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First European record of the giant ramshorn snail *Marisa cornuarietis* (Linnaeus, 1758) (Gastropoda: Ampullariidae) from northern Spain

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ABSTRACT

First European record of the giant ramshorn snail *Marisa cornuarietis* (Linnaeus, 1758) (Gastropoda: Ampullariidae) from northern Spain

The South American giant ramshorn snail *Marisa cornuarietis* is reported for the first time in Europe, inhabiting a freshwater natural ecosystem in northern Spain. We present a diagnosis of the species in order to facilitate the recognition of this new European alien species and its differentiation from other native freshwater snails. We also include brief notes on its biology and ecology at its new locality. Finally, we discuss its invasive potential and the possible impacts that it may cause in the native ecosystems if it becomes invasive.

Key words: Mollusca, ampullariids, *Marisa cornuarietis*, freshwater snails, alien species, invasive species, Iberian Peninsula.

RESUMEN

Primer registro europeo del caracol “cuerno de carnero gigante”* Marisa cornuarietis *(Linnaeus, 1758) (Gastropoda: Ampullariidae) procedente del norte de España

La presencia del caracol sudamericano Marisa cornuarietis *es detectada por primera vez en la península Ibérica en un ecosistema dulceacuícola natural del norte de España; dicho hallazgo constituye también el primer registro de la especie para Europa. Se presentan sus principales caracteres diagnósticos, lo que facilita la identificación de esta especie exótica introducida y su diferenciación de otras especies de caracoles dulceacuícolas nativos. Asimismo, se incluyen notas breves sobre su biología y ecología en su nueva localidad. Finalmente, se discute su potencial invasor y los posibles impactos que pueda causar en los ecosistemas receptores, si llegara a convertirse en una especie invasora.*

Palabras clave: *Mollusca, ampuláridos,* Marisa cornuarietis*, gasterópodos dulceacuícolas, especies exóticas invasoras, península ibérica.*

INTRODUCTION

Members of the family Ampullariidae Gray are operculate freshwater snails with natural distributions in South America, Africa and Asia (Cowie & Thiengo, 2003; Hayes *et al.*, 2009). Their systematics and phylogeny still remain unclear, with numerous synonymies and continuous changes in their phylogenetic relationships (see Jørgensen *et al.*, 2008 and Hayes *et al.*, 2009 for recent molecular phylogenies). Currently, nine genera and more than 120 species are considered valid, of which the majority belong to the genera *Pomacea* Perry, *Pila* Röding and *Lanistes* Montfort (Cowie & Thiengo, 2003).

Some of the largest freshwater snails can be found among the ampullariids, which include the very invasive *Pomacea* spp., with a large history of invasion events into new regions due to aquaculture activities or domestic aquarium release/escape (Rawlings *et al.*, 2007). No native ampullariids occur in Europe. To date, only *Pomacea maculata* Perry, 1810, formerly *Pomacea insularum* (d'Orbigny, 1835) (see Hayes *et al.*, 2012), a species belonging to the *Pomacea canaliculata* complex, has been reported from Spain in the Ebro Delta (first detection 2009: López-Soriano *et al.*, 2009; specific assignation López *et al.*, 2010), causing great concern and direct economic impacts of several million euros. In August 2013, Ampullariidae, covering all species belonging to this family, has been included in the Spanish legislation as invasive species (RD 630/2013). Here, we report the occurrence of the giant ramshorn snail, *Marisa cornuarietis* (Linnaeus, 1758), from northern Spain, constituting the first record of the species in Europe. We present brief notes on the taxonomy and distribution of *M. cornuarietis* and discuss the potential pathways for introduction to Europe as well as the presumed impacts that it may cause if it becomes indeed invasive.

MATERIAL AND METHODS

Location: Colloto, Nora River (43°22′N, 5°47′W, elevation: 160 m, Oviedo, Asturias, Spain, Fig. 1). Water physicochemical parameters of the Nora River near this location can be consulted in Table 1.

Figure 1. Location in the Iberian Peninsula of the first European record of *Marisa cornuarietis*. *Localización en la península Ibérica de la primera cita europea de* Marisa cornuarietis.

Material examined: 2012, two specimens, adults, BOS-Gas 398. V-2013, two specimens, adults, BOS-Gas 399 and 400 (Fig. 2A,B, available at: http://www.limnetica.net/internet). 26--IX-2013, 1 specimen, adult, empty shell, BOS--Gas 401. 27-IX-2013, 16 specimens, juveniles, BOS-Gas 402 (Fig. 2C, http://www.limnetica.net/internet) and 403. BOS = Departamento de Biología de Organismos y Sistemas, University of Oviedo, Spain. The BOS Collection is being digitised and these data will be available in GBIF (see general workflow in Torralba-Burrial & Ocharan, 2013). Specimens were collected by hand (A. Arias leg.) among emergent vegetation and stones of the river bed (Fig. 2D, http://www.limnetica.net/internet). Juveniles were fixed and preserved in absolute ethanol. One specimen (BOS-Gas 403) was dissected and the radula studied using an Olympus SZX-ILLK200 90× stereoscopic microscope.

RESULTS AND DISCUSSION

Species diagnosis and description

Dextral, discoidal (planorboid) and flat shell with 3.5-4 spiral whorls and spire not elevated above the body whorl (Fig. 2A,B, http://www.limnetica.net/internet). Shell surface smooth, circumscribed with transverse striations (growth lines) especially pronounced near the aperture. Wide umbilicus. Kidney-shaped aperture making a slight angle with the shell axis. Yellowish to brownish corneous operculum. Shell with banding pattern, ground colour yellow to brownish with 3 to 6 spiral dark bands, not present on the apices of the shell. Adult studied specimens ranging from 29.30 mm to 37.30 mm (n = 3), while juveniles range from 6.55 mm to 13.30 mm ($X = 9.68 \pm 0.42$ mm; n = 16). Old specimens have very conspicuous transverse growth lines near the aperture of the shell. Shells of juvenile reddish-brown with an elevated spiral, making them globose-shaped (Fig. 2C, http://www.limnetica.net/internet). Several studied specimens with damaged shell surface.

Taenioglossate radula (radular formula 2.1. c. 1.2). Central tooth (or rachidian) elongated, broader than longer, with a main trapezoidal cusp and three smaller cones ending in only one on each side of the central cone; lateral teeth are multicuspid with one of these cusps larger than the others and inner cusp facing the central teeth; outer and inner marginal teeth are sickle-shaped and quite elongated. This is the same radula pattern as figured by Horne *et al.* (1992) for this species.

Live animals grayish to yellowish with dark spots; with cephalic and labial tentacles very long and conspicuous and short breathing siphon (Fig. 2C, http://www.limnetica.net/internet). Alcohol preserved animals have turned white with some grey spots; eyes black pigmented.

Among ampullariids, the genus *Marisa* Gray is differentiated by its planispiral shell. Several species belonging to this genus have been described, but most have been synonymised with *Marisa cornuarietis* (see Cowie & Thiengo, 2003). However, *Marisa planogyra* Pilsbry, 1933, is accepted as a recognised species with a native southern distribution in South America (Cowie & Thiengo, 2003). Morphological characters such as the smaller caliber of whorls and the shape of the last whorl, aperture and operculum can be used to differentiate the two species (Pilsbry, 1933), although conchological separation is difficult (Simone, 2004). These characters in the studied specimens were consistent with *M. cornuarietis* features. There are several colour morphs described in the literature. The most common colour pattern is almost brown or yellowish brown with dark bands in variable numbers and width, in some cases with the shell dark brown; others are xanthics without banding pattern ("gold variety") or albinos (Howells *et al.*, 2006). The combination of two features, the planispiral shell with banding longitudinal colour pattern and the presence of the operculum, clearly distinguish this species from all other freshwater snails inhabiting the Iberian peninsula (although the operculum is not present in empty shells, the first feature by itself may be equally diagnostic).

Biology

Marisa cornuarietis is an omnivorous though predominantly generalist herbivorous freshwater snail that inhabits ponds and flowing waters (Pointier & David, 2004). In laboratory studies this species prefers feeding on *Utricularia* spp. when available (Morrison & Hay, 2011), but they consume a broad range of aquatic macrophytes (88 % of macrophytes tested: Horgan *et al.*, 2014) with some differences in food choices between adults and juveniles (Cedeno-Leon & Thomas, 1982). Some experiments were realised using this snail in aquatic weed control in rice fields, but also rice seedlings are eaten by snails (Seaman & Porterfield, 1964). Adults *M. cornuarietis* can prey on other freshwater snails, both eggs and juveniles (Hofkin *et al.*, 1991), but only in cases with scarce alternative food (Howells *et al.*, 2006). Their diet is similar to the invasive *P. canaliculata* complex (Morrison & Hay, 2011).

Some physicochemical parameters of freshwaters could limit the colonisation and expansion of *M. cornuarietis*. Indeed, this large snail needs high calcium concentrations in the water (Dillon,

Table 1. Water physicochemical parameters of Nora River in the nearest point of the Superficial Water Control Network (CEMAS) (CHC2099 Lugones) between 2009-2013 (source: Confederación Hidrográfica del Cantábrico). *Parámetros físico-químicos del agua del río Nora en el punto más cercano de la Red de Control de Aguas Superficiales CEMAS (CHC2099 Lugones) entre 2009-2013 (fuente: Confederación Hidrográfica del Cantábrico).*

Variable	Minimum	Maximum	Mean	N samples
Ammonium (NH_4^+) mg/l	< 0.02	2.82	0.415	18
Nitrites (NO_2^-) mg/l	0.043	0.540	0.138	17
Calcium (Ca) mg/l	18.2	78.4	60.9	17
Dissolved oxygen (O_2) mg/l	7.5	11.9	10.04	8
pH	6.8	8.16	7.66	8
Temperature (°C)	7.8	20.4	—	18

2000). Concentrations below 25 mg/l are suboptimals, and an increase of calcium concentration in water increases the calcium uptake: at 100 mg/l specimens survivorship and shell thickness are higher than at 25 (Meier-Brook, 1978). Low temperatures have been considered as a limiting factor in its distribution across the invaded areas of North America (Howells *et al.*, 2006). Unlike other ampullariids, *Marisa* spp. oviposit gelatinous egg masses underwater, therefore temporal waters are not suitable to support their populations.

Habitat and distribution

The giant ramshorn snail inhabits many different water bodies like lakes, rivers, ponds, irrigation systems and swamps and typically at depths less than one metre near vegetation (Ferguson & Palmer, 1958). This species is very pollution tolerant, being able to survive several months in dissolved oxygen levels less than 0.5 ppm, in salinities up to 8.5 ppt and temperatures down to 13 °C (Ferguson & Palmer, 1958; Hunt, 1961; Akerlund, 1974). Incorrectly described by Linnaeus (1758) as inhabiting western Europe (see Cowie & Thiengo, 2003), its native range extends from the north part of South America (from Brazil and Bolivia to Venezuela, Colombia, Trinidad and Tobago) to Central America (Panama, Costa Rica) (Cowie & Thiengo, 2003). *Marisa cornuarietis* have been introduced, and have established populations, in North America (USA: Howells *et al.*, 2006; Rawlings *et al.*, 2007), some Caribbean islands (Cuba, Guadeloupe, Martinique, Puerto Rico: Pointier & Jourdane, 2000; Vázquez & Perera, 2010) and Africa (Egypt, Sudan, Tanzania: Brown, 1994). In Asia introduced populations have been detected, but later disappeared and are now considered extinct (i.e. Israel: Roll *et al.*, 2009).

Invasive potential and possible impacts

Although molluscs usually represent a small percentage of introduced species in freshwaters (circa. 4 % in Europe: Gherardi *et al.*, 2009), they may cause substantial impacts in these habitats (Olden *et al.*, 2013). In the Iberian Peninsula, only one bivalve species, the zebra mussel *Dreissena polymorpha* (Pallas, 1771), has involved costs of 11.6 millions of euros in the first five years since its detection in the Ebro Basin (Durán *et al.*, 2012). Economic and ecological impacts of alien populations of *M. cornuarietis* and other ampullariids have been recently reviewed (Howells *et al.*, 2006, Rawlings *et al.*, 2007, Horgan *et al.*, 2014). Those impacts seem to be density-dependent, with few impacts in areas with low snail densities, as in Egyptian populations (Brown, 1994). Alien *M. cornuarietis* populations in the USA have shown densities highly fluctuating annually (Howells *et al.*, 2006), with impacts on macrophytes when population density becomes high (Horne *et al.*, 1992) and without damage detections when population densities are low (Howells *et al.*, 2006). High decrement of macrophyte communities, including elimination of some species, was detected in Caribbean ponds with introduced *Marisa* (e.g. Pointier & David, 2004). In ponds of central part of Asturias, in the basin of the Nora River and sometimes nourished by river floods or its tributaries, there are populations of the bladderwort *Utricularia australis* R. Br. (Ocharan *et al.*, 2007), included in the Regional Catalogue of Threatened Species as Vulnerable. Due to *Marisa* preference for this genus of macrophytes, *U. australis* could be affected if *M. cornuarietis* achieves to invade these ponds.

Furthermore, *M. cornuarietis* impacts on freshwater snail populations are widely known. In this way, the giant ramshorn was used as a biological control agent against schistosomiasis and other water borne parasitic worm diseases which affect human health. In these regions (i.e. some Caribbean islands) this species has been deliberately introduced to help control populations of snails that act as intermediate hosts to the parasites (Pointier & Jourdane, 2000; Pointier & David, 2004). *Marisa cornuarietis* has a voracious omnivorous feeding habit which can have detrimental effects on aquatic vegetation and native snails through direct competition, accidental egg mass disruption or direct predation of eggs and juveniles (Dillon, 2000; Howells *et al.*, 2006). There are no protected freshwater snails in the studied area, although some endemic hidrobiids (genera *Alzoniella* Giusti & Bodon, 1984 and *Islamia* Radoman, 1973) live in springs in central Asturias and are included in the Red List of Spanish Invertebrates (Verdú *et al.*, 2011). In the river reach where *M. cornuarietis* inhabit, only a Planorbidae species and the alien hidrobiid *Potamopyrgus antipodarum* (Gray, 1843) were found among freshwater snails, although further studies on this macroinvertebrate community are needed.

Wild populations of the giant ramshorn snail in Europe were hitherto unknown. Their introduction pathway/s may be associated with pet/domestic aquarium trade or aquatic plants trade to pond gardening and subsequent wild release/escape of specimens, similar way to introduction in USA (Howells *et al.*, 2006; Rawlings *et al.*, 2007). Specimens of *M. cornuarietis* have been found in the Nora River several times in the last two years. Adult snails located in 2012 and May 2013, and juveniles found in October 2013 revealed that the giant ramshorn snail has a reproductively active population in this locality. Severely damaged periostracum in adult specimens, and partially damaged in juveniles, suggests that physicochemical conditions of the Nora River are not optimal for this species. Anyway, there is a wide range of variation in calcium concentration, with some measuring lower than suboptimal threshold (minimum value 18.2 mg/l: Table 1). However, the first phase of a biological invasion cannot be disregarded. The great habitat plasticity of this species, together with its popularity as an aquarium snail, stream flooding and natural migration will help the spreading of the species. Therefore monitoring and control of this population as well as searches for other populations should be undertaken in order to assess the real distribution of the species and prevent the potential impacts that may be caused if it becomes invasive.

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