

Characterization of the land snail *Ganula lanuginosa* (Boissy, 1835) (Mollusca: Hygromiidae): new invader of the Iberian Peninsula

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Abstract

Characterization of the land snail Ganula lanuginosa (Boissy, 1835) (Mollusca: Hygromiidae): new invader of the Iberian Peninsula. Recently, a well-established population of the hygromiid *Ganula lanuginosa* has been discovered in the Iberian Peninsula, specifically in Xàtiva (Province of Valencia, Spain), corresponding to the first record for the Iberian Peninsula and the Continental Europe. It is a land snail native to North Africa and also known from the European Mediterranean islands, namely the Balearic Islands (Spain), Sardinia (Italy) and Corsica (France). Morpho-anatomical studies of the shell and the reproductive system have been carried out, and these features have been compared with those of the most similar hygromiids, which has allowed us to correctly identify them. In addition, parasitological and ecological data are contributed and the geographical distribution map of *G. lanuginosa* in Spain is shown, including the new location.

Key words: Land mollusc, *Ganula lanuginosa*, introduced species, Valencian Community, Spain, Iberian Peninsula.

Resumen

Caracterización del caracol terrestre Ganula lanuginosa (Boissy, 1835) (Mollusca; Hygromiidae): nuevo invasor de la península ibérica: datos morfo-anatómicos, parasitológicos y ecológicos. Recientemente se ha descubierto una población bien establecida del higrómido *Ganula lanuginosa* en la península ibérica, concretamente en Xàtiva (Provincia de Valencia, España), correspondiendo a la primera localidad confirmada para la península ibérica y Europa continental. Es un caracol terrestre nativo del norte de África y conocido también de las islas mediterráneas europeas: Baleares (España), Cerdeña (Italia) y Córcega (Francia). Se han realizado estudios morfo-anatómicos de la concha y del aparato reproductor, y estas características se han comparado con las de los higrómidos más similares, lo que nos ha permitido su correcta identificación. Además, se aportan datos parasitológicos y ecológicos y se muestra el mapa de distribución geográfica de *G. lanuginosa* en España, incluyendo la nueva localización.

Palabras clave: Molusco terrestre, *Ganula lanuginosa*, especie introducida, Comunidad Valenciana, España, península ibérica.

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Introduction

Recently, during the alarm phase for the SARS–CoV–2 coronavirus that causes the COVID–19 pandemic, the biologist José Manuel Cerdá, a collaborator of the Museu Valencià d'Història Natural (MVHN) found, during the walks allowed by the authorities to the residents of the area, some shells of a land snail unknown to him in the surroundings of Xàtiva (Province of Valencia) (Martínez–Ortí, 2021). This species did not appear in the lists of terrestrial molluscs of the malacological works on Valencian terrestrial molluscs carried out by Martínez–Ortí (1999) and Martínez–Ortí & Robles (2003), nor in the literature. The initial observation of the sample in the MVHN was of great interest when discovering that it was a hygromiid that had not been previously cited neither in the Valencian Community nor in the Iberian Peninsula. For its correct identification, the shell and the reproductive system are studied and compared with several species of hygromiids present in Spain, with shells more similar to the new taxon discovered in the Province of Valencia. One of them corresponds to the genus *Hygromia* Risso, 1826 and another two to genus *Ganula* Gittenberger, 1970, although their known species live quite far from the new continental location. *Ganula* was considered a subgenus of *Hygromia* and later restituted to the genus level by Giusti & Manganelli (1987). From these two currently valid genera, it seems to correspond, due to the greater morpho-anatomical similarity, with the second mentioned, of which two species are known, *G. lanuginosa* (Boissy, 1835), originally from North Africa and living on the Balearic Islands, where it was introduced centuries ago, and *G. gadirana* Muñoz, Almodóvar & Arrébola, 1999, exclusive to Campo de Gibraltar in the province of Cádiz (Gasull, 1963; Gittenberger, 1970; Puente, 1994; Muñoz *et al.*, 1999; Schileyko, 2005; Ruiz Ruiz *et al.*, 2006; Arrébola *et al.*, 2008; Welter–Schultes, 2012). Finally, considering all these data, the hygromiid found in the Province of Valencia has been identified, ecological and parasitological data are provided and the updated geographical distribution map of this species in Spain is shown.

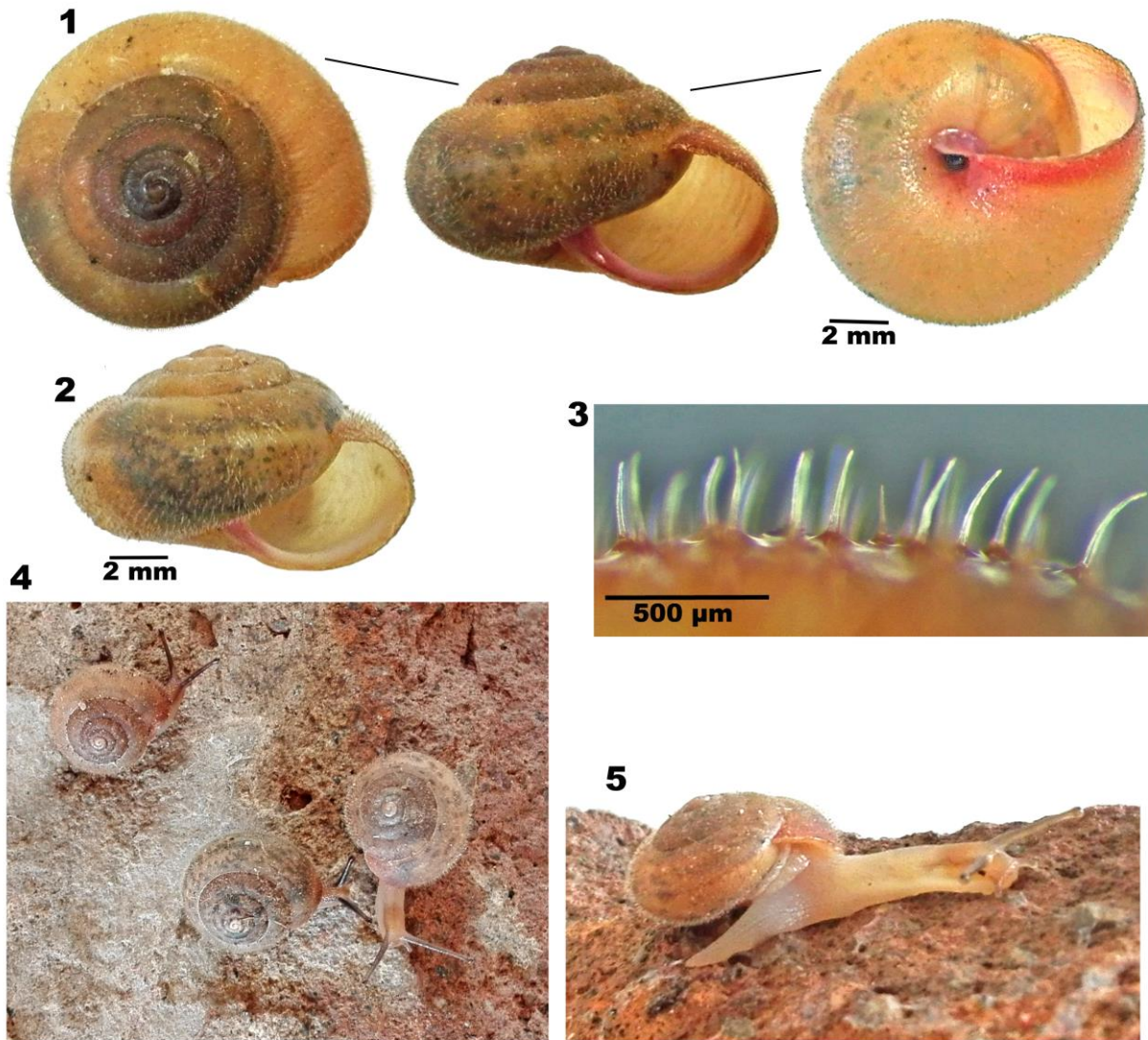
Material and methods

The material was initially collected by our collaborator, at the end of March 2020 in various piece of ground of the Les Pedreres housing development in Xàtiva (UTM: 30SYJ1318; 100 m altitude). Subsequently, new samplings were carried out in the same place on June 5, 2020 by the author. The sample is deposited at the MVHN of Alginet (Spain) with the code MVHN–120620TT04, and is made up of 15 shells and 17 specimens preserved in 70% ethanol. Also in this study are included shells of *G. lanuginosa* from Mallorca (Balearic Islands, Spain), code MVHN–280610ZB08, of *G. gadirana* from the outskirts of Algeciras (Cádiz), with code MVHN–1382, and of *Hygromia limbata* (Draparnaud, 1805) from Lescun, near the Aspe River (Eastern Pyrenees, France), with code MVHN–110720KH01. The images of all the shells were taken using a Leica M80 stereomicroscope, with an attached IC90E camera (Figs 1–10).

Results and discussion

The study carried out on the shell and the reproductive system confirms that the species found in Xàtiva (Valencia) corresponds to *Ganula lanuginosa* (Boissy, 1835) (Martínez–Ortí, 2021), a species that is cited and confirmed herein by morpho-anatomical studies of the reproductive system, as for the first record in the Valencian, Iberian and continental European malacofauna.

Morpho-anatomical data (Figs 1–7, 11–13): It has a medium-sized shell, dextral, globose, translucent, cornea, yellowish or violet, finely striated, spire having between 5 and 5½ whorls, slightly convex, the last whorl rounded with a weak whitish keel, densely hairy with short white periostracal hairs set on small tubercles, rounded, sloping and slightly droopy aperture, simple peristoma with a slight pinkish-reddish inner lip, small, narrow umbilicus and partially covered by peristome reflection (Figs 1–7) (Gasull, 1963; Gittenberger, 1970; Schileyko, 2005; Welter–Schultes, 2012).

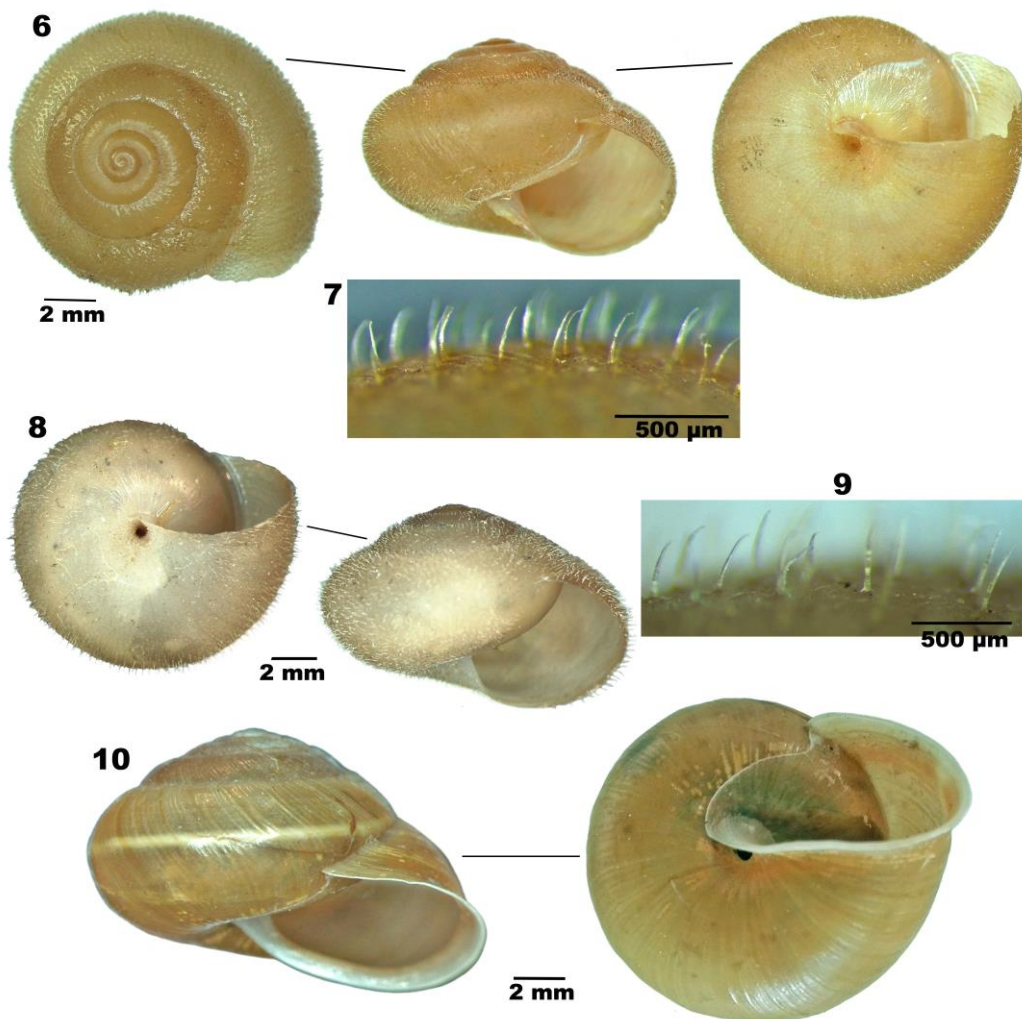


Figures 1–5. Shell of *Ganula lanuginosa*. Les Pedreres, Xàtiva (Valencia, Spain) (MVHN–120620TT04); 3. Periostracal hairs. Scale reference for figures 4 and 5 are the shell size in figures 1 and 2.

Figuras 1–5. Concha de Ganula lanuginosa. Les Pedreres, Xàtiva (Valencia, España) (MVHN–120620TT04); 3. Pelos periostracales. La referencia de escala para las figuras 4 y 5 es el tamaño de las conchas en las figuras 1 y 2.

From the specimens of Xàtiva 16 have been measured with dimensions between 10.5 mm and 11.8 mm in width and between 7.2 mm and 8.8 mm in height. Welter–Schultes (2012) indicated a range between 11 and 13 mm in diameter and between 7 and 9 mm in height. Schileyko (2005) indicated dimensions for the genus *Ganula* between 11.0 and 14.0 mm in

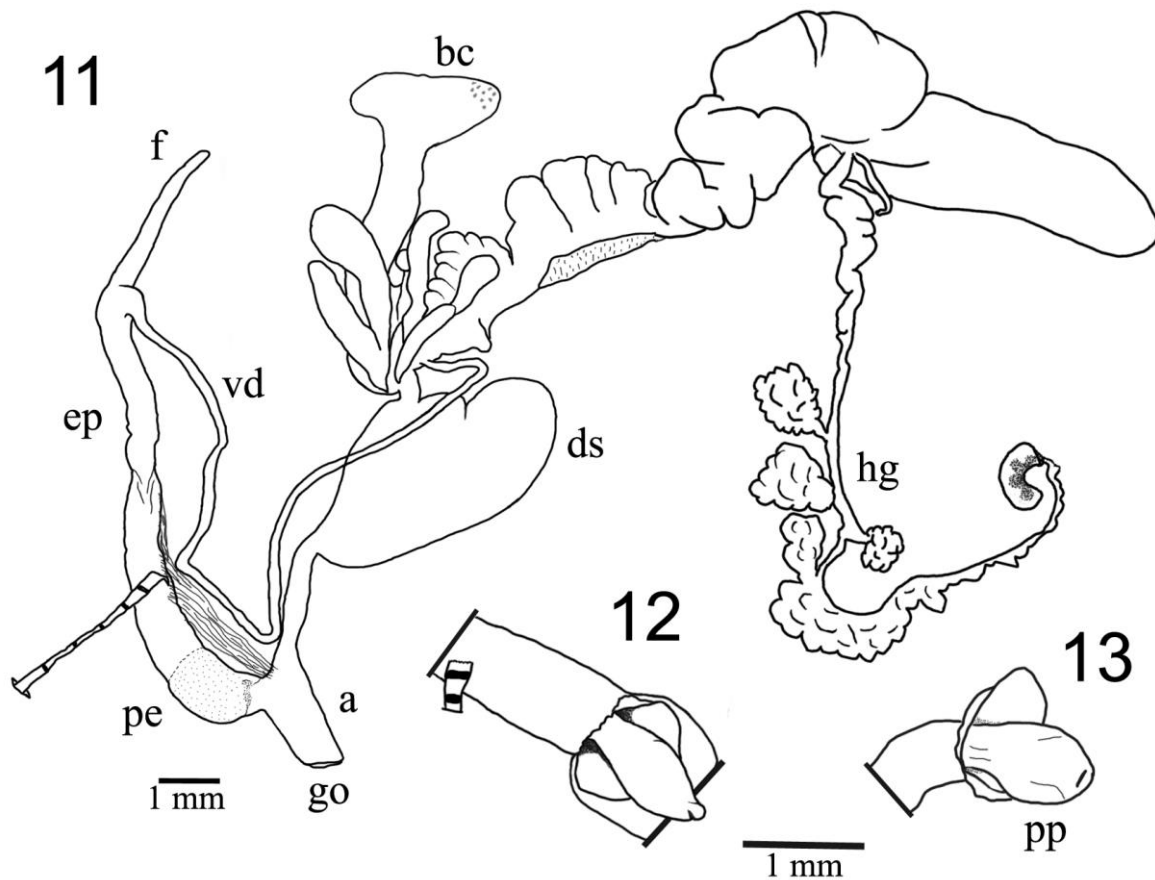
diameter and between 8.0 and 9.0 mm in height. Conchiologically it can be initially confused with other hygromiids, such as *Hygromia limbata* (Draparnaud, 1805) (Fig. 10) or *Ganula gadirana* (Figs 8, 9), both taxa living in Spain. *H. limbata* has a medium to large sized shell, corneal light to brown in colour, without hairiness on the teleoconch, often with a clear band of varying intensity on the last whorl and with a slight carina, with patent white internal callous rib, inside the aperture, and with dimensions between 12.0 and 17.2 mm in diameter and between 8.0 and 14.0 mm in height (Germain, 1930; Gittenberger, 1970; Faci, 1991; Prieto & Puente, 1992; Puente, 1994; Kerney & Cameron, 1999; Welter–Schultes, 2012; own data). After the detailed revision of the shell of the present Valencian sample, we can discard the assignment to this species. *G. gadirana* has a very similar shell, almost identical to *G. lanuginosa*. However, *G. lanuginosa* has a convex-depressed shell on its upper face, with less deep sutures, less convex whorls, slightly longer and less widely spaced periostracal hairs, somewhat wider umbilicus and with a narrow pink or reddish inner lip (Gasull, 1963; Muñoz *et al.*, 1999).



Figures 6–10. Shells of hygromiids similar to *Ganula lanuginosa* of Xàtiva (Valencia); 6, 7. *Ganula lanuginosa*. Palma near to Génova, Mallorca (Balearic Islands, Spain) (MVHN–280610ZB08); 7. Periostracal hairs; 8, 9. Shell of *G. gadirana*. Outskirts of Algeciras (Cádiz, Spain) (MVHN–1382); 9. Periostracal hairs of *G. gadirana*; 10. Shell of *Hygromia limbata*. Lescun (Pyrénées-Orientales, France) (MVHN–110720KH01).

Figuras 6–10. Conchas de higrómidos similares a Ganula lanuginosa de Xàtiva (Valencia, España); 6, 7. Ganula lanuginosa. Palma cerca de Génova, Mallorca (Islas Baleares, España) (MVHN–280610ZB08); 7. Pelos periostracales; 8, 9. Concha de G. gadirana. Afueras de Algeciras (Cádiz, España) (MVHN–1382); 9. Pelos periostracales de G. gadirana; 10. Concha de Hygromia limbata. Lescun (Pirineos Orientales, Francia) (MVHN–110720KH01).

Regarding the reproductive system, *G. lanuginosa* has the right ommatophore between the vagina and the penis, as occurs in hygromiids. It is characterized by being provided with a stimulator apparatus on one side of the vagina with a thick dart sac and a smaller internal accessory sac. Flagellum and penis approximately equal in size, and epiphallus almost twice as long as either. Epiphallus and penis are joined by a muscular band that extends to the atrium. The penial papilla of *G. lanuginosa* is elongated, with a wider middle area and an apical orifice, and is housed in a muscular sheath, from which part of the papilla comes out and is surrounded by the glandular tissue of the distal penial area (Figs 12–13) (Gittenberger, 1970; Giusti & Manganelli, 1987; Puente, 1994). It has four digitiform mucous glands, simple or bifurcated. Gittenberger (1970) points out that one is always bifurcated and Muñoz *et al.* (1999) point out that all four. In the two examined specimens from Xàtiva, three of them were bifurcated and one simple, with seven digitiform glands in total (Fig. 11). The dart is curved in one direction, without a crown and with two stripes at its apex (Gittenberger, 1970; Puente, 1994).



Figures 11–13. 11. Reproductive system of *Ganula lanuginosa* from Xàtiva (Valencia, Spain) (MVHN–120620TT04); 12. Penial papilla; 13. Penial papilla of other specimen. (abbreviations: a=atrium; bc=bursa copulatrix; ds=dart sac; ep=epiphallus; f=flagellum; go=genital opening; hg= hermaphrodite gland; pe=penis; pp=penial papilla; vd=vas deferens).

Figuras 11–13. 11. Aparato reproductor de Ganula lanuginosa de Xàtiva (Valencia, España) (MVHN–120620TT04); 12. Papila penial; 13. Papila penial de otro ejemplar. (abreviaturas: a=atrio; bc=bursa copulatrix; ds=saco del dardo; ep=epifalo; f=flagelo; go=orificio genital; hg=glándula hermafrodita; pe=pene; pp=papila penial; vd=vaso deferente).

In the specimens studied, although in general they were adults or sub-adults, we have not found darts inside the sac. *H. limbata* presents clear differences with respect to *G. lanuginosa*, such as the possession of a short flagellum, a very long penis and epiphallus, with eight simple mucous glands, bursa copulatrix duct long, with the dart sac more slender and smaller than the accessory sac, and elongated cylindrical penial papilla (Gittenberger, 1970; Faci, 1991; Prieto & Puente, 1992; Puente, 1994; Schileyko, 2005). The genitalia of *G. lanuginosa* differs from *G. gadirana* in the configuration of the stimulatory apparatus, by showing the longest flagellum, the least number of mucous glands, the longest atrium, the absence of orifices in the penial papilla and also presenting a muscular sheath that surrounds it in its proximal area (Muñoz *et al.*, 1999; own data) (Figs 11–13).

Ecological and parasitological data: *G. lanuginosa* is a calcareous and xerophilous species with a wide ecological tolerance. It lives in different types of habitats, as are ruderal (roadside and highways, uncultivated places), orchards, gardens, meadows, rocky areas, forest and Mediterranean scrub, where it can be found under rocks and stones, on the ground, among the litter, from near the sea to 600 m altitude (Gasull, 1963; Puente 1994; Arrébola, 2011a; Welter–Schultes, 2012). The specimens of *G. lanuginosa* from Xàtiva have been found mainly among ruderal vegetation such as edge oats (avena borde) (*Avena sterilis* Linnaeus, 1758), the fennel (*Foeniculum vulgare* Miller, 1768), the tomato plant (*Solanum lycopersicum* Linnaeus, 1758), uncultivated, and the olive grove (*Dittrichia viscosa* Linnaeus, 1753), among others, also on the ground, semi-buried, under stones and urban waste, plastic objects, etc., present in the area, at an altitude of 100 m. The population is large and well established, presenting both adults and juveniles. It has been found living in the town of Xàtiva with other terrestrial gastropods: *Caracollina lenticula* (Michaud, 1831), *Ceruellia virgata* (Da Costa, 1778), *Cochlicella barbara* (Linnaeus, 1758), *Cornu aspersum* (O.F. Müller, 1774), *Eobania vermiculata* (O.F. Müller, 1774), *Microxeromagna lowei* (Poitiez & Michaud, 1852), *Otala punctata* (O.F. Müller, 1774) and *Xerotricha conspurcata* (Draparnaud, 1801).

The parasites of *G. lanuginosa* are unknown and of *Ganula gadirana*, the other species of the genus *Ganula*, only the finding of nematodes in the lung cavity is known (Muñoz *et al.*, 1999). Other species of *Hygromia* are known as intermediate hosts for various digenea flukes such as *Brachylaema fuscata* (Rudolphi, 1819), and nematodes like *Protostrongylus* sp. and *Angiostrongylus dujardini* Drozd & Doby, 1970 (Cordero & Manga, 1996), pending further study that could contribute to the knowledge of their parasites and their veterinary and sanitary importance.

Geographical distribution (Fig. 14): *G. lanuginosa* is a Mediterranean species native to North Africa, which extends from Morocco to Tunisia, and which has colonized the European islands of the Balearic Islands (Spain), Sardinia (Italy) and Corsica (France) since the Middle Ages (Sacchi, 1957; Gasull, 1963; Falkner, Ripken & Falkner, 2002; Schileyko, 2005; Welter–Schultes, 2012). Fossil are unknown from Europe (Gasull, 1963). Giusti & Manganelli (1987) pointed out that *G. lanuginosa* is autochthonous to the south of the island of Sardinia, and was part of the ancient fauna of the Sardinian-Corsican complex before separating from the southwest flank of the European continent, where the other known populations of the Balearic Islands and the south of the Iberian Peninsula would remain. On the other hand, various authors point out that *G. gadirana* only lives in the Province of Cádiz and that the previous citations of *G. lanuginosa* from the province of Málaga should not be considered valid because they are not supported by anatomical evidence of the reproductive system in order to confirm the identification, also considering that more specimens have not found again (Puente, 1994; Muñoz *et al.*, 1999; Ruiz Ruiz *et al.*, 2006; Arrébola & Ruiz Ruiz, 2008; Arrébola, 2011a, 2011b). However, other authors such as Welter–Schultes (2012) and Bank & Neubert (2017) they do

consider the *G. lanuginosa* citations valid in Andalusia. The new population found in the Valencian Community is scattered over various piece of ground of the Les Pedreres housing development of Xàtiva and some nearby roads, which run between orange groves, and constitutes the first confirmed population of this species in the Iberian Peninsula and in continental Europe (Fig. 14). It is unknown how it got to Xàtiva, although we consider that its presence is probably due to accidental anthropic action. The large number of specimens, both adults and juveniles, and their wide dispersal throughout the area, indicates that the population is well established and allows us to assume that it was introduced several years ago. *G. lanuginosa* is not currently considered an invasive species, as is the case with other hygromiids (Cowie *et al.*, 2009), since it is only known from three European countries of the western Mediterranean. This introduction is similar to that which occurred with other native species from North Africa that reached the Balearic Islands and/or the Iberian Peninsula, such as *Sphincterochila cariosula* (Michaud, 1833) (Gasull, 1963; Fechter & Falkner, 1990; Ruiz Ruiz *et al.*, 2006) or *Helix melanostoma* Draparnaud, 1801 (Martínez–Ortí, 2002).

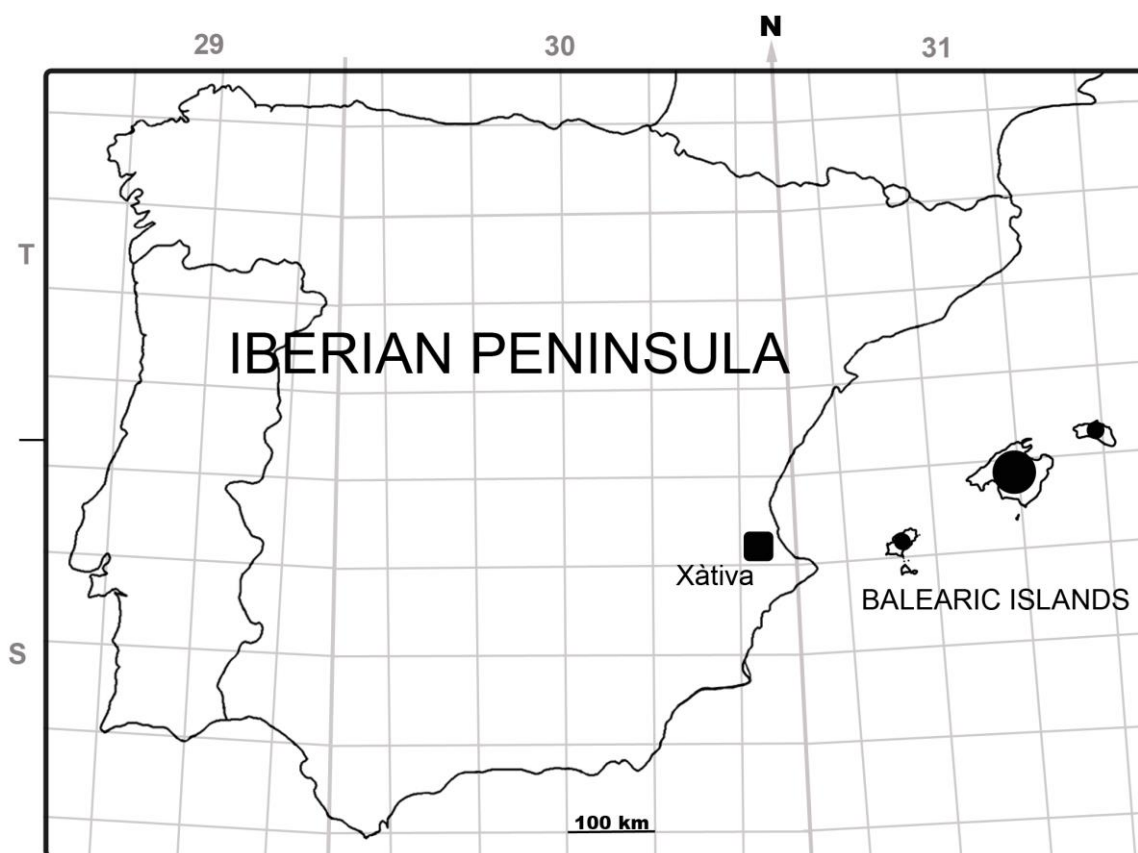


Figure 14. Map of geographical distribution of *Ganula lanuginosa* in Spain. (points: presence on the Balearic Islands; black square Les Pedreres, Xàtiva, Valencia).

Figura 14. Mapa de distribución geográfica de *Ganula lanuginosa* en España. (puntos: presencia en las islas Baleares; cuadro negro: Les Pedreres, Xàtiva, Valencia).

In our opinion, this species, like many other non-native species, can be considered invasive and also cause of important impacts on biodiversity, agriculture, trade and animal and human health, and can become major public nuisances and damage natural ecosystems (Cowie, 2005; Cowie *et al.*, 2009; Martínez–Ortí, 2020). The most appropriate thing would be to carry out a plan for the control and eradication of *G. lanuginosa* in the new Valencian location. However, it is important to point out that no such plan has ever been carried out to eradicate other non-native

continental molluscs in the Valencian Community. These plans should be taken into account in Spain in the nearest future, like the one proposed by Martínez–Ortí (2020) for *Xerolenta obvia* (Menke, 1828) in Aragón (Spain), currently under execution, to control and eradicate these introduced land snails, as is already being done in other countries, such as the USA or Australia (Robinson & Slapcinsky, 2005; Micic, 2020).

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