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The non-indigenous freshwater molluscs, and particularly *Helisoma scalare* (Jay, 1839) (Gastropoda Planorbidae), of Lake Albano (Rome, Italy)

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ABSTRACT In this work, the allochthonous freshwater molluscs of Lake Albano are examined. Particular attention is paid to the history of the planorbids of this lake and to its recent taxonomic attribution as *Helisoma scalare* (Jay, 1839).

KEY WORDS Lake Albano; *Helisoma scalare*; freshwater molluscs; alien species.

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INTRODUCTION

Despite its relatively small size and low mobility, continental molluscs, gastropods and bivalves, are defined as successful invasive species and have already drawn attention of specialists in the field of biological invasions (Vinarski et al., 2015). In the last several hundred years, many species of snails have proved to be very successful invaders, able even to cross oceans and continents (Kirschner et al., 1997; Pointier et al., 2005; Gittenberger et al., 2006; Gittenberger, 2011; Kappes & Haase, 2012). The "100 of the World's Worst Invasive Alien Species'' list (Global Invasive Species Database, 2021) contains several species of snails as *Achatina fulica* Bowdich, 1822, *Dreissena polymorpha* (Pallas, 1771)*, Pomacea canaliculata* (Lamarck, 1822) and *Potamocorbula amurensis* Schrenk, 1861. Since the second half of the 19th century, there have been reports of the presence of non-indigenous freshwater molluscs in Italy, even if the real origin was not known. Most species of molluscs were introduced in Italy more recently, in the second half of the 20th century, as the result of the development of commercial routes and the intensification of intercontinental traffic (Cianfanelli et al., 2007a).

In particular, allochthonous freshwater molluscs have also been found in Lake Albano (Latium, Italy): *Helisoma scalare* (Jay, 1839), *Corbicula fluminea* (Müller, 1774), and *Physella (Acutiana) acuta* (Draparnaud, 1805). The native freshwater molluscs of this lake are threatened not only by the strong impact of alien species, but also by the presence of *Trichobilharzia franki* Müller et Kimmig, 1994 the causative agent of swimmer's itch, or cercarial dermatitis.

The aim of this paper is to reconstruct the history of *H. scalare* in Lake Albano, investigate the populations of other freshwater snails present and provide some data on the characteristics of this lake environment.

MATERIAL AND METHODS

Study area

Lake Albano, also called Lake Castelgandolfo and Lake Castello, is located in the Italian region

Lazio, 293 m a.s.l., 24 km southeast of Rome city centre (Fig. 1). It fills a deep crater within the Colli Albani which has still preserved the distinct volcanic relief of the so-called Vulcano Laziale. The Vulcano Laziale is the last and southernmost of a chain of volcanoes (Volsinii, Vico, and Sabatino) aligned along the Tyrrhenian coast of central Italy. When the eruptive activity ended, about 40,000 years ago, the various craters were filled with water forming a sequence of volcanic lakes. The lake has an oval shape, is about 3.5 km long and 2 km wide with a surface area is 6.02 km², and a depth 170 m (Table 1). Being relatively small, it is the deepest volcanic lake of the Italian Peninsula, and with the steepest shores. From the west, south and east the crater is surrounded by relatively high (150–250 m), very steep slopes and inward facing cliffs consisting mainly of pyroclastic rocks and partly of basaltic rocky walls, while the northern slope is more gentle and somewhat lower (Caputo et al., 1974; Alexandrowicz, 2003). The sand is grey or even black, as it is mainly made up of fine pyroclastic material with a mixture of basalt grains. The crater of Lake Albano is associated with the terminal phase of volcanic activity, developed as an eccentric edifice in the western part of the Latian Volcano. It is dated to the Late Quaternary (27–20 thousand years BP) and corresponds with the last glacial period: the Würm or the Vistulian (Cosentino et al., 1993; Casto & Zarlenga, 1996). The Lake Albano is fed by underwater springs, has an artificial emissary from Roman times, excavated near Castel Gandolfo in 398–397 BC (Medici, 2007).

Samples

All the samples object of the present study are stored in the author's private collection (CMMGR, Rome, Italy). The taxonomic-nomenclatural framework of taxa cited in the note, with some exceptions, relied on Bodon et al. (2021). For the most recent taxonomic revisions, the website www.molluscabase.org has been consulted.

RESULTS AND DISCUSSION

Helisoma scalare *(Jay, 1839)*

Glöer (2019) identifies the Planorbidae of the lakes of the province of Rome as *Helisoma scalare* (see also Bodon et al., 2021).

This species was described from the "*Everglades of Florida*" by Jay (1839). *Helisoma scalare* in the original localities lives on submerged macrophytic vegetation, rock or other benthic substrates in cooler and clearer lakes and spring-fed rivers.

In Italy, the first report of *H. scalare* for Lake Albano dates back to 1986 and at the time it was recognized as unidentified Planorbidae (Mastrantuono, 1990; Mastrantuono et al., 2011). In a previous study on the coastal community of Lake Albano (Stella, 1951), the presence of this planorbid was not registered, and this suggests that the snail probably arrived in the lake between 1950 and 1986. Some authors referred 1988 as the date of the first

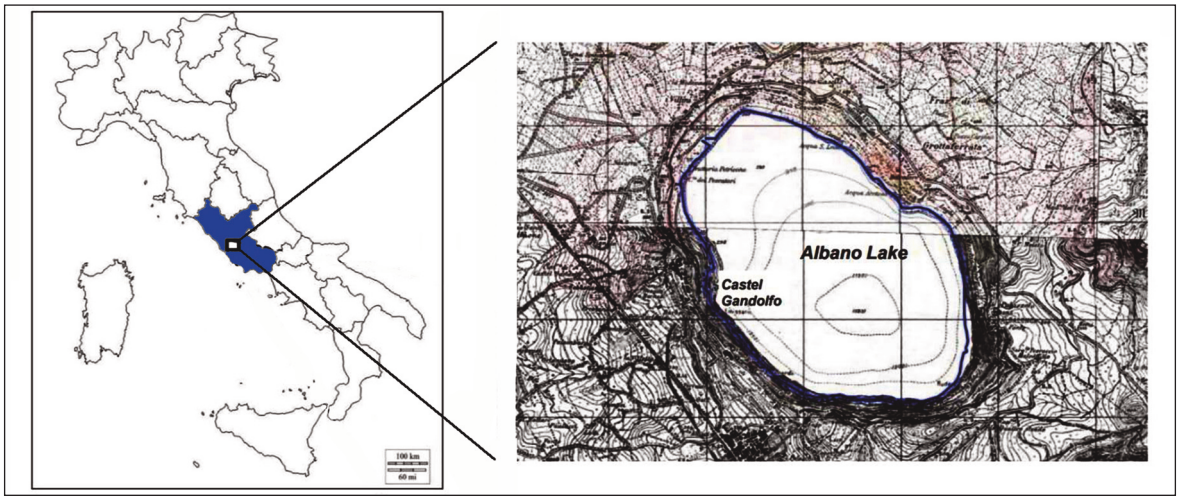

Figure 1. Study area: Lake Albano (Rome, Italy).

Characteristics	Units	Value
Lake level	m a.s.l.	293
Watershed area (Wa)	Km²	9.6
Maximum watershed altitude	m a.s.l.	556
Lake area	Km²	6.02
Wa/La ratio		1.6
Lake perimeter	Km	10
Maximum depth	m	170
Mean depth	m	77
Volume	10^6 m³	464
Water renewal time	y	47.6

Table 1. Main morphometric and hydrological characteristics of Lake Albano.

discovery (Giusti et al., 1995 and Manganelli et al., 1995 sub *Helisoma duryi*). Later, this species was reported by Alexandrowicz (2003: sub *Planorbella duryi*), Mienis (2004: sub *P. duryi seminole*), Cianfanelli et al. (2007a: sub *H. duryi*) and Gherardi et al. (2008: sub *H. duryi*).

The Seminole rams-horn species *H. duryi* (Wetherby, 1879) was originally described in 1879 from Florida (Wetherby, 1897: sub *Planorbis duryi*). Pilsbry (1934) listed also some subspecies: *H. duryi seminole* Pilsbry, 1934; *H. duryi normale* Pilsbry, 1934; *H. duryi intercalare* (Pilsbry, 1887); *H. duryi preglabratum* (Marshall, 1926) and *H. duryi eudiscus* Pilsbry, 1934.

Helisoma duryi has been found also in some states of the USA (Texas, New Mexico and Utah) and it is known to be fossil in the Pliocene (Cenozoic) (Baker, 1945).

Helisoma duryi was introduced in Africa by Brown (1967), Van Bruggen (1974) and Appleton (1977) from five localities in the Republic of South Africa and Namibia. Later, *H. duryi* was also found in various countries of the World: Tanzania, Kenya, Sudan, South America and islands of the Caribbean Sea, Brasil, Peru, Cuba, Isle of Youth, Martinique, Guadeloupe, Jamaica, Islands of Hawaii (Paraense, 1976; Perera et al., 1984; Englund et al., 2001; Pointier, 2001; Hyslop, 2003; Vázquez Perera & Perera Valderrama, 2010; Agudo Padrón & Lenhard, 2010). All these regions are characterized by a warm and tropical climate, quite appropriate for this snail (Alexandrowicz, 2003).

Over the past twenty years, *H. duryi* has been introduced to Europe. In temperate zones, it can lives only in basins with heated water, mainly in greenhouses, among plants coming from the tropical zone. A relatively rich population has been described by the Krakow Botanical Garden (Alexandrowicz, 1993). It is the component of on assembly with *Melanoides tuberculata* (O.F. Müller, 1774), *Physella acuta* and a few other species that inhabit a basin in the main greenhouse (Alexandrowicz, 1993). Fechter & Falkner (1990) mentioned the presence of *H. duryi* in Europe, both in botanical gardens and in open basins with heated water, particularly in Austria (Baden, Villach). The species occurs on Malta (Beckmann, 1987, 1988; Giusti et al., 1995; Cachia, 1999, Mifsud et al., 2003; Cilia, 2017), in some greenhouses in north-western Germany (Fechter & Falkner, 1990), in Corsica (Falkner et al., 2002), in Mainland France (Vimpère, 2004) and in Siberia (Sitnikova et al., 2010; Vinarski et al., 2015). Regarding its presence in Spain, *H. duryi* was reported for the city of Barcelona (Altaba et al., 1988; Bros, 2009); the Ebro Delta, Tarragona (Salgado & Soriano, 2013); Elche, Alicante (Soria & Sahuquillo, 2009); Mallorca, Balearic Islands (Pons et al., 2003); the Canary Islands (Nilsson et al., 1998; Groh & Garcia, 2004); Community of Valencia and Cataluña (Salgado et al., 2014). The migration route to Europe is unknown, but specimens inhabiting reservoirs in Poland, Austria and Germany are known to came from Florida or South Africa (Alexandrowicz, 2003).

In Italy, *H. duryi* was found in Liguria, Toscana, Lazio, Puglia, Calabria, Sicilia, Sardegna (Bodon et al., 2021).

Regarding the introduction of *H. duryi* and *H. scalare* in Italy, one of the most accredited hypotheses is that relating to the intentional release of this mollusc which is widely used in aquariology (Appleton, 1977; Giusti et al., 1995; Alexandrowicz, 2003, 2004; Mienis, 2004; Cianfanelli et al., 2007a; Reitano et al., 2007; Hallgass & Vannozzi, 2010; Mienis & Rittner, 2012). Other hypotheses concern the fish trade for sport fishing (Cianfanelli et al., 2007a; Mastrantuono et al., 2011) and the trade in nursery plants (Pons et al., 2003; Salgado et al., 2014). Alexandrowicz (2004) reports that *H.*

scalare may have reached Lake Albano through ornamental aquatic plants, imported from tropical countries in the gardens of the Pope's residence in Castelgandolfo. Another attractive introduction hypothesis could refer to the Olympic Games of Rome in 1960, when international canoeing and rowing races took place on Lake Albano. In this case, *H. scalare* could have arrived attached to the equipment of the American team (Mastrantuono et al., 2011). This is a very probable hypothesis given that it is well known that molluscs, often in the larval state, can be easily transported by boats. Even for *Dreissena polymorpha*, the hypothesis of arrival in Italy via pleasure boats has been reported and confirmed by genetic investigations, which have highlighted the German origins of the specimens of Lake Garda (Giusti & Oppi, 1972; Roncaglio & Borsani, 2005; Cianfanelli et al., 2007b; Quaglia et al., 2008; Cappelletti & Ciutti, 2017).

Corbicula fluminea *(O.F. Müller, 1774)*

Invasive bivalve native to Southeast Asia, this species has a fairly wide distribution range (Asia, North and South America, Europe and part of Africa). As regard the distribution in Europe, around 1970, it seemed limited to the Caspian-Caucasian area (Illies, 1978) but, later, its presence was also ascertained in France and Portugal (Mouthon, 1981), in The Netherlands and Germany (Blanken, 1990; Kinzelbach, 1991; Van Peursen, 2004), in Spain (Araujo et al., 1993; Teodosio et al., 2004), in Belgium (Swinnen et al., 1998; Vanden Bossche, 2002), in Hungary (Csànyi, 1999), in Czech Republic (Beran, 2000), in Romania (Bij de Vate & Hulea, 2000), in Bulgaria (Hubenov, 2001), in France (Chevallier, 2003) and, finally, in Poland (Domagala et al., 2004). In Italy, Mienis (1991) points it out for Sicily (Trapani) on specimens collected by Coen around 1940. The same author (Mienis, 1991) made several hypotheses on this finding, observing how the date of collection corresponded to the first report of this species for North America in 1938 (Hanna, 1966). The first certain reports of this species in Italy (Bedulli et al., 1995) refer to environments of flowing waters, and in particular in the main course of the medium-low Po river and in the delta branches of the Po di Goro, Venice and Donzella (Fabbri & Landi, 1999; Malavasi et al., 1999). The species has also been reported in Lake of Garda (Nardi & Braccia, 2004; Ciutti et al., 2007; Ciutti & Cappelletti, 2009), in the Lake Maggiore (Kamburska et al., 2013), in the Senio river in province of Ravenna (Pezzi, 2008), in the Emilian canal Romagnolo (Stagioni, 2009), in the Ticino river in the province of Pavia (Nicolini & Lodola, 2011), in the Serchio river in the province of Lucca (Ercolini & Cenni, 2015). Recently the species was reported for the first time in Lazio in Lake Albano, in the Maccarese canals (Grano & Di Giuseppe, 2020) and in Tevere river in Rome (Grano et al., 2020). For new data from northern and central Italy see Bodon et al. (2020).

Physella (Acutiana) acuta *(Draparnaud, 1805)*

Physella (Acutiana) acuta, a species with medium-sized, sinistral, ovate shell (height of up to about 17 mm), is common and abundant in lotic and lentic environments. The systematic and taxonomy of this physid is not well resolved, indeed *Physella acuta* was also called *Haitia acuta* (Draparnaud, 1805) (Taylor, 2003; Roll et al., 2009) and *Phisa acuta* Draparnaud, 1805 (Paraense & Pointer, 2003; Früh et al., 2017; Miyahira et al., 2021). It was introduced to Europe from North America (Taylor, 2003); its first report in Italy dates back to Issel (1866), who described it as *Physa pisana*. Evidence of the early occurrence of *P. acuta* in southern Europe also comes from a shell (or shells) once kept in the private Museum of Niccolò Gualtieri (1688–1744), a pioneer of conchological studies in Italy. His *Index testarum conchyliorum* (Gualtieri, 1742), has been acclaimed as "*a masterpiece of eighteenth-century illustrated malacological literature*" (Manganelli & Benocci, 2011). It includes an illustration of a physid shell (Gualtieri, 1742) that may be identified as *P. acuta* (Vinarski, 2017). Perusal of historical malacological collections demonstrates that its introduction was one of the causes of the gradual rarefaction of the indigenous basommatophora *Physa fontinalis* (Linnaeus, 1758) (Manganelli et al., 2000). For example, the malacological collection of the Museum of Natural History of Florence includes many shells of *P. fontinalis* collected since 1857 from areas where the species no longer exists; after 1868, the first shells of *P. acuta* appeared, becoming increasingly numerous and from many parts of Italy (Cianfanelli et al., 2007a). *Physella acuta* is currently present in all 20 Italian regions,

including highly polluted water bodies, often forming large populations (Feliksiak, 1939; Saraceni, 1971; Moretti et al., 1979; Melone, 1981). The human-mediated dispersal is the most frequently invoked mechanism explaining its initial arrival and the subsequent rapid widespread in Europe and other continents. However, the real path through which *P. acuta* arrived in Europe it is still a matter of debate (Vinarski, 2017).

Other freshwater molluscs from Lake Albano

Mastrantuono (1995) refers the occurrence for Lake Albano of two gastropods, *Bithynia tentaculata* (Linnaeus, 1758) and a unidentified planorbid, and two bivalves, *Pisidium (Cingulipisidium) nitidum* Jenyns, 1832 and *Pisidium* sp. Mienis (2004) reports another alien species, *Physella acuta*, and two native species as *Bithynia tentaculata* and *Radix auricularia* (Linnaeus, 1758). Moreover, Alexandrowicz (2004) pointed out the presence of the following snails: *Bithynia tentaculata*, *Bithynia boissieri* (Küster, 1852) (sub *B. leachii*), *Physella acuta*, *Radix auricularia*, *Peregriana labiata* (Rossmässler, 1835) (sub *Lymnaea peregra*), *Gyraulus (Torquis) laevis* (Alder, 1838), *Gyraulus (Gyraulus) albus* (Müller, 1774), *Gyraulus (Armiger) crista* (Linnaeus, 1758), *Ancylus fluviatilis* s.l. Müller, 1774, and *Pisidium (C.) nitidum*. Finally, Mastrantuono et al. (2011) reports *Physella (A.) acuta*, *Peregriana labiata* (sub *Lymnaea peregra*), *Radix auricularia* and *Bithynia tentaculata*. The forum of the web site www.naturamediterraneo.com also reports *Pisidium (Euglesa) personatum* Malm, 1855 and *Planorbarius corneus* (Linnaeus, 1758). *Lymnaea stagnalis* (Linnaeus, 1758) was found in the artificial outflow stream (Galeazzi et al., 2015). Some molluscs have also been found in the deeper areas of the lake. In the profundal macrobenthos of Lake Albano were identified five taxa (Bazzanti et al., 1993): one unidentified planorbid, *Pisidium (Pseudeupera) subtruncatum* (Malm, 1855), *P. (Euglesa) casertanum* (Poli, 1791), *P. (C.) nitidum* and *Pisidium* sp. Some of these molluscs, such as *Pisidium (P.) subtruncatum* and *Pisidium* sp., colonized the sediments down to a depth of 50–65 m.

Of particular historical interest are the reports of freshwater molluscs in Lake Albano by Augusto Statuti (1882). He is the author of the first catalog of terrestrial and freshwater molluscs in the province of Rome. Statuti (1882) reported 151 species, based mainly on personal data and on specimens from the collection of the brothers Giovanni and Giuseppe Rigacci, currently stored in the Civic Museum of Zoology of the Municipality of Rome (Hallgass & Vannozzi, 2009). Even though many of the species are no longer recognized by modern taxonomy, the original nomenclature from 1882 was retained: Ancylus simplex "*frequente presso i laghi di Castello e Nemi*"; Limnæa ovata "*fu trovata anche presso il Lago di Albano*"; Limnæa palustris *var.* fusca "*si trova sui bordi limacciosi del Lago di Albano*"; Planorbis albus "*non è raro presso il Lago di Albano*"; Planorbis carinatus "*non rara presso i laghi di Castello e Nemi*"; Planorbis nitidus "*abita i terreni aquitrinosi sulle rive del Lago di Albano*"; Pisidium casertanum "*vive nei laghi di Castello e Nemi nelle vicinanze di Roma*".

The swimmer's itch

In the summer 2017, many cases of dermatitis were recorded in people bathing in the waters of the Albano Lake. Following these reports, competent authorities instructed the Istituto Zooprofilattico Sperimentale del Lazio e della Toscana "M. Aleandri" (IZSLT) to investigate the possible causes of the outbreak and to suggest preventive measures (De Liberato et al., 2019).

Trichobilharzia franki has been identified as the causative agent of dermatitis and *Radix auricularia* as its intermediate host. Swimmer's itch, or cercarial dermatitis, is a pathological condition caused by the penetration of free-swimming larvae (cercariae) of flukes of the family Schistosomatidae in human skin, inducing an allergic inflammatory response normally limited to the outer dermal layers. Following reports on the rise of the cases of dermatitis from many European countries, swimmers itching is now considered an emerging disease on the continent (Soldánová et al., 2013). With regard to any preventive measures, as for other parasites with a tendentially wild cycle, even for *T. franki* in Lake Albano effective pest control is very difficult, unless high ecological impact measures, such as the use of molluscicides and the mechanical destruction of snails, are adopted (Jouet et al., 2008, 2010; Soldánová et al., 2013; De Liberato et al., 2019).

CONCLUSIONS

Lake Albano has some water characteristics that can create problems for local populations of freshwater molluscs. In 2008, *H. scalare* had disappeared from the Lake Albano (Mastrantuono et al., 2011). The reason for this disappearance is not clear, but the dramatic lowering of the water level in the lake, of about 4–5 m in the last decade, has probably played a significant role. This reduction in the water level has largely destroyed the aquatic vegetation, which it is completely lacking in almost the entire perimeter and depths of the lake (Mastrantuono et al., 2009). Lake Albano has very marked peculiarities able to determine drastic biocenotic variations and this can lead to the disappearance and sudden reappearance of these aquatic molluscs. This lake, being devoid of natural outflow streams, is subject to important variations in level, especially in response to atmospheric precipitation. In the artificial outflow stream, since 1992, the water in excess of the lake no longer flows (Medici, 2007). The lake suffers from a particular state of eutrophy, which is also testified by persistent algal formations (Medici & Rinaldi, 2004; Medici, 2005, 2007), and it is interested by eutrophication and organic water pollution, mainly due to high anthropic pressure (De Liberato et al., 2019). The water quality resulting from elevated levels of nitrogen and phosphorus (Ellwood et al., 2009). The distributions of *Euglesa* spp. in the lake and also of other indicator taxa belonging mainly to tubificies and chironomids suggest the existence in the lake of three biologically different zones, the first of which (20-35 m) still considered to be in acceptable conditions. In the range between 50 and 95 m, an increasing degradation of water quality has been highlighted and a complete absence of fauna below 120 m depth has been observed. Thus, depth distribution of benthic fauna in Lake Albano clearly reflects the environmental stress caused by the vertical oxygen decline (Bazzanti et al., 1993). Currently, despite the serious problem of decreasing the water level persists, *H. scalare* is present with consistent populations. In some stretches of the shoreline, there are thanatocenoses with thousands of specimens of this species, so much so that the notoriously black sand of this lake actually seems white. Previous authors found two different forms of *H. scalare* in this lake: a flat form and a scalarid form (Alexandrowicz, 2003; Mastrantuono et al., 2011). The current population appears to consist exclusively of flat-shaped specimens. On the other hand, the allochthonous mollusc *Corbicula fluminea* whose presence was ascertained only two years ago (Grano & Di Giuseppe, 2020), to date seems almost completely disappeared. As for the 2001 discovery in Lake Nemi, where *H. scalare* was absent in 1981 (Mastrantuono, 1986), the probable possibility is that the species originated from Lake Albano via transferred birds or fish. Currently, contrary to what happens at Lake Albano, the species is absent despite careful research on the shores of Lake Nemi.

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