Risk map of transmission of urogenital schistosomiasis by *Bulinus truncatus* (Audouin, 1827) (Mollusca Gastropoda, Bulinidae) in Spain and Portugal

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Abstract
Risk map of transmission of urogenital schistosomiasis by Bulinus truncatus *(Audouin, 1827) (Mollusca Gastropoda, Bulinidae) in Spain and Portugal.* We present a geographical distribution map of *Bulinus truncatus* based on historical and current localities in Spain and Portugal, that corresponds to the risk map of urogenital schistosomiasis for this freshwater snail. We reviewed samples of the species deposited at the Museu de Ciències Naturals of Barcelona and the Museo Nacional de Ciencias Naturales of Madrid, together with our own data, including some unpublished contributions. This map will help determine the optimal area for this species and identify areas of greatest risk for urogenital schistosomiasis in the two countries. We emphasize that global change and climate change may favour the presence of both the vector (*B. truncatus*) and the parasite (*Schistosoma haematobium*) in Spain and Portugal.

Key words: *Bulinus truncatus*, Bulinidae, Urogenital schistosomiasis, Risk map, Spain, Portugal

Resumen
Mapa del riesgo de contraer schistosomiasis urogenital provocada por Bulinus truncatus *(Audouin, 1827) (Mollusca Gastropoda, Bulinidae) en España y Portugal.* Se da a conocer el mapa de la distribución geográfica de *Bulinus truncatus* en España y Portugal en el que se recopilan las localidades históricas y actuales, que coincide con el mapa del riesgo de contraer schistosomiasis urogenital provocada por este caracol de agua dulce. Se revisan las muestras de esta especie depositadas en el Museu de Ciències Naturals de Barcelona y en el Museo de Ciencias Naturales de Madrid, así como datos propios, incluidas algunas aportaciones inéditas. Este mapa permitirá conocer el área óptima de esta especie y determinar las zonas de mayor riesgo de contraer schistosomiasis urogenital en los dos países. Se pone de manifiesto que el cambio global y el cambio climático pueden favorecer la presencia tanto del vector (*B. truncatus*) como del parásito (*Schistosoma haematobium*) en España y Portugal.

Palabras clave: *Bulinus truncatus*, Bulinidae, Schistosomiasis urogenital, Mapa de riesgo, España, Portugal

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Introduction

Bulinus O. F. Müller, 1781 is a genus of the Family Bulinidae P. Fischer and Crosse, 1880. It is of great health interest because most of its species are vectors of parasites that can cause serious diseases in humans, such as schistosomiasis (bilharziasis) (Malek and Cheng, 1974; Brown, 1980). Urogenital schistosomiasis was recently confirmed in the island of Corsica (France), with both the trematode *Schistosoma haematobium* (Bilharz, 1852) and its vector, the bulinid gastropod mollusc *Bulinus truncatus* (Audouin, 1827), coexisting (Berry et al., 2014; Holtfreter et al., 2014; Boissier et al., 2015, 2016). It should be noted that the epidemic in Corsica is not only due to the pure *S. haematobium* strain but also to a hybrid of *S. haematobium* and *S. bovis* (Sonsino, 1876), with which the epidemic acquires zoonotic connotations and great potential for dispersion, broadening the spectrum of reservoirs and vectors of the causal agent (Huyse et al., 2009; Boissier et al., 2016; Kincaid–Smith et al., 2017).

Urogenital schistosomiasis can cause squamous bladder cancer and prostate cancer, acute appendicitis, and infertility in women (Gabbi et al., 2006; Figueiredo et al., 2015; Grácio, 2018). It was detected in the Iberian Peninsula at the beginning of the 20th century in the Algarve in Portugal (Sampaio Xavier and Fraga de Azevedo, 1966). It is currently known in Spain and Portugal, although the trematode has only been found in sub–Saharan migrants. No cases of autochthonous transmission have been reported to date (Martínez–Ortí et al., 2015). In Spain, the disease has been diagnosed in four hospitals: 1) Poniente Hospital in El Ejido (Almería) (Salas–Coronas in Ríos 2011, Salas–Coronas et al., 2018); 2) Hospital Universitario Materno–Infantil de Canarias, in Gran Canaria (Ramos Macías et al., 2010); 3) Vall d'Hebron Hospital in Barcelona (Bocanegra et al., 2014); and 4) Hospital Clinic de Barcelona (Calvo–Cano et al., 2015). The ages of patients ranged from 20 to 30 years. Several cases have also been detected in the São João Hospital in Porto, Portugal (Dr. Rogério Ruas, pers. comm.), and cases have also been documented in returned military personnel from the former Portuguese African colonies (Vieira et al., 2007).

Several authors suggest that the lymnaeoid molluscs *B. truncatus* and *Planorbarius metidjensis* (Forbes, 1834) should be considered the intermediate hosts of *S. haematobium* and a *S. haematobium–S. bovis* hybrids, respectively, and therefore susceptible to the spread of the disease in Portugal and Spain (Fraga de Azevedo, 1965; Fraga de Azevedo and Xavier Sampaio, 1965, 1969; Ramajo–Martín, 1978; Grácio, 1983; Boissier et al., 2016; Kincaid–Smith et al., 2017).

B. truncatus is also a transmitter of *S. bovis* and experimentally of *S. margrebowiei* Le Roux, 1933 (Southgate and Knowles, 1977) and of *Paramphistonum cervi* (Schrank, 1790) and *P. microbothrium* Fischoeder, 1901, parasitizing small and large rumiants (Malek and Cheng, 1974; Brown, 1980; Pampiglione et al., 1988). It has also been experimentally demonstrated that it is the second intermediate host of *Echinostoma* spp. (Brown, 1980; Christensen et al., 1980).

B. truncatus presents a wider geographic area, extending along the coasts of the circum–Mediterranean region, much of Africa, the Middle East and the Irano–Turanian region. In Europe it is cited from various Mediterranean countries and Portugal (Martínez–Ortí et al., 2015), but it has not been mentioned in the Macaronesian islands (Bank et al., 2002). In North Africa it is known from Egypt to the south of Morocco and the Sahara, and from Angola to Malawi and Ethiopia in the south, as well as in the Middle East (Israel, Iran, Iraq, Jordan, Saudi Arabia, Syria and Yemen) (Germain, 1931; Larambergue, 1939; Brown, 1980; Schütt, 1987; Neubert, 1998; Martínez–Ortí et al., 2015).

This species does not present a fossil record in Europe, although the genus *Bulinus* is present. The oldest fossil record in Europe is known from other species of the genus *Bulinus*: *B. meneghinii* (Sacco, 1886) cited from Fossano (Piamonte, Italy) (7,246–5,552 Ma), *B. corici* Harzhauser and Neubauer, 2012 (15.97–13.65 Ma) from Jauring in the Aflenz basin (Austrian Alps) (Harzhauser et al., 2011) and *B. matejici* (Pavlović, 1931) from Miocene lacustrine deposits (ca. 15.97–11.63 Ma) of the Serbian Lake System at Ćerane near Kaona, Gornja Mutnica, Mađare and Pardik in central Serbia and the late Miocene of the Turiec Basin in Slovakia and Kosovo (Neubauer et al., 2017). Another five fossil species of *Bulinus* are present in Kosovo: *B. bouei* (Pavlović, 1931), *B. ornatus* (Pavlović, 1931), *B. pavlovici* (Atanacković, 1959), *B. stevanovici* (Atanacković, 1959) and *B. striatus* (Milošević, 1978).

Kincaid–Smith et al. (2017) questioned the spatial repartition of schistosome intermediate hosts in Europe and emphasized the urgency of determining the geographical distribution of the snail's intermediate host populations and monitoring their spatiotemporal dynamics.

Morelet (1845) cites *B. truncatus* for the first time in the Iberian Peninsula, in Coimbra in Portugal. For Spain, Graells (1846) later cites its presence in the locality of Barcelona and Bofill (1917) reports findings in the Balearic Islands. Currently in Spain its geographical distribution is circumscribed to various Mediterranean and Atlantic regions: Andalusia, the Balearic Islands, Catalonia, Valencia and Galicia, although we have proof of its living presence only in Andalusia (Rolán et al., 1987; Bech, 1990; Pérez–Quintero et al., 2004). However, in continental Portugal it is documented throughout the entire length of the country (Morelet, 1845; Nobre, 1913, 1941; Fraga de Azevedo et al., 1969a, 1969b; Sampaio et al., 1975, 1977; Medeiros and Simões, 1979). In Spain, in Ibiza and Gavà, and in Malta, *B. truncatus* is known from the Holocene, relatively recent (–12,000 –10,000 years) (Gasull, 1965; Marqués–Roca, 1974; Giusti et al., 1995).

The biogeographical data collected in this work is of great interest to public health before urogenital schistosomiasis possibly reaches the Iberian Peninsula, as recently occurred in Corsica. Therefore, knowing such as what location of the disease vector, *B. truncatus*, in the Iberian Peninsula and Balearic Islands, is of great interest to predict the possible transmissions of this disease and control the possible foci of transmis-

Fig. 1–3. *Bulinus truncatus:* 1, vegetable garden in Bonanova, Barcelona (Spain) (MNCN 15.05–26320, h = 6.1 mm). 2, Adra (Almeria, Spain) (MZB 84–7124, h = 7.9 mm); 3, Porto–Vecchio, Corsica (France) (MVHN–240815AF01, h = 8.0 mm).

Fig. 1–3. Bulinus truncatus*: 1, huerto de Bonanova, Barcelona (España) (MNCN 15.05–26320, h = 6,1 mm); 2, Adra, Almería (España) (MZB 84–7124, h = 7,9 mm); 3, Porto Vecchio, Córcega (Francia) (MVHN–240815AF01, h = 8,0 mm).*

sion. Kincaid–Smith et al. (2017) indicated the need for health authorities to better quantify the risks and prevent future outbreaks of urogenital schistosomiasis in Europe and to know more about the ecological features that cause the host–parasite interactions.

Material and methods

For a better knowledge of its geographical distribution and the places where it has been historically found in the Iberian Peninsula and the Balearic Islands, we performed an exhaustive review of the samples of this species deposited at the 'Museo Nacional de Ciencias Naturales' of Madrid (MNCN), the 'Museu de Ciències Naturals' of Barcelona (MCN), and our own data deposited in the Museu Valencià d'Història Natural (MVHN) of Alginet (Valencia), which has also allowed us to provide several new locations (Martínez–Ortí, 2017; Uribe and Agulló Villaronga, 2018).

All known bibliographic locations of *B. truncatus* in the Iberian Peninsula and the Balearic Islands are listed, and numerous samples deposited in the MNCN of Madrid and the MCN of Barcelona have been reviewed. The localities whose samples are deposited in the MVHN are also provided (tables 1, 2). In these tables of localities in Spain and Portugal, the place and municipality is named the first time it is cited, along with the author and year of publication; the same places mentioned by the same author or other authors later are not repeated. Four samples from the MNCN and 29 from the MCN have been reviewed, some of them corresponding to unpublished localities (figs. 1–3; tables 1, 2). The geographical coordinates of locations in the cities of islands such as Ibiza, Mallorca or Menorca, as places where the species are found, are not indicated as the precise localities are not known by some authors.

The geographical distribution map was made using an Excel spreadsheet (Microsoft Office 2014) and the Qgis version 2.18 geographic information system program.

Results

For the last two centuries, *B. truncatus* has been present on the coasts of Spain and Portugal. However, it has not been reported from the centre of the Iberian Peninsula, the Pyrenees or Cantabrian areas despite numerous malacological studies conducted in these areas (fig. 4), In Spain it has been described by several authors from 63 localities near the coast (fig. 4; table 1). Of the 32 revised samples of *B. truncatus* deposited at the MNCN and the MCN, six are unpublished, and two new locations are provided (table 1).There are no recent reports of *B. truncatus* in Portugal. From 1845 onwards it has been reported from 17 localities in the regions of Minho, Douro Litoral, and Beira Litoral in the north and the Algarve in the south, but it has not been reported since (Mendez Simoes, 2016) (fig. 4; table 2). Similarly, since 1983 it has not been found in France, and Larembergue (1939), indicated that *B. truncatus* should be eliminated from the list of molluscs living in mainland France as he did not find it during his samplings.

Discussion

The geographical distribution of *B. truncatus* has been predicted to spread both in Spain and Portugal, and also

Table 1. List of localities of *Bulinus truncatus* in Spain. Only the author indicating the location for the first time is shown. The locations are transcribed exactly as they appear in the original publications: UTM, Universal Transverse Mercator.

Tabla 1. Lista de las localidades de Bulinus truncatus *en España. Solo se indica el autor que señala el lugar por primera vez. Se transcriben las localizaciones tal y como aparecen en las publicaciones originales: UTM, sistema de coordenadas universal transversal de Mercator.*

Nº	Locality	Reference	UTM
1	Barcelona	Graells (1846)	31TDF28
2	Casa Antúnez, Barcelona	Chía (1887)	31TDF28
3	Between the hypodrome and the mouth of the Llobregat River (Barcelona)	Fagot (1892)	31TDF27
4	Besos River, Barcelona	Martorell and Bofill (1888)	31TDF38
5	'Menorca' (Balearic Islands)	Martorell and Bofill (1888)	–
6	Hostalrich (Girona)	Chía (1893)	31TDG62
7	Pubol Pond (Girona)	Chía (1893)	31TDG95
8	Hostalrich, Tordera River (Girona)	Chía (1916)	31TDG62
9	Albufera, Alcudia Lagoon (Mallorca, Balearic Islands)	Bofill (1917)	31SEE10
10	Albufera, Alcudia Lagoon (Mallorca, Balearic Islands)	Maluquer (1917)	31SEE10
11	Segles (irrigation canal) of de Deià (Mallorca, Balearic Islands)	Maluquer (1917)	31TEE60
12	'Ibiza' (Balearic Islands)	Bofill (1919)	–
13	Between the hypodrome and the mouth of the Llobregat River (Barcelona)	Bofill and Haas (1920)	31TDF27
14	Castelldefels (Barcelona)	Bofill and Haas (1920)	31TDF17
15	Mouth of Besos River (Barcelona)	Bofill et al. (1921)	31TDF38
16	Mataró (Barcelona)	Bofill et al. (1921)	31TDF59
17	Remolar Pond, Viladecans (Barcelona)	Haas (1929)	31TDF27
18	Santa Galdana (Menorca, Balearic Islands)	Aguilar–Amat (1933)	31SEE82
19	Bottom of Mahón ria, Colársega (Menorca, Balearic Islands)	Sacchi (1954)	31SFE01
20	Rice field irrigation canals of Son Canesias, Son Bou (Menorca, Balearic Islands)	Sacchi (1954)	31SEE91
21	Ferrerías River, Barranc d' Algendar River (Menorca, Balearic Islands)	Sacchi (1954)	31SEE82
22	Irrigation canal of Son Saura, Ciutadella (Menorca, Balearic Islands)	Sacchi (1954)	31SEE72
23	'Menorca' (Balearic Islands)	Sacchi (1957a)	–
24	'Mallorca' (Balearic Islands)	Sacchi (1957b)	–
25	Palma. Molinar de Levante (Mallorca, Balearic Islands)	Gasull (1965)	31SDD77
26	Palma. Mestre Pere Spring (Mallorca, Balearic Islands)	Gasull (1965)	31SDD78
27	La Pobla. 'Ca'n Roca' (Mallorca, Balearic Islands)	Gasull (1965)	31SEE00
28	La Pobla. 'Ca'n Pujolet' (Mallorca, Balearic Islands)	Gasull (1965)	31SEE00
29	La Pobla. 'Ca'n Blau' (Mallorca, Balearic Islands)	Gasull (1965)	31SEE00
30	Muro, Son San Juan Spring (Mallorca, Balearic Islands)	Gasull (1965)	31SEE00
31	Ratjada cove. Son Moll, Torrente (Mallorca, Balearic Islands)	Gasull (1965)	31SED39
32	Artá. Irrigation canal Molins Molinet (Mallorca, Balearic Islands)	Gasull (1965)	31SED29
33	Son Servera. Son Jordi, Torrente (Mallorca, Balearic Islands)	Gasull (1965)	31SED38
34	Alaior. Son Bou Beach (Menorca, Balearic Islands)	Gasull (1965)	31SEE91

Table 1. (Cont.)

Nº	Locality	Reference	UTM
35	Ferreries, Santa Galdana, Binissaid Spring (Menorca, Balearic Islands)	Gasull (1965)	31SEE82
36	Ciutadella, Son Saura Beach, irrigation canal (Menorca, Balearic Islands)	Gasull (1965)	31SEE72
37	Ciutadella, Cala Macarella, irrigation canal (Menorca, Balearic Islands)	Gasull (1965)	31SEE82
38	Mahón, María Spring (Menorca, Balearic Islands)	Gasull (1965)	31SFE01
39	Fornells, Coves Noves (Menorca, Balearic Islands)	Gasull (1965)	31TEE93
40	'Cala en Porter' (Menorca, Balearic Islands)	Gasull (1965)	31TEE91
41	San Antonio, Flandriense mudflats in the bay (Ibiza, Balearic Islands)	Gasull (1965)	31SCD51
42	Rocina Creek, El Rocio P. N. Doñana (Huelva)	Marazanof (1966)	29SQB21
43	El Saltillo Creek, P. N. Doñana (Huelva)	Marazanof (1966)	29SQB12
44	Water pond between Picamoixons and Alcover, Alt Camp (Tarragona)	Vilella (1967)	31TCF47
45	La Farola. Delta del Llobregat (Barcelona)	Altimira (1969)	31TDF27
46	Beach by the lighthouse, detritus from alluvial river deposits. Delta del Llobregat (Barcelona)	Altimira (1969)	31TDF27
47	Red clay on Gavà sands (Barcelona)	Marqués–Roca (1974)	31TDF17
48	Fornells (Menorca, Balearic Islands)	Hidalgo in Compte (1985)	31SEE93
49	Xuño Lake (La Coruña)	Rolán et al. (1987)	29TMH92
50	Ampùries, Alt Empordà (Girona)	Bech (1993)	31TEG06
51	'Veta del Martinazo', Guadalquivir river basin (Huelva)	Pérez–Quintero et al. (2004)	29SQB20
52	Prado river bed, Piedras River (Huelva)	Pérez–Quintero et al. (2004)	29SPB5220
53	Adra Lagoon (Almería)	Bayo (2005)	30SWF06
54	Villena, Rey irrigation canal (Alicante) (486 m) (MVHN–281214TY01)	Martínez–Ortí et al. (2015)	30SXH8572
55	El Ejido. Poniente Hospital (Almería) (MVHN–071214TP01)	Martínez–Ortí et al. (2015)	30SWF1867
56	Adra (Almería). Gasull coll. MZB 84–7124 (fig. 2)	unpublished	30SWF06
57	Mr Muntades' vegetable garden, neighbourhood of Bonanova (Barcelona) (Bech coll. MZB 2009–0535)	unpublished	31TDF28
58	Vegetable garden in Bonanova (Barcelona) (Altimira ex–coll., Ortiz de Zárate coll. MNCN–15.05/26320) (02/1957) (fig. 1)	unpublished	31TDF28
59	Palma de Mallorca, irrigation canal (Mallorca, Balearic Islands) (Cobos coll.; Compte ex–coll., MCNM–15.05/40630)	unpublished	31SDD78
60	Barcelona, in a private estate, exhausted locality (Altimira excoll.) (Cobos coll. MCNM–15.05/40640)	unpublished	31TDF28
61	Menorca (Ortiz de Zárate coll. MCNM–15.05/26314)	unpublished	–
62	O'Grove Lake (Pontevedra) (E. Rolán, pers. comm.)	unpublished	29TNH00
63	Mouth of the Verde River, Marbella (Málaga) (06/2013) (S. Torres Alba pers. comm.)	unpublished	30SUF2540

Table 2. List of localities of *Bulinus truncatus* in Portugal. Only the author indicating the location for the first time is shown.

Tabla 2. Lista de las localidades de Bulinus truncatus *en Portugal. Solo se indica el autor que señala el lugar por primera vez.*

Nº	Portuguese localities	Reference	UTM
64	Coimbra, environs	Morelet (1845)	29TNE4952
65	Porto	Nobre (1913)	29TNF3555
66	Matozinhos	Nobre (1913)	29TNF2656
67	Leça da Palmeira	Nobre (1913)	29TNF2561
68	Esmoriz	Nobre (1913)	29TNF3134
69	Senhor da Pedra, Ovar	Nobre (1913)	29TNF3123
70	Aveiro	Nobre (1913)	29TNE2999
71	Buçaco	Nobre (1913)	29TNE5766
72	Buarcos	Nobre (1913)	29TNE1046
73	Vala de Ceria	Nobre (1941)	29TNE5247
74	Monçao, Souza River	Nobre (1941)	29TNG4358
75	Fanzeres	Nobre (1941)	29TNF3957
76	Silves, Algarve	Fraga de Azevedo et al. (1969a, 1969b)	29SNB4916
77	Montemor–o–Vehlo, Algarve	Sampaio et al. (1975)	29TNE2647
78	Monchique, Algarve	Sampaio et al. (1975)	29SNB3930
79	Choupal, Mondego River, Coimbra	Medeiros and Simões (1979)	29TNE4752
80	Aldeia das Vinhas, Algarve	Grácio (1983)	29SNB7706

in the rest of Europe, due to the rise in global temperature, causing a potential increase in transmission of urogenital schistosomiasis in the continent (Mas–Coma et al., 1987; Mas–Coma et al., 2010; McCreesh and Booth, 2013; Abou–El–Naga, 2013; Martínez–Ortí et al., 2015; Kincaid–Smith et al., 2017). The introduction of the disease from Africa to Europe is a phenomenon related to global change (essentially immigration and tourism) and climate change (especially, in this case, the global warming experienced in southern Europe). Due to the large migratory movements currently occurring in southern Europe, and in Spain in particular, with a large number of sub–Saharan migrants arriving in different ways –mainly in small boats– , on the eastern and southern coasts of Spain, precise knowledge of the presence of the vector of the urogenital schistosomiasis, the bulinid *B. truncatus*, in our freshwaters, is of great importance.

The suggested dispersion of *B. truncatus* is most likely due to humans and birds. Neolithic colonists started to migrate around 10,500 years BCE and colonized the European continent. The synchronicity of the demographic growth with this phase of early human expansion and the exclusion of other factors suggests that Neolithic settlers, or traders, acted as vectors for the snails. Genetic analysis of Sardinian human populations connect Sardinia and Northern Africa through early human migrations (Jesse et al., 2011). Neither can it be ruled out that the period of Arab colonization played a role regarding the introduction of *B. truncatus* in the Iberian Peninsula. Birds may also be implicated in the passage from Africa to Southern Europe as passive transporters of the snail on their wings, feathers or legs, (Nobre, 1941; Russell–Hunter, 1978; Giusti et al., 1995; Boyer and Audibert, 2007; Jesse et al., 2011; Valledor and González, 2014; Neubauer et al., 2017). The Spanish Society of Ornithology (SEO, 2017) has notified the arrival to Spain of numerous species of African birds as a result of global warming. The passive transport of clusters or juveniles by insects such as larger water beetles (*Dytiscus* spp.) is also possible (Russell–Hunter, 1978).

B. truncatus is a ubiquitous species with a high capacity for self–fertilization. It lives in Spain in coastal environments such as lagoons, upwellings, and river mouths where there is little current or low velocity (Martínez–Ortí et al., 2015). When an individual reaches a new habitat it grows quickly and continuously, enabling it to expand its geographical area of occupation, even becoming a pest. Its eradication is practically impossible. Isolated snails in the natural environment grow even more quickly and produce many more clusters than when the population density increases and forms colonies, probably due to the absence of copulation (Bayomy and Joosse, 1987). In general, extinction in many of the known populations has been due to the destruction of the coast following the construction of urban areas, infrastructures, recreational areas and marinas, as well as the purposeful desiccation of water bodies to avoid the transmission of diseases transmitted by mosquitoes (fig. 2, tables 1, 2; Martínez–Ortí et al., 2015).

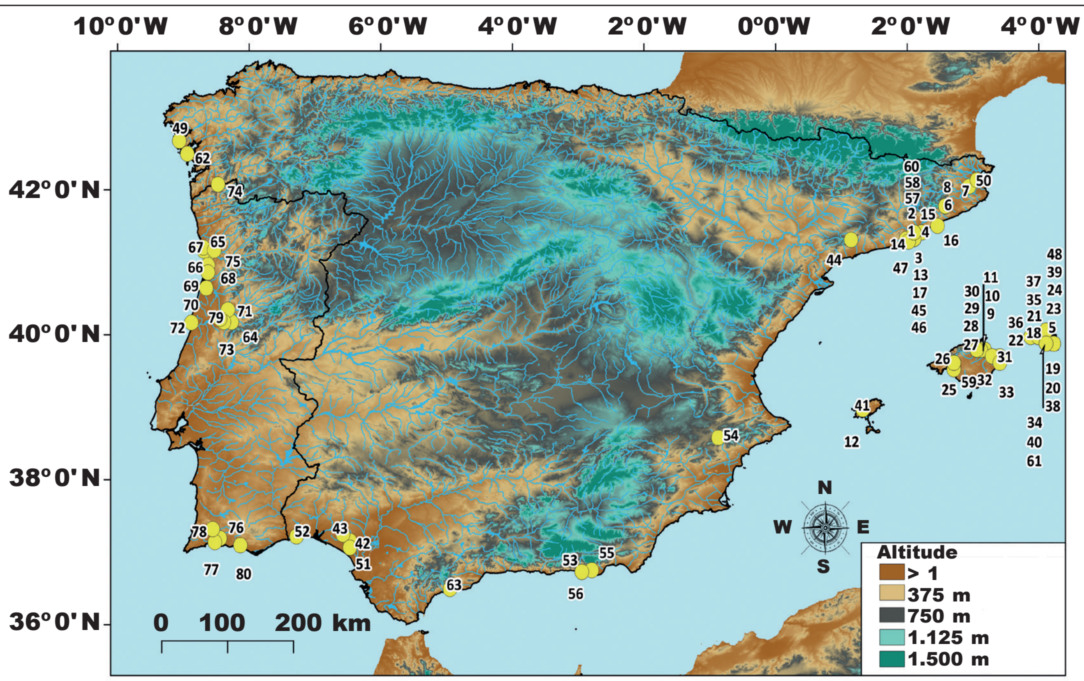

Fig. 4. Risk map of urogenital schistosomiasis vectorized by *Bulinus truncatus* in Spain and Portugal. Dotted numbers correspond to the locality codes shown in table 1.

Fig. 4. Mapa del riesgo de contraer schistosomiasis urogenital transmitida por Bulinus truncatus *en España y Portugal. Los números de los puntos corresponden con los códigos de las localidades que figuran en la tabla 1.*

This disease is geographically endemic in subtropical and tropical areas, such as the Caribbean and the eastern coast of South America, Africa and the Middle East (Crompton and Peters, 2010). The recent Corsica epidemic shows how African immigrants from regions where this parasitic disease is endemic have introduced the disease in Europe. This could occur in Spain if eggs of the parasite from infected individuals spread through urine in bodies of fresh water where the appropriate vector snails are found, thus establishing an autochthonous transmission upon completion of their biological cycle.

In view of the above, knowledge of the exact location of populations of *B. truncatus* in Spain and Portugal as shown in this paper confer exceptional interest from the point of view of public health. Knowing these locations will allow us to take specific and effective measures to try to eradicate these populations that are susceptible to transmitting urogenital schistosomiasis. The generated risk map will allow the development of models to predict the optimal area for this species in Spain and Portugal, and identify zones at greatest risk of establishment and expansion of the vector and the disease.

Greater efforts are thus needed to sample the areas where it has been cited so as to confirm its persistence in these areas. It would be interesting to review its presence in tourist areas such as the Albufera de l'Alcudia in Mallorca (Balearic Islands), the Natural Park of Doñana (Andalusia), the Albufera of Valencia, the deltas of rivers such as the Duero, Tajo, Guadiana and Ebro, and also the abundant coastal wetlands where *B. truncatus* can establish and thrive.

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