gills on each segment in the posterior part of the body; dorsal and ventral chaetae differ, with ventral chaetae simple–pointed to bifid and the dorsal bundles with hairs and bifid chaetae (Liebig et al., 2023). This thermophilic species originates from the Sino–Indian region, but is now found all over the world except for Antarctica, and is currently considered a cosmopolitan species because of human activity (Tobias, 1972; Timm, 1979; Timm and Abarenkov, 2023). Due to its fast dispersal, success in adaptation and mass occurrence in different biotopes, *B. sowerbyi* could be characterized as an invasive species (Raposeiro et al., 2009; Cebulska and Krodkiewska, 2017).

In North Africa (Maghreb), this species was known from only two localities in Morocco and from one locality in Libya (Martin and Boughrous, 2012). *Branchiura sowerbyi* was observed for the first time in Morocco from Sebou River at Moulay Yacoub Province, Fès–Meknès region (Baroudi, 1985) and later from the N'Fis River below the Lalla Takerkoust Reservoir, Marrakesh–Safi region (Juget and Yacoubi–Khebiza, 1997). It has remained unstudied since these first records. The aim of this paper is to update information about the current distribution of *Branchiura sowerbyi* in Moroccan waters, to point out its progressive dispersal, and to contribute to knowledge of its ecology in the invaded areas of North Africa.

Material and methods

As part of hydrobiological monitoring, field surveys have been conducted since 2014 in the northern part of Morocco, with a focus on Protected Areas, especially great geographical barriers such as the Middle Atlas Mountains, Sebou and Moulouya River basins. The benthic fauna was collected using a Surber sampler (surface of 20 x 25 cm and 0.4 mm mesh net),

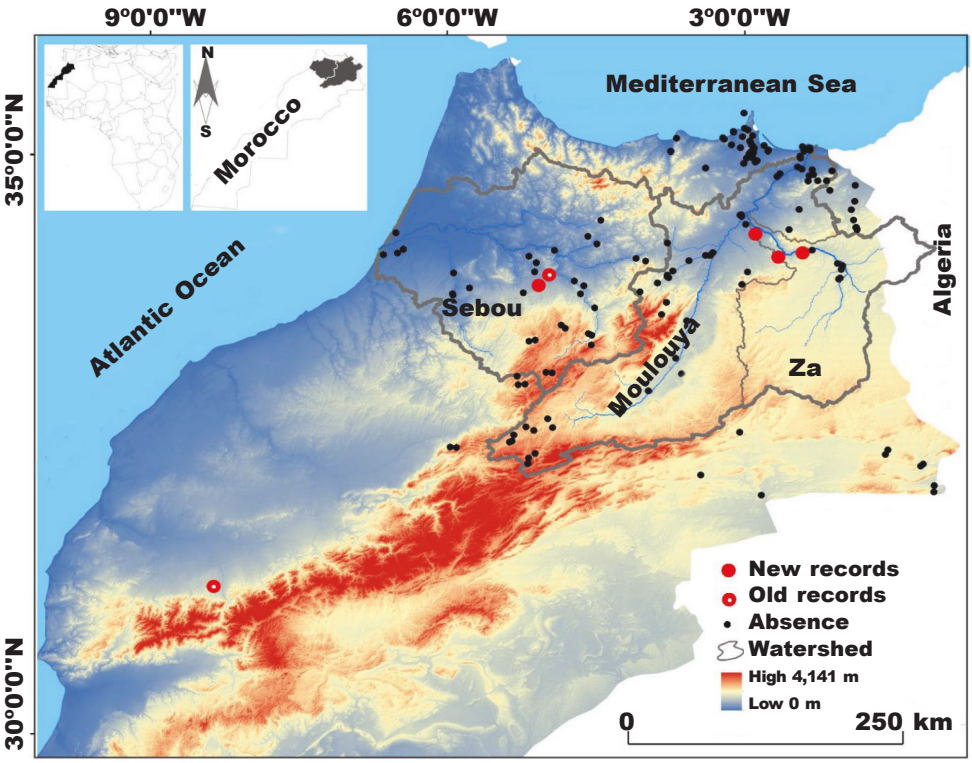

Fig. 1. Distribution map of *Branchiura sowerbyi* in Morocco.

Fig. 1. Mapa de distribución de Branchiura sowerbyi *en Marruecos.*

and eight samples were taken covering the whole micro–habitats heterogeneity represented within each locality, mainly determined by the type of substrate, macrophyte cover and flow velocity. The samples were stored in 75% ethanol.

Conductivity, pH, and dissolved oxygen were measured in situ with a multiparametric measuring device (WTW, Multi–Line P4). The other parameters, i.e. ammonium, nitrates, orthophosphates and biological oxygen demand (BOD_5) were measured in the laboratory.

Results

Since its first record in Morocco, *Branchiura sowerbyi* has quietly spread in the country and it is reported here for the first time in the Moulouya River from a number of localities. In addition, we record it from another locality of the Sebou River basin, from Ain Chkef Park (fig. 1, 2; table 1). The fact that this spread has gone undetected is related to the lack of studies carried out to date on Moroccan oligochaetes.

In the new localities, *B. sowerbyi* was often found associated with shallow, stagnant, or slowly flowing waters. Table 2 shows the abundance and the physicochemical parameters of the water in each new locality.

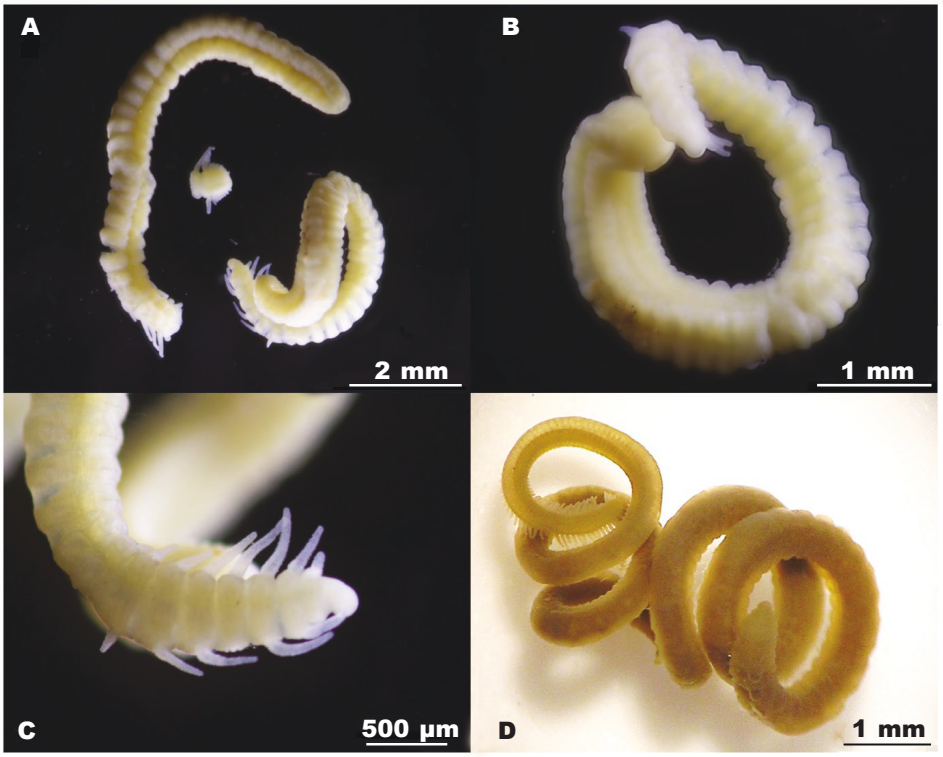

Fig. 2. General appearance of *Branchiura sowerbyi* collected from Morocco: A-C, juveniles from Ain Chkef (Sebou River basin); D, adult from Oued Za (Moulouya River basin).

Fig. 2. Aspecto general de un ejemplar de Branchiura sowerbyi *recolectado en Marruecos: A-C, formas juveniles de Ain Chkef (cuenca del río Sebou); D, ejemplar adulto de Oued Za (cuenca del río Moulouya).*

Discussion

Branchiura sowerbyi is recorded for the first time in the Oriental Region of Morocco, in the Za River, a major tributary of the Moulouya River. This area was poorly studied in terms of macroinvertebrate assemblages before 2014. Therefore, the alien worm could either have gone unnoticed for years since its first record in Morocco, or it could be in its early stages of invasion in this hydrographic network. Moreover, the 2020 record at Ain Chkef park is located very close to the record of 1985; both belong to the Sebou River basin. This recent record adds further evidence to support the long–standing presence of the worms in the Fez–Meknes area. The species was absent in the remaining sampling points (more than 150) situated in various regions of central and northern Morocco where we have been performing hydrobiological monitoring of the aquatic ecosystems since 2014 (e.g., see Mabrouki et al., 2020; Taybi et al., 2023 for details on localities). However, it is still possible that the invasive worm could have escaped our captures in some of these localities.

Table 1. Characteristics of the previous and new localities (fig. 1) of *Branchiura sowerbyi* in Morocco.

Tabla 1. Características de las localidades de registro antiguas y nuevas (fig. 1) de Branchiura sowerbyi *en Marruecos.*

Locality	Coordinates	River basin	Region	Sampling dates
Gafait	34º 14' 21.6" N 2º 24' 34.8" W	Za (Moulouya)	Oriental	17/05/2014
Za reservoir dam	34º 12' 23.1" N 2º 38' 52.3" W	Za (Moulouya)	Oriental	07/06/2014
Upstream Taourirt	34º 24' 37.8" N 2º 52' 19.5" W	Za (Moulouya)	Oriental	07/06/2014
Ain Chkef Parc	33º 59' 29.3" N 5º 01' 17.3" W	Sebou	Fes-Meknes	15/02/2020

Our work confirms the existence of the alien tubificid *B. sowerbyi* in Morocco, and therefore, in addition to the leech *Helobdella europaea* Kutschera 1987, the number of exotic freshwater annelids amounts to two species, and the total number of aquatic alien species with confirmed presence in the continental waters of the country rises to 43 taxa (Mabrouki et al., 2019; Ford et al., 2020; Taybi et al., 2023). The main areas harbouring xenodiversity in Moroccan freshwaters correspond to protected areas such as Ramsar Sites and sites of biological and ecological interests known as SIBE, where almost half of the alien species were introduced intentionally throught fish restocking programs, mainly using 'Asian carps' such as the common carp *Cyprinus carpio* (Linnaeus, 1758), the bighead carp *Hypophthalmichthys nobilis* (Richardson, 1845) and the silver carp *H. molitrix* (Valenciennes, 1844). Commercial activities around aquarium and ornamental species appear as the second source favouring colonization by alien freshwater animal species (Mabrouki et al., 2020; Taybi et al., 2023).

The introduction and propagation of *B. sowerbyi* worldwide is strongly correlated with the transport of exotic plants and fish stocking, accentuated by other human related activities and mechanisms (Paunovic et al., 2005; Georgieva et al., 2012). The introduction of this species in Morocco could be related to transport of ornamental plants, since its first record in the country was in the region of Fez, which has been heavily infested by exotic and aquatic plants (Khabbach et al., 2019; Mabrouki et al., 2023a). It has since spread elsewhere via various mechanisms (e.g., fish for stocking, active movement, and river currents).

Since Morocco represents a contact area between Europe and Africa and a compulsory passage for much of the fauna between the Palaearctic and Afrotropical regions, another hypothesis behind its introduction and dissemination in Morocco is through water fowl (bird excrements or hitchhiking) migrating from areas of Europe already invaded by the species, as is suggested for other exotic species in the country. Such a mechanism is hypothesised for exotics including the North American freshwater limpet *Ferrissia californica* (Rowell, 1863), the New Zealand Mudsnail *Potamopyrgus antipodarum* (J. E. Gray, 1843) and the freshwater leech *Helobdella europaea* Kutschera, 1987 (Mabrouki et al., 2019; Taybi et al., 2021; Mabrouki et al., 2023b).

Branchiura sowerbyi is known for its abilities to adapt to a wide range of environmental conditions. It can live in both natural and entropized environments, in sediments nearly

Table 2. Abundance of *Branchiura sowerbyi* and parameters of the water measured at the sampling localities: DO, disolved oxigen; BOD_5 biological oxygen demand.

Tabla 2. Abundancia de Branchiura sowerbyi *y parámetros del agua determinados en las localidades de muestreo: DO, oxígeno disuelto; BOD_5 demanda biológica de oxígeno.*

Sampling site	Abundance (indiv/0.4m²)	pH	Conductivity (µs/cm)	DO (mg/l)	BOD_5 (mg/l)	Nitrate (mg/l)
Gafait	4	7.9	650	7,5	3.15	1.66
Za reservoir Dam	4	7.3	1,990	7.12	5.05	3.31
Upstream Taourirt	1	7.3	1,863	6.70	4.15	2.78
Ain Chkef Parc	2	7.76	600	6.5	6.15	4.26

devoid of oxygen (Brinkhurst and Jamieson, 1971). The worm usually lives with its anterior buried in the sediment, while the posterior waves actively in the water layer above the bottom, often in large numbers (Dumnicka, 2016). The species has also been reported as abundant from areas influenced by organic enrichment as a consequence of urban pressures (Gonçalves et al., 2008; Raposeiro et al., 2009). For instance, the alien worm was found in good water conditions in the studied localities (table 2), but this plastic species could be in larger numbers in the polluted parts of Za River, which is one of the most threatened watercourses in the country, due to liquid pollution (Mabrouki et al., 2016; Bensaad et al., 2017; Taybi et al., 2020). Future prospections could reveal other population of this species.

Due to its invasive character, the presence of *B. sowerbyi* could disturb relations within the native benthic community and consequently influence the entire aquatic ecosystem (Raposeiro et al., 2009). Furthermore, it has been shown that *B. sowerbyi* is an alternate host for some fish parasites, such as *Thelohanellus hovorkai* Achmerov, 1960 (Myxosporea, Myxozoa), which can cause reduction of fish abundance (Liyanage et al., 2003; Paunovic et al., 2005). Climate changes and the increase in water temperatures, in addition to the continuous deterioration of freshwater ecosystems in Africa, will put this thermophilic species in a better position against native fauna, favouring its expansion (Verdonschot, 2007; Cebulska and Krodkiewska, 2017). Therefore, detecting and monitoring the expansion of this alien species within the colonized areas and studies improving biological, ecological and phylogenetic knowledge are urgently required.

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