

Taxonomic clarification of three taxa of Iberian geomitrids, *Helix montserratensis* Hidalgo, 1870 and subspecies (Gastropoda, Pulmonata), based on morpho-anatomical data

A. Martínez–Ortí & V. Bros

Martínez–Ortí, A. & Bros, V., 2017. Taxonomic clarification of three taxa of Iberian geomitrids, *Helix montserratensis* Hidalgo, 1870 and subspecies (Gastropoda, Pulmonata), based on morpho-anatomical data. *Animal Biodiversity and Conservation*, 40.2: 247–267.

Abstract

Taxonomic clarification of three taxa of Iberian geomitrids, Helix montserratensis Hidalgo, 1870, and subspecies (Gastropoda, Pulmonata), based on morpho-anatomical data.— Helix montserratensis (currently Xerocrassa montserratensis) is an Iberian geomitrid described by Hidalgo in 1870 from Montserrat (Barcelona, Spain). Two very similar taxa were described as varieties of this taxon based only on conchological characters: Helix montserratensis betulonensis and a less known taxon, Helix montserratensis delicatula. These varieties, especially betulonensis, were considered for a long time as subspecies of X. montserratensis, although some authors upgraded them to the rank of species based on anatomical data of the reproductive system in a few specimens. We review the type specimens and other samples of the three taxa collected at several localities where the three referred taxa are considered present. The morpho-anatomical characteristics of the shell and the reproductive system were studied in detail. The results allow us to clarify the taxonomic status of X. betulonensis and X. m.delicatula as X. montserratensis, indicating they should be considered junior synonyms of this species. Finally, the shell is redescribed and a map is provided showing the geographical distribution of X. montserratensis.

Key words: Mollusca, *Xerocrassa montserratensis*, Taxonomy, Morpho-anatomy, Catalonia, Spain

Resumen

Revisión taxonómica de tres taxones de geomitridos ibéricos, Helix montserratensis Hidalgo, 1870, y subespecies (Gastropoda, Pulmonata), basada en datos morfoanatómicos.— Helix montserratensis (actualmente Xerocrassa montserratensis) es un geomitrido ibérico descrito por Hidalgo en 1870 en Montserrat (Barcelona, España). Sobre la base de varios caracteres conquiológicos, se describieron dos taxones muy similares, como variedades de este taxón: Helix montserratensis betulonensis y otro menos nombrado, Helix montserratensis delicatula. Estas variedades, sobre todo betulonensis, se han considerado subespecies de X. montserratensis, aunque algunos autores las consideran especies diferentes, basándose en los datos anatómicos del aparato reproductor obtenidos de escasos ejemplares. Hemos revisado el material tipo y otras muestras procedentes de localidades donde se considera que están presentes los tres taxones tratados. Se han estudiado con detalle las características morfoanatómicas de la concha y el aparato reproductor de los ejemplares. Los resultados obtenidos nos permiten aclarar el estatus taxonómico de X. betulonensis y de X. m.delicatula, que corresponden en realidad a X. montserratensis, y que deben ser consideradas sinónimos posteriores de esta especie. Finalmente, se vuelve a describir la concha de X. montserratensis y se muestra el mapa de su distribución geográfica.

Palabras clave: Mollusca, *Xerocrassa montserratensis*, Taxonomía, Morfoanatomía, Cataluña, España

Received: 25 X 16; Conditional acceptance: 6 III 17; Final acceptance: 17 V 17

Alberto Martínez–Ortí, Museu Valencià d'Història Natural–iBiotaxa, Parc l'Hort de Feliu–Alginet, P. O. Box 8460, E–46018 València (Spain) and Dept. of FTF–Parasitology, Fac. Pharmacy, Univ. of Valencia, E–46100 Burjassot, Valencia (Spain).– Vicenç Bros, Oficina Tècnica de Parcs Naturals, Diputació de Barcelona, c./ Urgell 187, Edif. Rellotge 3a, E–08036 Barcelona (Spain) and Museu de Ciències Naturals de Barcelona, Laboratori de Natura, Psg. Picasso s/n., E–08003 Barcelona (Spain).

Corresponding author: A. Martínez–Ortí. E–mail: amorti@uv.es

Introduction

Helix montserratensis (currently *Xerocrassa montserratensis* [Puente, 1994; Puente et al., 2006; Altonaga et al., 2011; Martínez-Ortí, 2013]) is an Iberian geometrid, first described in 1870 by Hidalgo who found it on the mountain of Montserrat (Barcelona province). Another two very similar taxa were described as varieties of this taxon based on several conchological characters. The first of these, *Helix montserratensis betulonensis* Bofill, 1879 (currently *Xerocrassa betulonensis* [Puente, 1994; Martínez-Ortí & Uribe, 2008; Bros, 2009; Verdú & Galante, 2009]), was collected beside the Besós river, the 'Serralada Litoral Catalana', in Santa Coloma de Gramanet (Barcelona province). The second taxa, *Helix montserratensis delicatula* Bofill, 1898 (currently *Xerocrassa montserratensis delicatula*) of 'la Mata' (Sant Llorenç del Munt (Barcelona province), has been barely mentioned since its description.

The *H. montserratensis* species has since been redescribed or referred to in many works (Kobelt, 1873; Hidalgo, 1875–84; Pfeiffer, 1876; Westerlund, 1876–78; Bofill, 1879, 1882, 1898; Servain, 1880; Martorell & Bofill, 1888; Fagot, 1891; Maluquer, 1901; Thieux, 1907; Marcet, 1909–1910; Haas, 1929). Arnet & Bofill (1879) cited *H. montserrarensis* from 'la Mata' and two decades later, Bofill (1898) described the variety *delicatula* from this locality in the massif of Sant Llorenç del Munt.

Bofill & Haas (1920) and Bofill, Haas & Aguilar-Amat (1921) mentioned these taxa at various localities in the basins of the Llobregat and Besós rivers. Hesse (1934) studied the reproductive system of *X. montserratensis* and Ortiz de Zárate (1946) described in detail the genitalia and the radula of specimens collected in Montserrat. Altimira (1971) elevated the variety *betulonensis* to the rank of species based on anatomical data of the reproductive system, although on few specimens. Puente (1994) made a bibliographic compilation and studied the anatomy, also of few specimens, from Montserrat, Gallifa and the Serralada de Marina, keeping the nomenclature proposed by Altimira (1971) as a valid and distinct species.

Xerocrassa betulonensis was detected in the 'Serralada Litoral Catalana' (Cabañas et al., 1992; Ventura, 1992), in various locations in the south of Barcelona, and in the Serra de Collserola (Serralada Litoral catalana) (Bofill & Haas 1920; Bofill et al., 1921; Altimira, 1971). *X. montserratensis* and *X. betulonensis* shared locations from the counties of Vallès Occidental, Bages, Maresme and Anoia (Bros, 1985, 2000, 2006, 2013). Altimiras et al. (2005) expanded considerably the geographical distribution of *X. montserratensis* from different localities of the county of Osona (Barcelona and Girona). Almera & Bofill (1898) in Can Ubac in Rubí (Vallès Occidental) also cited *X. montserratensis* as subfossil.

The three taxa were attributed to the genus *Xerocrassa* Monterosato, 1892, mainly by the presence of a stimulator apparatus with two rudimentary dart sacs, without darts inside and atrial appendage (Forcart, 1976; Gittenberger, 1993; Puente, 1994; Martínez-Ortí, 1999; Martínez-Ortí et al., 2000) (figs.

4, 7). The first description of the reproductive system of a specimen of *X. montserratensis* was made by Hesse (1934: fig. 57), with material of L. Pfeiffer. According to Hesse (1934), the flagellum is tiny (sic), a characteristic that differs considerably from that which this species in fact presents. This author pointed out that he only studied a specimen preserved in ethanol and as he wanted to preserve the shell, the dissection was incomplete, an opinion shared by Ortiz de Zárate (1946: pp. 348–349). Because the animal was deeply retracted inside the shell, the flagellum was probably sectioned as a result of an incomplete dissection. The flagellum, long and with many kinks in its retracted state, can fracture easily during its extraction (author's observation). The anatomical data provided by Ortiz de Zárate (1946) and Puente (1994) concluded that *Helix montserratensis* belonged to the genus *Xerocrassa*, resulting in the combination *Xerocrassa montserratensis*, which remains today. The study of the reproductive system was key to considering *X. montserratensis* and *X. betulonensis* as different, valid species (Altimira, 1971; Puente, 1994).

Despite the remarkable scientific and conservation interest, the taxa studied in the present work have been subject, over the years, to ambiguous and sometimes contradictory considerations regarding taxonomy and nomenclature, emphasizing the need to elucidate their taxonomic status.

The inclusion of this species in the Red List of Threatened Species published by the IUCN with the category 'endangered B1ab(iii) + 2ab(iii)' (Martínez-Ortí, 2013) is of note. The species has been mentioned in several recently published works that refer to the effects of different disturbances in their populations (Santos et al., 2009; Bros, 2011; Bros et al., 2011; Santos et al., 2012). The taxonomic status of *X. betulonensis* and *X. m. delicatula*, in relation to *X. montserratensis*, also merits clarification for conservation reasons.

Material and methods

Shell characters

We examined the type material of the three taxa. The type series of *H. montserratensis* consists of a syntype that is deposited in the Muséum d'Histoire Naturelle, MNHN, of Paris with the accession number MNHN-23274. It is considered herein as lectotype (ICZN, 1999: Art. 74.1.1). The type locality corresponds to 'Montserrat' (province of Barcelona). Another syntype should be in the Hidalgo collection deposited in the Museo Nacional de Ciencias Naturales of Madrid, but it has not been found (Fischer-Piette, 1950; Templado et al., 1993: p. 285).

The type series of *Helix montserratensis* var. *betulonensis* includes a syntype which was designated as lectotype by Martínez-Ortí & Uribe (2008). It is deposited in the Bofill collection in the Museu de Ciències Naturals de Barcelona, with the code MZB 81–4808, its *locus typicus* being "En las inmediaciones del Besós, hacia Badalona, Santa Coloma" (around the Besós River, towards Badalona, Santa Coloma).



Fig. 1. Shell of *Xerocrassa montserratensis* showing the three studied areas on its surface: BLW. Beginning of the last whorl from the peristoma; ELW. End of the last whorl; ETW. End of the third whorl and beginning of the fourth whorl.

Fig. 1. Concha de *Xerocrassa montserratensis* en la que se muestran las tres zonas de estudio seleccionadas: BLW. Inicio de la última vuelta desde el peristoma; ELW. Final de la última vuelta; ETW. Final de de la tercera vuelta e inicio de la cuarta).

The type series of *H. montserratensis* var. *delicatula* includes five syntypes deposited in the Artur Bofill collection in the Museu de Ciències Naturals de Barcelona, MCNB with the code MZB 81–4766 [Martínez–Ortí et al., (in press)]. The *locus typicus* is 'La Mata, San Llorenç del Munt', Barcelona province (Bofill, 1898). This locality corresponds to the mountain of Montcau, close to la Mata ("al dirigirnos desde la Mata a la cumbre y pasando por la pudinga característica de la montaña")("...going towards the top of la Mata passing through the characteristic pudding stone" (Bofill, 1898: p. 335).

A lectotype of this variety has been designated by Martínez–Ortí et al. (in press) with the code MZB 81–4766–A, in parallel to four paralectotypes (MZB 80–4766–B; MZB 80–4766–C, MZB 80–4766–D and MZB 80–4766–E).

Various conchological characters of 73 specimens (see annex) and the anatomy of the reproductive system of 17 specimens were studied. Three major shell characters were used by Bofill (1879, 1898) to differentiate *H. montserratensis* and its varieties *betulonensis* and *delicatula*: 1) the different size in shell diameter; 2) the regularity, dimensions and number of ribs on the surface of the shell; and 3) the spire being flatter in *X. betulonensis* than in *X. montserratensis*.

The number of ribs was estimated from three areas of 2.0 mm each in length and easy to locate (fig. 1).

One of them is between the end of the third whorl and the beginning of the fourth whorl (ETW), another is at the beginning of the last whorl from the peristoma (BLW), and the third is at the end of the last whorl (ELW).

The spire is considered the height of the shell between the apex and the beginning of the last whorl.

The shell and the reproductive system were measured using stereomicroscopy with a trailer micrometer. Detailed studies of the protoconch and the ribs of the teleoconch were made in the MEB S–4100, at the S. C. S. I. E. of the University of Valencia.

Reproductive system data

Thirteen specimens were measured, accounting for their reproductive system characters. Three of them correspond to *X. m. montserratensis* and come from two localities: the *locus typicus* and 'Els Munts'. Two more specimens were measured to scale on the figures provided by Ortiz de Zárate (1946) and Puente (1994). Two specimens came from the typical locality (Montcau) of *X. m. delicatula* and eight specimens of *X. betulonensis* came from another three localities: Santa Coloma de Gramanet (*locus typicus*), Sentmenat, and Gallifa. Some of the anatomical data of the reproductive system of *X. m. montserratensis* and *X. betulonensis* should be considered approximate because they were obtained by measuring the organs to scale on the figures drawn by Puente (1994: plate XXII and plate XXIII, respectively) and Ortiz de Zárate (1946: fig. 5) for *X. montserratensis*.

We performed the dissection of these specimens, drew some of the genitalia and measured several organs (figs. 5, 7).

Among the anatomical characters of the reproductive system we paid special attention to those used by Ortiz de Zárate (1946), Altimira (1971) and Puente (1994) to differentiate *X. betulonensis* from *X. m. montserratensis*. We measured the penis according to Ortiz de Zárate (1946) and Altimira (1971), and also Puente (1994), who focused only on the more thickened portion of this organ, i.e. the proximal penis (fig. 6: Pep), not taking into account the less thickened and distal portion (Ped), which reaches the muscle retractor of the penis. The same occurs with the epiphallus, considered by these authors as the addition of the distal penis (Ped) and the epiphallus (Ep).

Given the difficulties in finding mature specimens in the field, one specimen of *X. betulonensis* from the *locus typicus* was kept in captivity for several months until it reached sexual maturity.

Results and discussion

Shell: conchological characters and morphometric data (figs. 2–3, 5–6, 8–9)

Diameter measures obtained on 73 specimens are summarized in table 1. Figure 8 shows the relationship between height/diameter (H/D) from which we can deduce that the majority of these specimens keep a high similarity between the three taxa. These

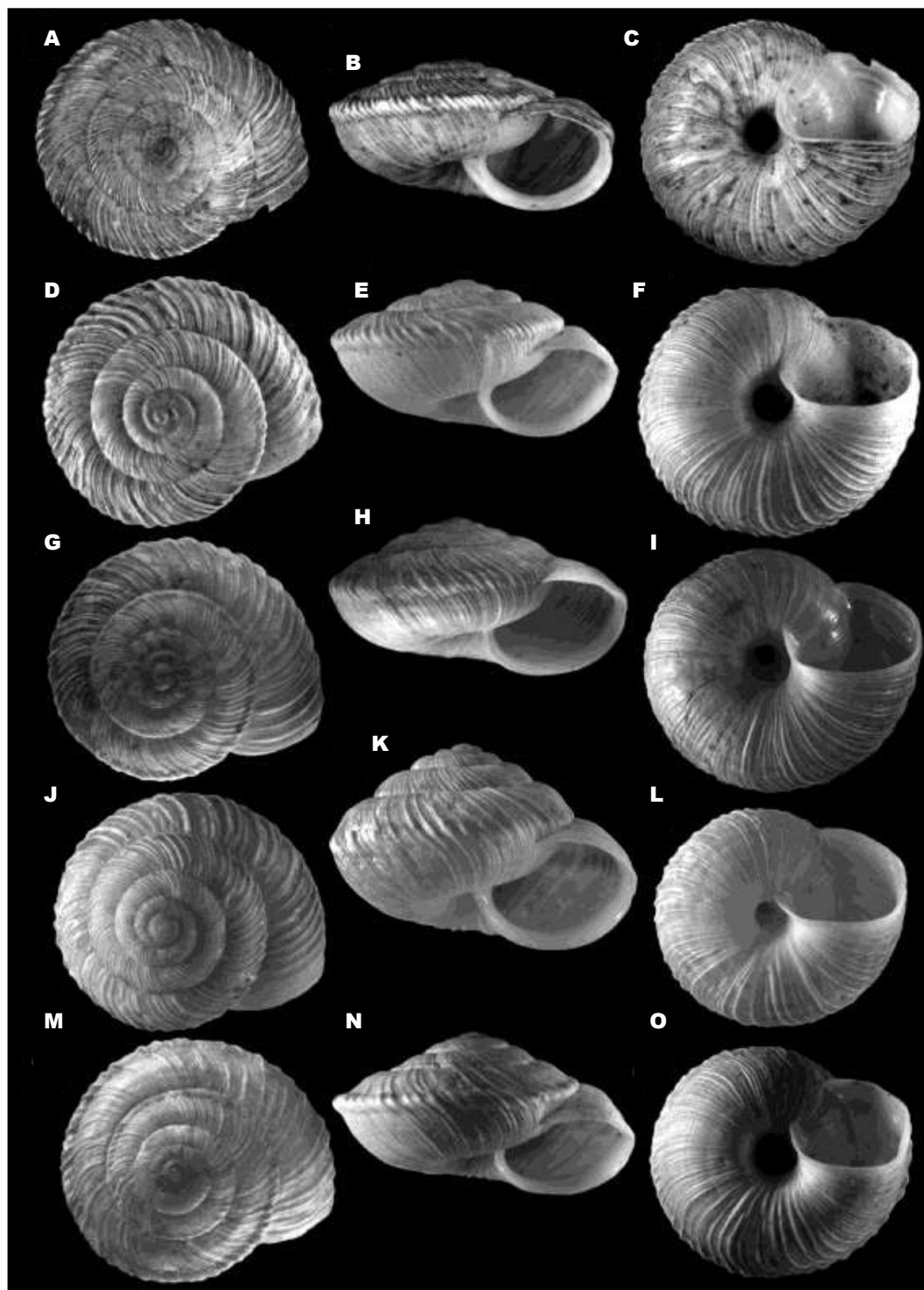


Fig. 2. *Xerocrassa montserratensis* and *X. m. delicatula*: A–C. Lectotype of *Helix montserratensis* Hidalgo, 1870 (MNHN 23274) ($\varnothing = 12.1$ mm) (Photograph by P. Maestrati from MNHN of Paris); D–F. Lectotype of *Helix montserratensis* var. *delicatula* Bofill, 1898 (MZB 81–4766) ($\varnothing = 8.7$ mm); G–I. Montserrat ($\varnothing = 10.1$ mm); J–L. Els Munts ($\varnothing = 9.9$ mm); M–O. Montcau ($\varnothing = 11.7$ mm).

Fig. 2. *Xerocrassa montserratensis* y *X. m. delicatula*: A–C. Lectotipo de *Helix montserratensis* Hidalgo, 1870 (MNHN 23274) ($\varnothing = 12,1$ mm) (Fotografía realizada por P. Maestrati del MNHN de París); D–F. Lectotipo de *Helix montserratensis* var. *delicatula* Bofill, 1898 (MZB 81–4766) ($\varnothing = 8,7$ mm); G–I. Montserrat ($\varnothing = 10,1$ mm); J–L. Els Munts ($\varnothing = 9,9$ mm); M–O. Montcau ($\varnothing = 11,7$ mm).

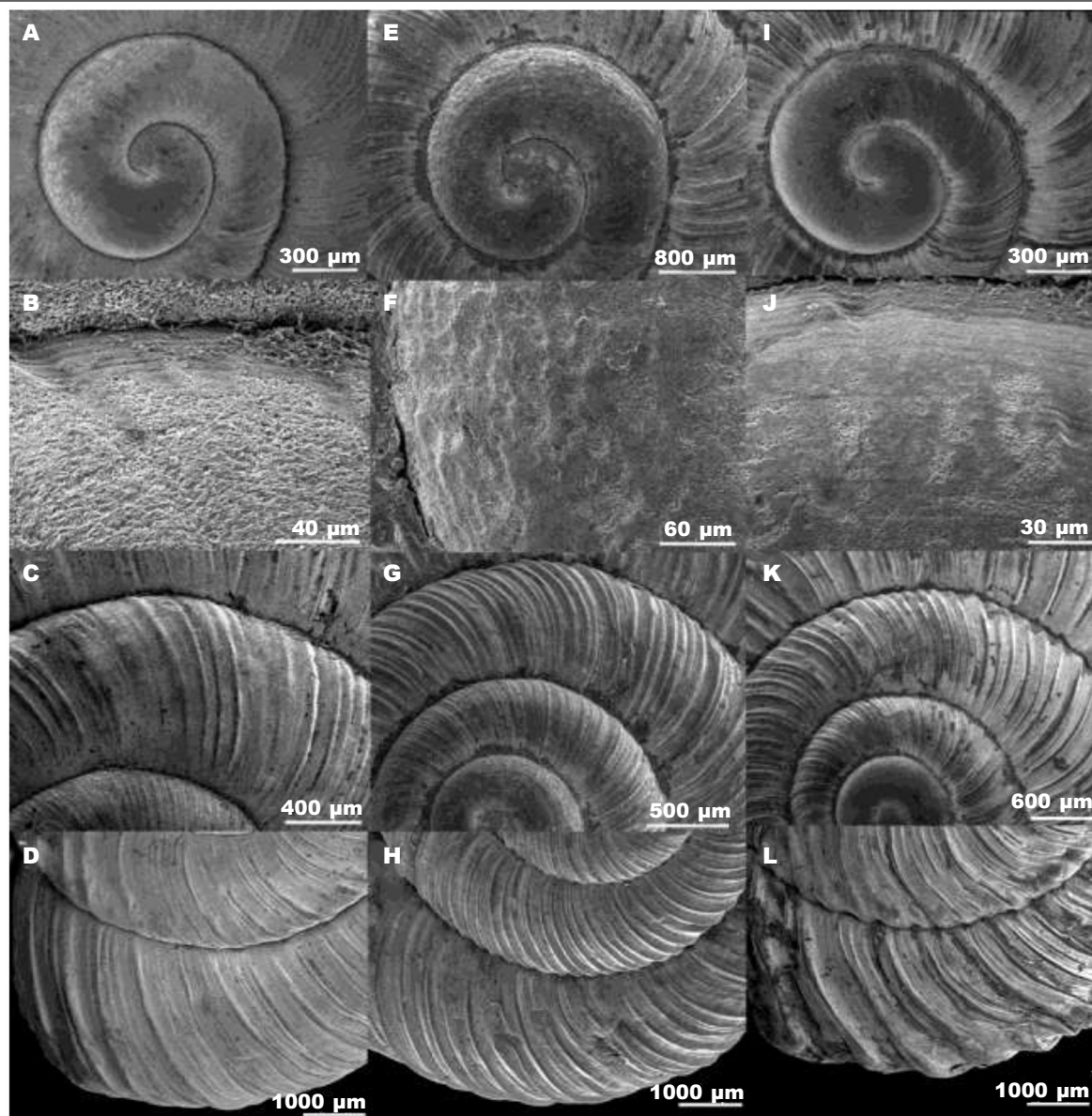


Fig. 3. Details of the shell of *X. m. montserratensis* and *X. m. delicatula* by SEM: A–D. Sant Jeroni. Montserrat (*locus typicus*); E–H. Els Munts; I–L. Montcau.

Fig. 3. Detalles de la concha de X. m. montserratensis y X. m. delicatula al MEB: A–D. Sant Jeroni. Montserrat (locus typicus); E–H. Els Munts; I–L. Montcau.

comparisons demonstrate that the diameter of the shell and its H/D relationship do not allow a proper taxonomic identification between these three taxa. In addition, it is verified that the diameter of most shells of the three nominal taxa varies between 8.0 and 11.0 mm (annex).

Respect to the number of ribs, Bofill (1879, 1898) indicated that *X. m. betulonensis* and *X. m. delicatula* had fewer ribs than *X. m. montserratensis*. Our results are shown in figures 1, 3, 6; table 2).

Exceptionally, a specimen of *X. betulonensis* of Gallifa presented 33 ribs in the end of the third whorl,

while the other nine studied shells of this locality reached 24 ribs, a number that matches the rest of taxa. These data indicate that rib number should not be considered valid to differentiate the three taxa.

The spire data are summarized in table 3. Only three examined of 20 *X. montserratensis* specimens studied exceeded 1.1 mm, corresponding to the maximum value obtained for *X. betulonensis* (annex). These data do not allow differentiation of the taxa, although the spire of *X. montserratensis* and *X. m. delicatula* can be a little higher than the spire of *X. betulonensis* in some cases (annex).

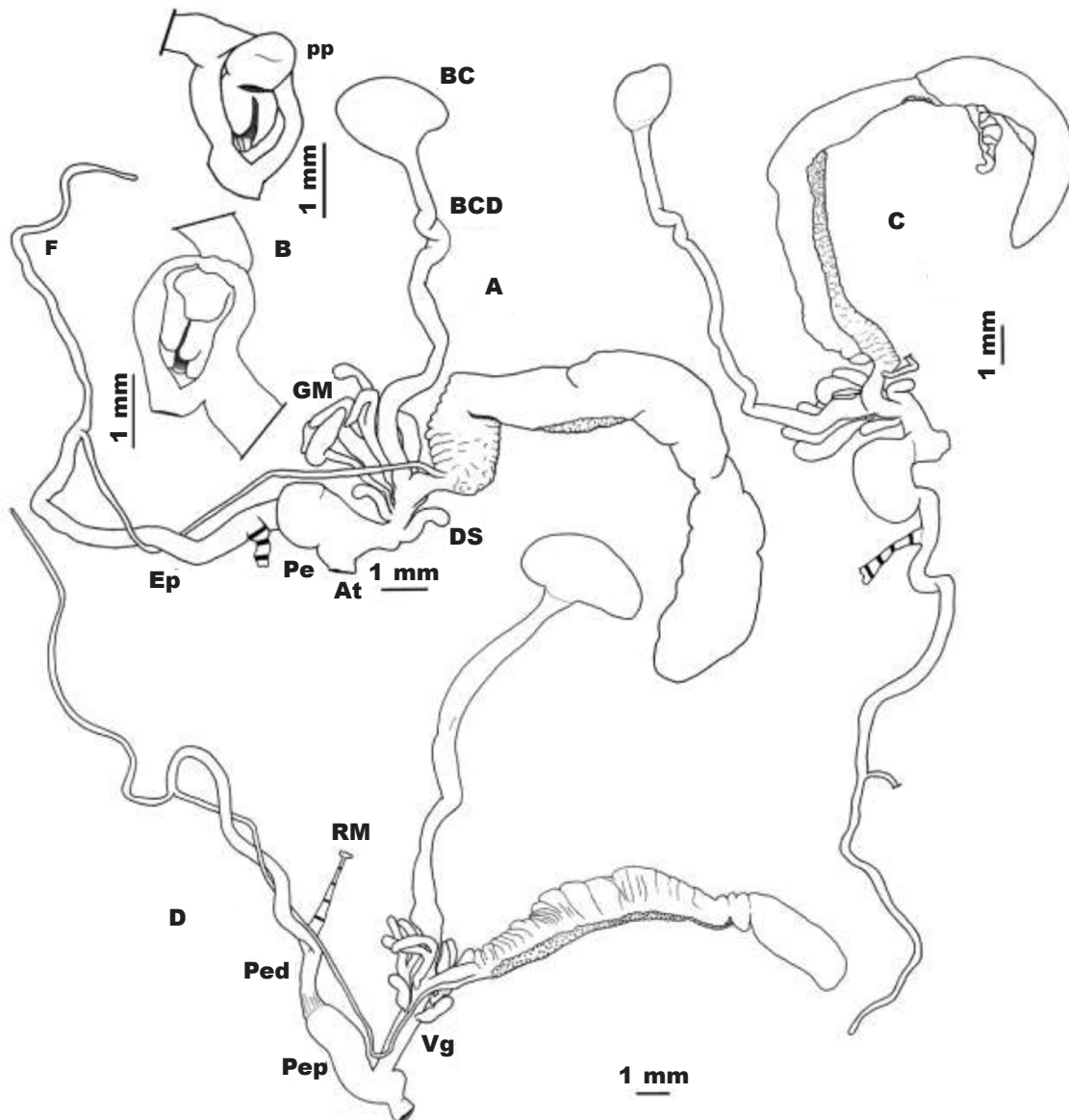


Fig. 4. Reproductive system of *X. m. montserratensis* and *X. m. delicatula*: A–B. Montserrat, Sant Jeroni (Barcelona) (*locus typicus*); B. Penial papilla; C. Els Munts (Barcelona); D. Montcau (Barcelona). (Abbreviations: At. Atrium; BC. Bursa copulatrix; BCD. Bursa copulatrix' duct; DS. Dart sac; Ep. Epiphallus; F. Flagellum; GM. Mucous glands; Pe. Penis; Ped. Distal penis; Pep. Proximal penis; pp. Penial papilla; Vg. Vagina.)

Fig. 4. Aparato reproductor de *X. m. montserratensis* y *X. m. delicatula*. A–B. Montserrat, Sant Jeroni (Barcelona) (*locus typicus*); B. Papilla penial; C. Els Munts (Barcelona); D. Montcau (Barcelona). (Abreviaturas: At. Atrio; BC. Bursa copulatrix; BCD. Conducto de la bursa copulatrix; DS. Saco del dardo; Ep. Epifalo; F. Flagelo; GM. Glándulas mucosas; Pe. Pene; Ped. Pene distal; Pep. Pene proximal; pp. Papila penial; Vg. Vagina.)

The shells of the population of Els Munts assigned by Altimiras et al. (2005) to *X. montserratensis* show a more globose shape than the rest of the populations, with a range of height/diameter ratio ($n = 10$) between 0.614 and 0.701 (figs. 2J–2L; table 1), while for the examined population coming from the *locus typicus*

(Sant Jeroni) it varies between 0.512 and 0.694 ($n = 11$) (figs. 2A–2C, 2G–2I; annex).

The carinate periphery of the shells of Els Munts population is little marked, unlike what is seen in *X. montserratensis* and *X. betulonensis*, where it is more evident. However, we do not consider these

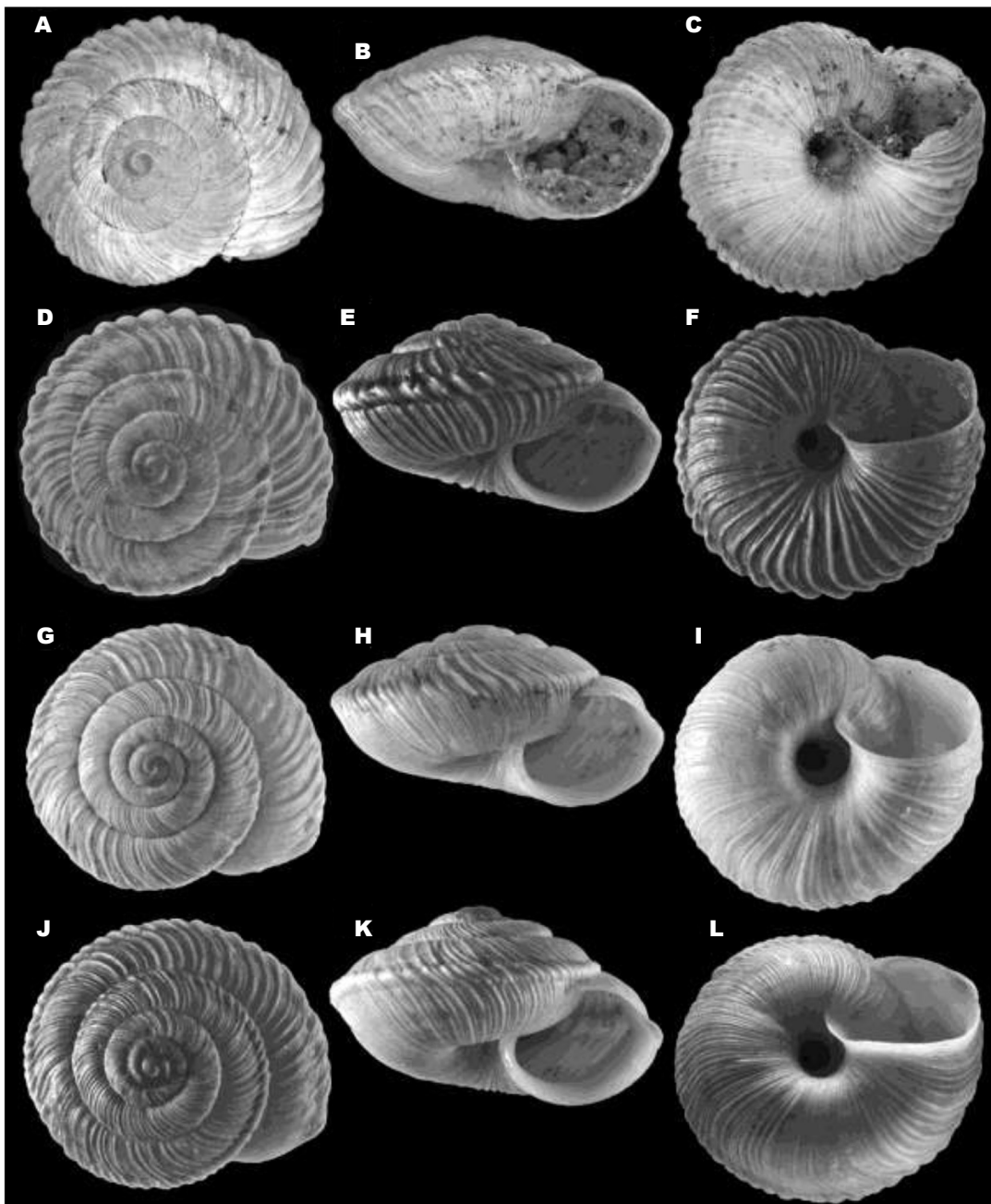


Fig. 5. *Xerocrassa betulonensis*: A–C. Lectotype of *Helix montserratensis* var. *betulonensis* Bofill, 1879 (MZB 81–4808) ($\varnothing = 9.4$ mm); D–F. Santa Coloma de Gramanet (Barcelona) (topotype) ($\varnothing = 9.1$ mm); G–I. Gallifa (Barcelona) ($\varnothing = 8.2$ mm); J–L. Sentmenat (Barcelona) ($\varnothing = 8.4$ mm).

Fig. 5. *Xerocrassa betulonensis*: A–C. Lectotipo de *Helix montserratensis* var. *betulonensis* Bofill, 1879 (MZB 81–4808) ($\varnothing = 9,4$ mm); D–F. Santa Coloma de Gramanet (Barcelona) (topotipo) ($\varnothing = 9,1$ mm); G–I. Gallifa (Barcelona) ($\varnothing = 8,2$ mm); J–L. Sentmenat (Barcelona) ($\varnothing = 8,4$ mm).

differences sufficiently relevant to differentiate them taxonomically from other known populations of *X. montserratensis*. About *X. m. delicatula*, we examined 15 specimens from two localities [La Mata (*locus typicus*) and Montcau] obtaining values (H/D) ranging

between 0.504 and 0.618. Finally, for *X. betulonensis*, we examined 37 specimens, and the range was between 0.489 and 0.666, from three localities (annex).

The diameter of the protoconch varied between 0.9 and 1.15 mm with up to 1½ whorls in *X. m. montse-*

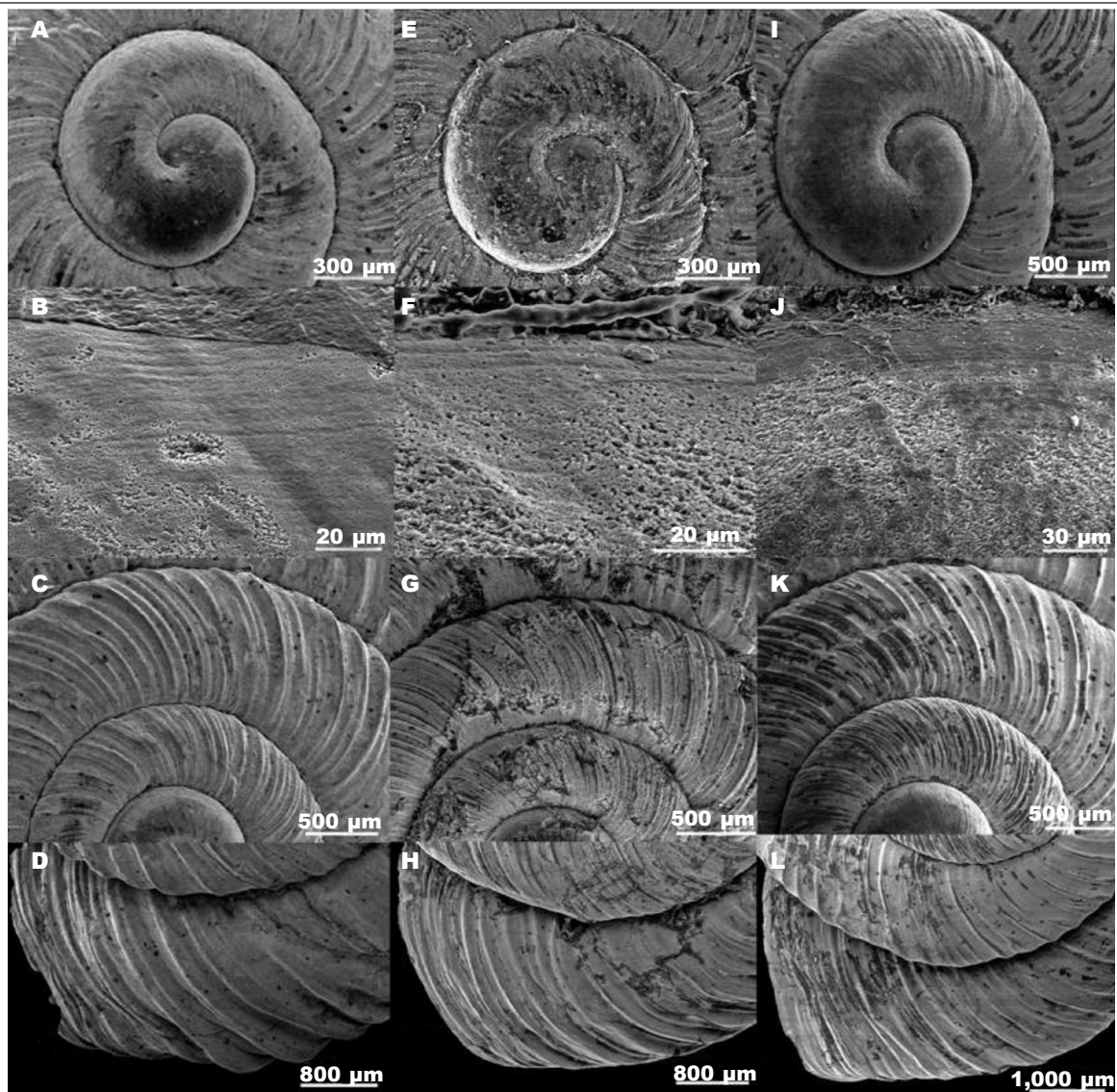


Fig. 6. Details of the shell of *Xerocrassa betulonensis* by SEM: A–D. Santa Coloma de Gramanet (Barcelona); E–H. Gallifa (Barcelona); I–L. Sentmenat (Barcelona).

Fig. 6. Detalles de la concha de *Xerocrassa betulonensis* al MEB. A–D. Santa Coloma de Gramanet (Barcelona); E–H. Gallifa (Barcelona); I–L. Sentmenat (Barcelona).

rratensis, from 0.95 to 1.25 mm and until $1\frac{5}{8}$ whorls in *X. m. delicatula* and between 0.95 and 1.2 mm and up to $1\frac{1}{2}$ whorls in *X. betulonensis* (figs. 3A, 3E, 3I; 6A, 6B, 6I; annex).

All examined specimens of the three nominal taxa showed a sculpture composed of spiral lines, similar to those of other species of *Xerocrassa* (figs. 3B, 3F, 3J; 6B, 6F, 6J) (Martínez-Ortí, 2006, fig. 5), and other geometrids, such as *Xerotricha conspurcata* (Draparnaud, 1801), *Microxeromagna lowei* (Potiez & Michaud, 1835) or *Helicella madritensis* (Rambur, 1868) (Martínez-Ortí, 1999: pl. 16: fig. 10; Martínez-Ortí, 2008: figs. 5, 9, 25). In measures carried

out in other conchological characters, such as the dimensions of the aperture, the diameter of the umbilicus and the height of the last whorl, we did not find any significant differences to discriminate any of these taxa (annex).

Reproductive system: morphometric data (figs. 4, 7)

Tables 4 and 5 show the measures of different genital organs of 13 specimens. One of our specimens of Gallifa was aphalic (fig. 7B).

We carried out measurements following two criteria: for the penis and the set of its two anatomical parts

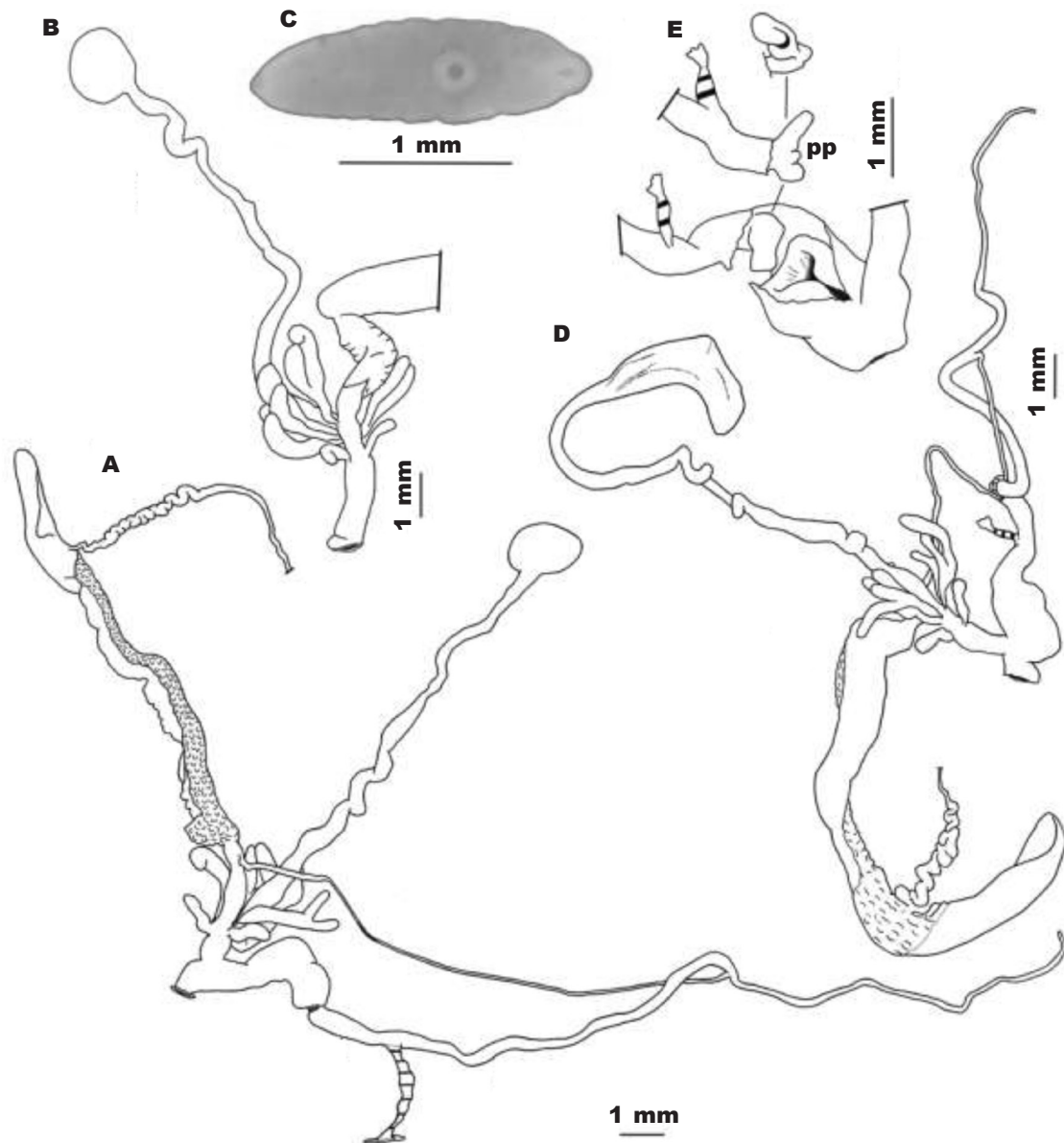


Fig. 7. Reproductive system of *Xerocrassa betulonensis*: A. Santa Coloma de Gramanet (Barcelona) (*locus typicus*); B. Gallifa (Barcelona) (aphallic specimen); C. Metacercariae of brachylaimid found in the kidney of the aphallic specimen; D–E. Sentmenat (Barcelona). E. Penial papilla. (For abbreviations see fig. 4.)

Fig. 7. Aparato reproductor de *Xerocrassa betulonensis*: A. Santa Coloma de Gramanet (Barcelona) (*locus typicus*); B. Gallifa (Barcelona) (*ejemplar afálico*); C. Metacercaria de un braquiláimido hallada en el riñón del ejemplar afálico; D–E. Sentmenat (Barcelona); E. Papila penial. (Para las abreviaturas, véase fig. 4.)

(Pe = Pep + Ped), and for the epiphallus corresponding to the organ which goes from the muscle retractor to the end of the vas deferens, and which corresponds to the beginning of the flagellum (figs. 4, 7; tables 4–5).

Ortiz de Zárate (1946) considered that in *X. m. montserratensis* the flagellum is equal to or slightly higher than the epiphallus in *X. betulonensis*, considering also as part of the epiphallus the thin and distal

portion of the penis (EpPed). This criterion is not met in all cases, finding flagella in *X. m. montserratensis*, that are shorter than the older measures of the epiphallus obtained in *X. betulonensis* (tables 4–5). Therefore, we do not consider that this criterion is valid to differentiate the two taxa.

Later, Altimira (1971) differentiated *X. betulonensis* from *X. m. montserratensis* by the epiphallus being shorter than the flagellum and also presenting two

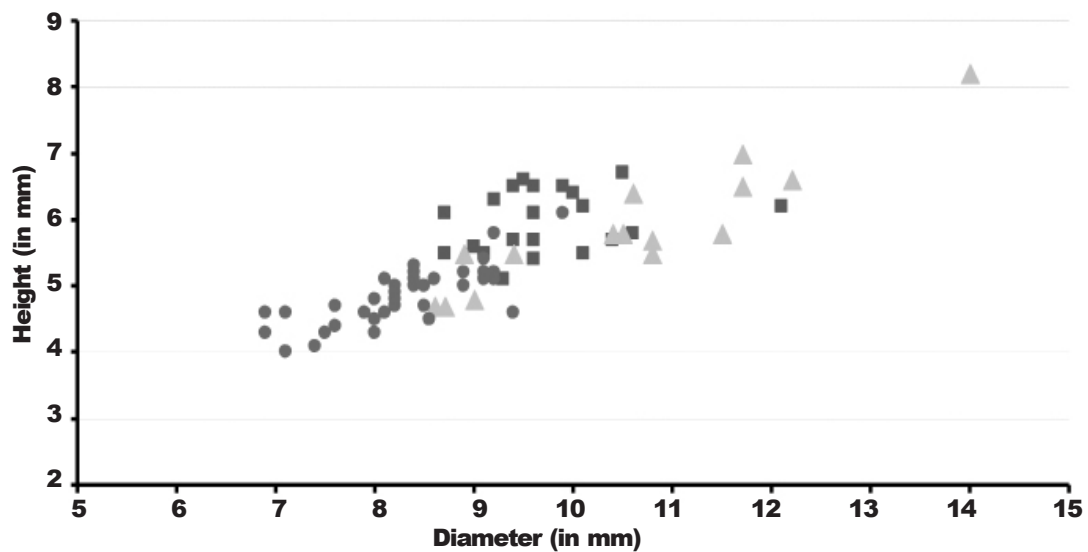


Fig. 8. Height/diameter ratio of the shells of *X. m. montserratensis* (■), *X. m. delicatula* (●) and *X. betulonensis* (▲) (in mm).

Fig. 8. Gráfico de la relación entre la altura y el diámetro de las conchas de *X. m. montserratensis* (■), *X. m. delicatula* (●) y *X. betulonensis* (▲) (en mm).

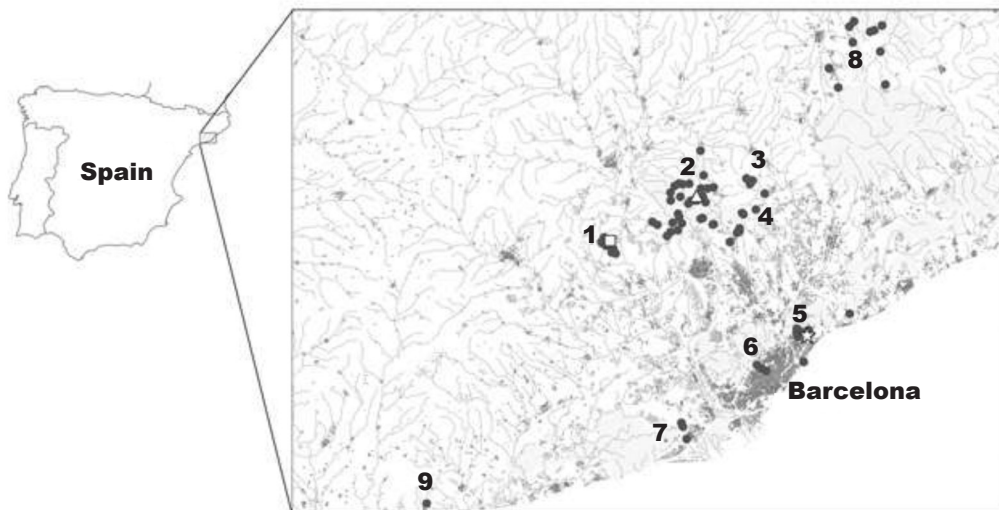


Fig. 9. Geographical distribution of *Xerocrassa montserratensis*. Both recent and historical quotes collected. Many of these populations are or may be currently extinct. Localities studied in the province of Barcelona: 1. Montserrat (*locus typicus* of *X. m. montserratensis*); 2. Sant Llorenç del Munt–Montcau (*locus typicus* of *X. m. delicatula*); 3. Gallifa; 4. Sentmenat; 5. Santa Coloma de Gramanet (*locus typicus* of *X. betulonensis*); 6. Collserolla; 7. Garraf; 8. Els Munts; 9. Roda de Berà (Tarragona).

Fig. 9. Distribución geográfica de *Xerocrassa montserratensis*. Citas recopiladas, tanto recientes como históricas. Muchas de estas poblaciones están o pueden estar actualmente extintas. Localidades estudiadas de la provincia de Barcelona: 1. Montserrat (*locus typicus* de *X. m. montserratensis*); 2. Sant Llorenç del Munt–Montcau (*locus typicus* de *X. m. delicatula*); 3. Gallifa; 4. Sentmenat; 5. Santa Coloma de Gramanet (*locus typicus* de *X. betulonensis*); 6. Collserolla; 7. Garraf; 8. Els Munts; 9. Roda de Berà (Tarragona).

Table 1. Measurements of the shell diameter of specimens of the three taxa in mm: Min. Minimal value; Max. Maximum value; \bar{x} . Mean; SD. Standard deviation; n. Number of specimens.

Tabla 1. Medidas del diámetro de las conchas de ejemplares de los tres taxones en mm: Min. Valor mínimo; Max. Valor máximo; \bar{x} . Media; SD. Desviación estándar; n. Número de ejemplares.

	Min	Max	\bar{x}	SD	n
<i>X. m. montserratensis</i>	8.7	12.1	9.73	0.76	21
<i>X. m. delicatula</i>	8.6	14.0	10.59	1.51	15
<i>X. betulonensis</i>	7.1	9.9	8.31	0.73	37

trifid mucous glands, while *X. m. montserratensis* has a longer epiphallus than the flagellum, and does not present trifid mucous glands. Puente (1994) found bifid mucous gland trunks in two examined specimens of *X. betulonensis* and also saw specimens with the epiphallus shorter than the flagellum but longer in the other specimen [epiphallus *sensu* Altimira (1971) and Ortiz de Zárate (1946)]. These results of Puente (1994) questioned the use of these two morpho-anatomical characters to discriminate these two taxa.

In our specimens of *X. betulonensis*, the mucous glands generally present 3 or 4 bifid trunks, not finding any trifid, as in *X. m. montserratensis*, as already noted Puente (1994); this corroborates our criterium not to consider it as an anatomical feature with taxonomic value.

As regards the second character, as also already noted by Puente (1994), we found great variability in the lengths of the two organs for both taxa. Consequently, we neither consider this character as valid to differentiate these taxa. We also measured the last taxonomic character taking into account the penis in

Table 3. Measurements of spire of the specimens of the three taxa in mm. (For abbreviations see table 1.)

Tabla 3: Medidas de la espira de ejemplares de los tres taxones. (Para las abreviaturas, véase tabla 1.)

	Min	Max	\bar{x}	SD
<i>X. m. montserratensis</i>	0.4	1.4	0.92	0.25
<i>X. m. delicatula</i>	0.3	1.1	0.71	0.2
<i>X. betulonensis</i>	0.5	1.6	0.86	0.35

its whole extension, but neither did we obtain results that allow us to use this measurement to differentiate these taxa (tables 4–5). However, Puente (1994), with only two specimens, found differences in four anatomical characters of the reproductive system to differentiate *X. m. montserratensis* from *X. betulonensis*: 1) the ratio of flagellum/length of the complex penis+epiphallus (F/Pe + Ep); 2) the length of the epiphallus (Ep) and its ratio with the penis (Pe); 3) the ratio between the diameter of the dart sacs and of the mucous glands; and 4) the length and thickness of the vagina. For the ratio of the flagellum/length of the complex penis + epiphallus (F/Pe + Ep), Puente (1994) indicated that it was greater in *X. betulonensis* (0.5–0.9) than in *X. montserratensis* (0.5). Our results for *X. montserratensis* vary between 0.52 and 0.78, clearly exceeding the value given to this species by Puente (1994). For *X. betulonensis*, the value of the F/Pe + Ep varies between 0.61 of a specimen of Gallifa and 1.63 of a specimen from the type locality (table 5). For *X. m. delicatula* this value varies between 0.64 and 0.74. The dispersion of values obtained in this study allows us to consider this as a non-valid character to discriminate the taxa.

Regarding the epiphallus (in the sense of Altimira and Ortiz de Zárate, Ep + Ped), it has been alleged

Table 2. Number of ribs for each sampled zone in specimens of the three taxa. (For abbreviations see table 1.)

Tabla 2. Número de costillas de cada zona muestreada en ejemplares de los tres taxones. (Para las abreviaturas, véase tabla 1.)

	Between 3rd/4th whorl			Last whorl peristoma			Last whorl		
	Min	Max	\bar{x}	Min	Max	\bar{x}	Min	Max	\bar{x}
<i>X. m. montserratensis</i>	11	25	12.9	5	11	6.9	4	9	6.35
<i>X. m. delicatula</i>	16	29	22.73	7	13	9	5	11	8.46
<i>X. betulonensis</i>	14	33	19.1	6	15	10.13	5	14	10.13

Table 4. Measurements (in mm) of various organs of the reproductive system of *Xerocrassa m. montserratensis* and *X. m. delicatula*: LT. *Locus typicus*; M. Els Munts; OZ. Ortiz de Zárate (1959); P. Puente (1994); At. Atrium; BCD. Bursa copulatrix' duct; DSD. Diameter of the dart sacs; DSL. Length of the dart sacs; Ep. Epiphallus; F. Flagellum; FO. Free oviduct; Pe. Penis; Ped. Distal penis; Pep. Proximal penis; RM. Retractor muscle of penis; VgD. Diameter of the vagina; VgL. Length of the vagina.

Tabla 4. Medidas (en mm) de diversos órganos del aparato reproductor de *Xerocrassa m. montserratensis* y *X. m. delicatula*: LT. *Locus typicus*; M. Els Munts; OZ. Ortiz de Zárate (1959); P. Puente (1994); At. Atrio; BCD. Conducto de la bursa copulatrix; DSD. Diámetro de los sacos del dardo; DSL. Longitud de los sacos del dardo; Ep. Epifalo; F. Flagelo; FO. Oviducto libre; Pe. Pene; Ped. Pene distal; Pep. Pene proximal; RM. Músculo retractor del pene; VgD. Diámetro de la vagina; VgL. Longitud de la vagina.

	<i>X. m. montserratensis</i>					<i>X. m. delicatula</i>	
	LT (1)	LT (2)	M	OZ*	P*	LT (1)	LT (2)
Pe	3.55	4.0	4.0	3.68	4.7	6.8	5.1
Pep	2.05	2.25	3.0	2.3	2.18	4.05	3.35
Ped	1.5	1.75	1.0	1.38	1.9	2.75	1.75
Ep	5.6	6.7	7.55	9.62	9.5	9.5	5.35
EpPed = Ep+Ped	7.1	8.45	8.55	11.0	11.4	12.25	7.1
F	7.15	7.9	6.15	11.5	8.5	10.5	7.75
Pe+Ep+F	14.8	16.85	16.7	24.8	22.7	24.05	16.45
F/Pe + Ep	0.78	0.73	0.52	0.95	0.57	0,64	0.74
Ep/Pe	1.57	1.67	1.88	2.61	2.02	1.39	1.04
EpPed/Pep	3.46	3.75	2.85	4.78	5.2	3.02	2.11
BCD/Pe+ Ep	0.80	0,63	0,86	0,66	0,65	0,65	1.12
VagD	0.6	0.75	0.6	–	0.6	0.65	0.6
VagL	2.0	2.75	2.1	–	3.8	2.75	2.0
VgL/Vgd	3.3	3.6	3.5	0	6.3*	4.2	3.3
FO	0.75	1.25	1.25	–	1.5	1.25	1.5
At	0.75	0.75	0.75	–	1.0	0.75	1.25
DSL	1.25	1.25	1.05	–	0.8	1.25	0.75
DSD	0.25	0.35	0.25	–	0.33	0.4	0.25
GMD	0.4	0.45	–	–	0.4	0.35	0.35
RM	1.25	0.85	1.25	4 d.	3.3	3.0	4.0
BCD	7.4	6.75	10.0	8.9	9.3	10.75	11.75
BC	1.65x1.3	2.1x2.0	1.55x1.25	–	2.2x2.0	3.5x2.0	1.75x1.0
GMD/DSD	1.6	1.28	–	–	1.6	0.87	1.4
DSD/GMD	0.62	0.77	–	–	< 1	1.14	0.71
Pe+Ep+F/BCD	2.0	2.49	1.67	2.78	2.6	2.23	1.4

that it is 3–4 times longer than the penis (Pep) in *X. betulonensis*, while in *X. m. montserratensis* it is 5 times longer (Puente, 1994).

In our three specimens of *X. m. montserratensis* the results vary between 2.85 and 3.75 times, for 2 specimens of *X. m. delicatula* between 2.11 to 3.02 times, and for 7 specimens of *X. betulonensis* varies between 2.16 and 5.6 times. Again, these results do not allow

us to consider this criterion valid to differentiate these three nominal taxa, which do not conform to the values proposed by Puente (1994, tables 2–3). Nevertheless, we made the same calculation for the ratio Ep/Pe, with the penis being up to the retractor muscle, and the results vary for *X. m. montserratensis* between 1.57 and 2.61, for *X. betulonensis* between 1.41 and 3.59 times, and for *X. m. delicatula* between 1.04 and 1.39

Table 5. Measurements (in mm) of various organs of the reproductive system of *Xerocrassa betulonensis*: LT. Locus typicus; S. Sentmenat; G. Gallifa; EpPed. Epiphallus sensu Ortiz de Zárate (1946) and Altimira (1971). (For other abbreviations see table 4.)

Tabla 5. Medidas (en mm) de varios órganos del aparato reproductor de *Xerocrassa betulonensis*: LT. Locus typicus; S. Sentmenat; G. Gallifa; EpPed. Epifalo sensu Ortiz de Zárate (1946) y Altimira (1971). (Para las otras abreviaturas, véase tabla 4.)

	<i>X. betulonensis</i>								Puente (1994)	
	LT (1)	LT (2)	S (1)	S (2)	G (1)	G (2)	G (3)	G (4)	G (1)*	G (2)*
Pe	5.1	1.65	2.5	2.25	1.6	1.8	1.85	–	4.0	4.3
Pep	2.75	1.25	1.75	1.25	1.35	1.3	1.25	–	2.4	2.8
Ped	2.35	0.40	0.75	1.0	0.25	0.5	0.6	–	1.6	1.5
Ep	7.5	2.85	5.9	6.0	5.75	5.75	5.35	–	6.5	6.1
EpPed=Ep+Ped	9.85	3.25	6.65	7.0	6.0	6.25	5.95		8.1	7.6
F	8.75	6.15	6.0	6.25	4.5	5.5	5.0	–	7.5	8.5
Pe+Ep+F	21.35	10.65	14.4	14.5	11.85	13.05	12.2	–	17.0	18.9
F/Pe+Ep	0.69	1.36	0.71	0.75	0.61	0.72	0.69	–	0.71	0.81
Ep/Pe	1.47	1.72	2.36	2.66	3.59	3.19	2.89	–	1.62	1.41
EpPed/Pep	3.58	2.16	3.8	5.6	4.4	4.8	4.76	–	3.37	2.71
BCD/Pe+Ep	0.85	1.27	1.42	1.27	1.15	1.22	1.0	–	0.52	0.61
VagD	0.57	0.5	0.5	0.55	0.55	0.45	0.4	0.4	0.6	0.8
VagL	1.6	0.75	2.0	2.15	2.75	2.0	2.0	2.0	2.0	2.6
VgL/VgD	2.8	1.5	4.0	3.9	5.0	4.4	5.0	5.0	3.3	3.25
FO	1.0	0.75	0.85	0.85	1.0	0.95	0.85	–	1.5	1.8
At	0.5	0.55	0.8	0.3	0.7	0.5	0.55	–	0.8	0.9
DSL	1.0	0.4	0.75	0.85	0.8	0.75	0.8	0.9	1.1	1.2
DSD	0.25	0.15	0.25	0.3	0.25	0.25	0.3	0.3	0.28	0.33
GMD	0.4	0.15	0.25	0.25	0.45	0.4	0.35	0.4	–	–
RM	2.1	0.5	1.8	1.35	2.25	1.0	0.5	–	1.3	1.6
BCD	10.75	5.75	12.0	10.5	8.5	9.25	7.25	9.75	5.5	6.4
BC	1.85x1.05	1.1x0.6	3.35x1.25	3.25x1.0	1.55x1.5	2.2x0.9	1.75x1.1	1.7x1.5	2.2x1.5	1.8x1.4
GMD/DSD	1.6	1.0	1.0	0.83	1.8	1.6	1.16	1.33	–	2.2
DSD/GMD	0.625	1.0	1.0	1.2	0.55	0.62	0.85	0.75	≈1	≈1
Pe+Ep+F/BCD	1.98	1.85	1.2	1.38	1.39	1.41	1.68	–	3.0	2.9

times. These results again indicate that this criterion does not allow us to differentiate *X. m. montserratensis* from *X. betulonensis*, although in *X. m. delicatula*, with two specimens measured, it appears in the lower part of the range (tables 4–5).

Between the diameter of the dart sacs and that of the mucous glands, Puente (1994) indicates that the ratio tends to be 1 in *X. betulonensis* and smaller in *X. montserratensis*.

We obtained values for 2 specimens of *X. m. montserratensis* that vary between 0.62 and 0.77 mm,

and between 0.55 and 1.2 mm for 8 specimens of *X. betulonensis*. Two specimens of *X. m. delicatula* varied from 0.71 to 1.14 mm (tables 4–5). The data confirm that neither is this character sufficiently valid to differentiate the studied taxa.

Finally, Puente (1994) indicates that the vagina is long and thin in *X. montserratensis*, but shorter and thicker in *X. betulonensis* and *X. betulonensis*. Data from our study are summarized in table 6. Only one specimen of *X. montserratensis* presented notable dimensions, 0.6x3.8 mm. In some specimens of *X.*

Table 6 Measurements of the vagina in mm. Abbreviations: VgD. Diameter of vagina; VgL. Length of vagina; n. Number of specimens.

Tabla 6. Medidas de la vagina en mm. Abreviaciones: VgD. Diámetro de la vagina; VgL. Longitud de la vagina; n. Número de ejemplares.

VgD	VgL	VgL/VgD	n
<i>X. m. montserratensis</i>			
0.6–0.75	2.0–3.8	1.5–5.0	6
<i>X. m. delicatula</i>			
0.6–0.65	2.0–2.75	3.3–4.2	2
<i>X. betulonensis</i>			
0.4–0.8	0.75–2.6	3.3–6.3	10

betulonensis, the vagina is longer and thinner although in other specimens it is shorter and thicker, indicating intra-population variability. These data, like the rest of the characters proposed by Puente (1994), show that this relationship does not clearly differentiate some of the taxa studied.

The remaining anatomical characters, such as the length of the free oviduct, the atrium, the length of the dart sacs, the penis, the penis diameter, and the bursa copulatrix' duct and its dimensions, do not allow us to discriminate any of the taxa treated (tables 4–5).

An exception was found with an aphyllid specimen of Gallifa (table 5: specimen nº 4; fig. 7B). In the same specimen a metacercariae of a digenean trematode of the family Brachylaimidae Joeux et Foley, 1930, was found lodged in the kidney, an organ that is usually next to the hepatopancreas, pericardial cavity and pedal gland in land snails (Manga, 1983; Bargues, 1986). Its relevance stems from the fact that is the first record of a brachylaimid trematod in metacercariae stage in *X. montserratensis*, a parasite of small mammals, using this species as an intermediate host.

Taxonomical clarification

Results obtained according to morpho-anatomical characters and measures from both the shell and reproductive system show that taxonomical criteria used so far to discriminate the three studied taxa should not be considered. The results show the scarce variability in the measures obtained from the shells and from the different organs of the reproductive system which have been traditionally used to discriminate these three taxa. This allows us to establish the correct taxonomic status of the three taxa, *X. m. montserratensis*, *X. m. delicatula* and *X. betulonensis*, that actually correspond to a unique species, *X. montserratensis*. Thus *X. betulonensis* and

X. m. delicatula are junior synonyms of *Xerocrassa montserratensis* (Hidalgo, 1870) because they were described subsequently.

Redescription of the shell de *Xerocrassa montserratensis* (Hidalgo, 1870)

Redescription based on the study of 73 shells of three taxa: *X. m. montserratensis* (n = 21), *X. m. delicatula* (n = 15) and *X. betulonensis* (n = 37) (figs. 1–3, 5–6; annex): shell from 4 to 5¼ whorls, of regular growth, below convex and above flattened, light brown, grey and sometimes whitish. The dimensions vary between 6.1 and 14.0 mm in diameter and between 4.1 and 7.0 in height. The shape varies according to the locality of origin: it can be conically depressed, with a highly convex base, more globose in some places. The protoconch shows up to 1½ whorls, with a 1.25 mm maximum diameter and surface with spiral ornamentation. The apical area, and sometimes the umbilicus, presents a dense and regular pattern, costulated or ribbed, with between 11 and 33 ribs in the area of greater density, at the beginning of the third whorl. In the last whorl it presents a marked peripheral carinate that is more subtle in some localities. The umbilicus goes from slightly wide to narrow, varying between 1.35 mm and 3.1 mm. The aperture is rounded-oval, sometimes slightly angled. The peristome is acute, with patent thickening inside of whitish colour in adult specimens.

Geographical distribution

Xerocrassa montserratensis is currently distributed in the province of Barcelona (fig. 9): the 'Serralada Prelitoral Catalana' (Montserrat, Sant Llorenç del Munt, Serra de l'Obac, Gallifa, Puig de la Creu, El Farell and Guilleries), Serralada de Marina, Collserola and surroundings. About the populations on this species in the province of Girona, in Viladrau, region of Osona (Altimiras et al., 2005), we visited the area and we only found very old, damaged shells that do not confirm their current presence. In the province of Tarragona in Altafulla and Roda de Berà (Altimira, 1971), as shown later, we have no definitive data that corroborate its current presence.

After having prospected many specimens in the present study, we only found living specimens in the studied localities and its surroundings. We are unaware of evidence that living individuals have been found in recent times in the mountains of Collserola (Bros, 2004, 2009; Torre et al., 2014).

For biogeographical purposes, we have included bibliographic references that mention this species found in sediments of riverbanks in quaternary deposits; it is not always specified whether the samples correspond to live specimens or only shells or subfossils.

One sample of *X. montserratensis* deposited in the malacological collection at the Natural Sciences Museum of Barcelona is linked to locations far from the aforementioned distribution area. Two labels inside the sample convey incoherent information about the geographic origin of this record: Roda de

Berà and Altafulla, two locations separated by some 10 km between them (both in Tarragona province). We visited the area and thoroughly sampled suitable habitats for *X. montserratensis* but we did not find any specimen attributable to this taxon. We consequently reject this information.

Acknowledgements

We would like to thank Àngel Miño, Cinta Pérez and Mireia Vila from the 'Oficina Tècnica de Parcs Naturals de la Diputació de Barcelona', Jordi Calaf of the Natural Parc of Montserrat mountain. We are also grateful to Dr. Francesc Uribe and Miguel Prieto from the Museu de Ciències Naturals de Barcelona, for providing us with the study and assignment of material studied type, and Jacint Altimiras by providing data of geographical distribution. In addition, we thank the Muséum National d'Histoire Naturelle of Paris for sending photographs of the lectotype of *X. montserratensis*, Dr. María Yolanda Manga for help in the identification of the trematode, and the mathematician Mr. Vicent Escutia for his assistance in the statistical analysis. We also thank the section of electronic microscopy at the SCSIE of the University of Valencia for their help in the use of the scanning electron microscope. Finally, our thanks to the two reviewers and the editor who helped to improve various aspects of the manuscript.

References

- Almera, J. & Bofill, A., 1898. Moluscos fósiles recogidos en los terrenos pliocénicos de Cataluña. Descripciones y figuras de las formas nuevas y enumeración de todas las encontradas en dichos yacimientos. *Boletín de la Comisión del Mapa Geológico de España*, 24: 1–233.
- Altimira, C., 1971. Notas malacológicas. Contribución al conocimiento de la fauna malacológica terrestre y de agua dulce de Cataluña. *Miscel·lània Zoològica*, 3(1): 7–10.
- Altimiras, J., Bech, M., Rodríguez, M. T., Ondina, M. P., Alonso, M. R. & Ibáñez, M., 2005. Noves cites malacològiques a la comarca d'Osona. *Butlletí del Centre d'Estudis de la Natura B–N*, 6(3): 257–265.
- Altonaga, K., Puente, A. I., Martínez-Ortí, A., Prieto, C. E. & Gómez-Moliner, B. J., 2011. *Xerocrasssa montserratensis* (Hidalgo, 1870). In: *Atlas y Libro Rojo de los Invertebrados amenazados de España (Especies Vulnerables)*: 971 (J. R. Verdú, C. Numa & E. Galante, Eds.). Dirección General de Medio Natural y Política Forestal, Ministerio de Medio Ambiente, Medio Rural y Marino, Madrid.
- Arnet, R. & Bofill, A., 1879. Excursió a Sant Llorenç del Munt. *Butlletí de l'Associació d'Excursions Catalana*, 1: 23–127.
- Bargues, M. D., 1986. *Contribución al Conocimiento de la Evolución de los Digénidos de la familia Brachylaimidae Joeux et Foley, 1930 (Trematoda: Brachylaimoidea) a Nivel de Molusco Gasterópodo Primer Hospedador Intermediario*. PhD Thesis. Universitat de València, Valencia.
- Bofill, A., 1879. Catálogo de los moluscos testáceos terrestres del llano de Barcelona. *Crónica Científica*, 3: 1–24.
- 1882. Una excursió a Montserrat (8 a 12 de juny de 1880). *Anuari de l'Associació d'Excursions Catalana*, Any primer: 54–69.
- 1898. La "*Helix Montserratensis*" Su origen y su distribución en el tiempo y en el espacio. *Memorias de la Real Academia de Ciencias y Artes de Barcelona*, 2: 331–343.
- Bofill, A. & Haas, F., 1920. Estudi sobre la malacologia de les Valls Pirenaïques: Conca del Llobregat. *Treballs del Museu de Ciències Naturals de Barcelona*, 3(13): 380–830.
- Bofill, A., Haas, F. & Aguilar-Amat, J. B., 1921. Estudi sobre la malacologia de les Valls Pirenaïques: Conques del Besòs, Ter, Fluvià, Muga i litorals intermitges. *Treballs del Museu de Ciències Naturals de Barcelona*, 3(14): 837–1241.
- Bros, V., 1985. Contribució al coneixement dels mol·luscs terrestres del massís de Sant Llorenç del Munt i la Serra de l'Obac. In: *El medi natural del Vallès. I Col·loqui de Naturalistes Vallesans. Annals del CEEM*, 1: 63–68.
- 2000. Els mol·luscs Gasteròpodes (*Mollusca, Gastropoda*) del massís de Sant Llorenç del Munt i la serra de l'Obac. *Monografies*, 29: 87–95.
- 2004. Mol·luscs terrestres i d'aigua dolça de la serra de Collserola (Barcelona, NE península Ibèrica). *Arxius de Miscel·lània Zoològica*, 2: 7–44.
- 2006. Cargols terrestres (Gastropoda, Stylomatophora) del Parc Natural de la Muntanya de Montserrat (Barcelona, NE península Ibèrica). *Arxius de Miscel·lània Zoològica*, 4: 1–41.
- 2009. Inventari faunístic dels mol·luscs continentals de la serra de Collserola (Barcelona, NE de la península Ibèrica): resultat d'una revisió bibliogràfica. *Arxius de Miscel·lània Zoològica*, 7: 1–45.
- 2011. Composició de la comunitat de mol·luscs de les codines en el Parc Natural de Sant Llorenç del Munt i l'Obac, i l'impacte del trepig i l'erosió en el Montcau. *Monografies de Sant Llorenç del Munt i l'Obac*, 7: 51–60.
- 2013. Les comunitats de mol·luscs terrestres del Parc de la Serralada de Marina (Serralada Litoral Catalana, Barcelona): aportacions per a la gestió i la conservació. *Butlletí de la Institució Catalana d'Història Natural*, 77: 81–94.
- Bros, V., Moreno-Rueda, G. & Santos, X., 2011. Post-fire management affects response of Mediterranean animal communities: the case study of terrestrial gastropods. *Forest Ecology and Management*, 261: 611–619.
- Cabañas, J., Escobar, J., Moreno, M., Nebot, J. & Seró, J., 1992. Fauna malacològica de Santa Coloma de Gramanet. *Puig Castellar (IV èp.)*, 3–4: 155–165.
- Fagot, P., 1891. Histoire malacologique des Pyrénées françaises et espagnoles. Liste des espèces. *Bull. Société Ramond de Bagnères-de-Bigorre*, 26(1): 1–28, 277–296.

- Fischer-Piette, E., 1950. Liste des types décrits dans le Journal de Conchyliologie et conservés dans la collection de ce Journal. *Journal de Conchyliologie*, 90: 8–333.
- Forcart, L., 1976. Die Cochlicellinae and Helicellinae von Palastina und Sinai. *Archiv für Molluskenkunde*, 106(4–6): 123–189.
- Gittenberger, E., 1993. On *Trochoidea geyeri* (Soós, 1926) and some conchologically similar taxa (Mollusca: Gastropoda Pulmonata: Hygromiidae). *Zoologische Mededelingen*, 67: 303–319.
- Haas, F., 1929. *Fauna malacològica terrestre y de agua dulce de Cataluña*. Treballs del Museu de Ciències Naturals, 13. Edició facsímil 1991: *Treballs del Museu de Zoologia*, vol. 5: 1–491. Museu de Ciències Naturals de Barcelona.
- Hesse, P., 1934. Zur Anatomie und Systematik paläarktischer Stylommatophoren. *Zoologica*, 34(85): 1–57.
- Hidalgo, J. G. B., 1870. Description de trois espèces nouvelles d'Helix d'Espagne. *Journal de Conchyliologie*, 18: 298–299.
- 1875–84. *Catálogo Iconográfico y descriptivo de los moluscos terrestres de España, Portugal y las Baleares*. Ed. S. Martínez, Madrid.
- ICZN (International Commission of Zoological Nomenclature), 1999. International code of zoological nomenclature (the Code), fourth edition. The International Trust for Zoological Nomenclature, c/o Natural History Museum, London [online version at <http://www.iczn.org/iczn/index.jsp>].
- Kobelt, W., 1873. Nachträge und Berichtigungen zu meinen Catalog der im europäischen Feunengebiet lebenden Binnenconchylien. *Malakozoologische Blätter*, XXI: 177–190.
- Maluquer, J., 1901. Contribució a la fauna malacològica de Catalunya. I. Moluscos recullits en la muntanya de Montserrat. *Butlletí de la Institució Catalana d'Història Natural*, 1: 52–59.
- Manga, M. Y., 1983. *Los Helicidae (Gastropoda, Pulmonata) de la provincia de León*. Ed. Diputación Provincial de León. Institución Fray Bernardino de Sahagún, León.
- Marcet, A., 1909–1910. Fauna malacològica de Montserrat. *Revista Montserratina*, III, IV.
- Martínez-Ortí, A., 1999. Moluscos terrestres testáceos de la Comunidad Valenciana. PhD Thesis, Universitat de València, Valencia [digital version by ProQuest LLC, 2014].
- 2006. Descripción de un nuevo higrómido ibérico: *Xerocrassa edmundi* spec. nov. (Gastropoda, Pulmonata). *Iberus*, 24(2): 81–68.
- 2008. Taxonomical clarification of the Iberian endemic *Helicella (Xerotracha) mariae* Gasull, 1972 (Gastropoda, Pulmonata Hygromiidae). *Basteria*, 72: 147–154.
- 2013. *Xerocrassa montserratensis*. The IUCN Red List of Threatened Species. Version 2015.2. <www.iucnredlist.org> (Downloaded on 23 August 2015).
- Martínez-Ortí, A., Faci, G. & Robles, F., 2000. Taxonomical revision of *Trochoidea (Xerocrassa) Ilopisi* Gasull, 1981 (Gastropoda, Pulmonata, Hygromiidae, Geomitrinae), from the province of Castellón, Spain. *Basteria*, 64: 7–14.
- Martínez-Ortí, A. & Uribe, F., 2008. Los ejemplares tipo de las colecciones malacológicas del Museo de Ciències Naturals de Barcelona y del Museo Valencià d'Història Natural. *Arxius de Miscel·lània Zoològica*, 6: 1–156.
- Martínez-Ortí, A., Prieto, M. & Uribe, F., (in press.). Nuevas aportaciones al catálogo de ejemplares tipo de la colección malacològica del Museo de Ciències Naturals de Barcelona. *Arxius de Miscel·lània Zoològica*.
- Martorell, M. & Bofill, A., 1888. *Catálogo de la Colección Conchiològica que fué de D. Francisco Martorell y Peña, legada por dicho señor a la ciudad de Barcelona y existente en el Museo de Martorell de la propia ciudad*. Tipo-Litografía de los sucesores de N. Ramírez y C^a, Barcelona.
- Ortiz de Zárate, A., 1946. Observaciones anatómicas y posición sistemática de varios Helicidos españoles. *Boletín de Real Sociedad Española de Historia Natural*, 44: 347–351.
- 1950. Observaciones anatómicas y posición sistemática de varios Helicidos españoles. *Boletín de Real Sociedad Española de Historia Natural*, 48: 21–85.
- Pfeiffer, L., 1876. *Monographia Helicetorum Viventium. Sistens descriptiones systematicas et criticas omnium huius familiae generum et specierum hodie cognitarum*. vol., 7: 1–674.
- Puente, A. I., 1994. *Estudio taxonómico y biogeográfico de la superfamilia Helicoidea Rafinesque, 1815 de la Península Ibérica e Islas Baleares*. Ph. D. Thesis, Universidad del País Vasco, Bilbao.
- Puente, A. I., Prieto, C. E., Altonaga, K. & Gómez, B. J., 2006. *Xerocrassa montserratensis* (Hidalgo, 1870). In: *Libro Rojo de los Invertebrados de España*: 388 (J. R. Verdú & E. Galante, Eds.). Dirección General para la Biodiversidad, Ministerio de Medio Ambiente, Madrid.
- Santos, X., Bros V. & Miño, A., 2009. Recolonization of a burned Mediterranean area by terrestrial gastropods. *Biodiversity and Conservation*, 18: 3153–3165.
- Santos, X., Bros, V. & Ros E., 2012. Contrasting responses of two xerophilous land snails to fire and natural reforestation. *Contributions to Zoology*, 81: 167–180.
- Servain, G., 1880. *Etudes sur les mollusques recueillis en Espagne et en Portugal*. Saint-Germain Ed., Paris.
- Thieux, E., 1907. Note sur la "*Jacosta betulonensis*" (Bofill) var.é de la montserratensis (Hidalgo). *Butlletí de la Institució Catalana d'Història Natural*, 4: 37–39.
- Templado, J., Baratech, L., Calvo, M., Villena, M. & Aparicio, M. T., 1993. *Los ejemplares tipo de las colecciones malacológicas del Museo Nacional de Ciencias Naturales*. C.S.I.C. Monografía, 9, Madrid.
- Torre, I., Bros, V. & Santos, X., 2014. Assessing the impact of reforestation on the diversity of Mediterranean terrestrial Gastropoda. *Biodiversity and Conservation*, 23: 2579–2589.
- Ventura, D., 1992. Fauna malacològica terrestre i

- d'aigua dolça de la comarca del Maresme i del seu entorn (prov. de Barcelona). In: *Primeres Jornades naturalistes del Maresme*: 19–33. Ed. Natura, Entitat de Medi Ambient, Argentona.
- Verdú, J. R. & Galante, E., (Eds.), 2009. *Atlas de los Invertebrados Amenazados de España (Especies en Peligro Crítico y en Peligro)*. Dirección General para la Biodiversidad, Ministerio de Medio Ambiente, Madrid.
- Westerlund, C. A., 1876–78. *Faunae molluscorum europæorum extramarinorum prodromus*. Lundae, Lund, Sweden.
-

Annex. Measurements and data from shells of *Xerocrassa m. montserratensis* and *X. m. delicatula*: ApD. Diameter aperture; ApH. Height aperture; BLW. Beginning of the last whorl from the peristoma; Coll. Collection; D. Diameter; ELW. End of the last whorl; ETW. End of the third whorl and beginning of the four whorl; H. Height; H/D. Ratio between height and diameter; LW. Last whorl; PrD. Diameter of the protoconch; S. Spire; U. Umbilicus; W. Whorls; WPr. Whorls of the protoconch.

	Taxa	Locality	Coll	D	H	H/D
1	<i>X. m. montserratensis</i>	<i>Locus typicus</i>				
		Lectotype, MNHN-23274	Hidalgo	12.1	6.2	0.512
2	<i>X. m. montserratensis</i>	Topotypes	Bros	10.5	6.7	0.638
3	<i>X. m. montserratensis</i>	"	Bros	10.4	5.7	0.548
4	<i>X. m. montserratensis</i>	"	Bros	9.6	5.7	0.593
5	<i>X. m. montserratensis</i>	"	Bros	8.7	5.5	0.632
6	<i>X. m. montserratensis</i>	"	Bros	9.5	6.6	0.694
7	<i>X. m. montserratensis</i>	"	Bros	9.3	5.1	0.548
8	<i>X. m. montserratensis</i>	"	Bros	9.1	5.5	0.604
9	<i>X. m. montserratensis</i>	"	Bros	9.6	5.4	0.562
10	<i>X. m. montserratensis</i>	"	Bros	10.1	5.5	0.544
11	<i>X. m. montserratensis</i>	"	Bros	10.6	5.8	0.547
12	<i>X. m. montserratensis</i>	Els Munts	Bros	9.4	6.5	0.614
13	<i>X. m. montserratensis</i>	"	Bros	9.2	6.3	0.684
14	<i>X. m. montserratensis</i>	"	Bros	10.0	6.4	0.64
15	<i>X. m. montserratensis</i>	"	Bros	10.1	6.2	0.613
16	<i>X. m. montserratensis</i>	"	Bros	9.6	6.1	0.635
17	<i>X. m. montserratensis</i>	"	Bros	9.9	6.5	0.656
18	<i>X. m. montserratensis</i>	"	Bros	9.0	5.6	0.622
19	<i>X. m. montserratensis</i>	"	Bros	8.7	6.1	0.701
20	<i>X. m. montserratensis</i>	"	Bros	9.6	6.5	0.677
21	<i>X. m. montserratensis</i>	"	Bros	9.4	5.7	0.606
22	<i>X. m. delicatula</i>	La Mata (Lectotype; MZB 81-4766)	Bofill	8.7	4.7	0.54
23	<i>X. m. delicatula</i>	Paralectotype (MZB 81-4767)	Bofill	9.0	4.8	0.533
24	<i>X. m. delicatula</i>	Paralectotype (MZB 81-4768)	Bofill	9.4	5.5	0.585
25	<i>X. m. delicatula</i>	Paralectotype (MZB 81-4769)	Bofill	8.6	4.7	0.546
26	<i>X. m. delicatula</i>	Paralectotype (MZB 81-4770)	Bofill	8.9	5.5	0.618
27	<i>X. m. delicatula</i>	Topotypes	Bros	11.7	6.5	0.555
28	<i>X. m. delicatula</i>	"	Bros	10.5	5.8	0.552
29	<i>X. m. delicatula</i>	"	Bros	11.5	5.8	0.504
30	<i>X. m. delicatula</i>	"	Bros	10.8	5.5	0.509
31	<i>X. m. delicatula</i>	"	Bros	10.8	5.7	0.527
32	<i>X. m. delicatula</i>	"	Bros	10.6	6.4	0.603
33	<i>X. m. delicatula</i>	"	Bros	12.2	6.6	0.54

Anexo. Medidas y datos obtenidos de las conchas de *Xerocrassa m. montserratensis* y *X. m. delicatula*: ApD. Diámetro de la abertura; ApH. Altura de la abertura; BLW. Inicio de la última vuelta desde el peristoma; Coll. Colección; D. Diámetro; ELW. Final de la última vuelta; ETW. Final de la tercera vuelta e inicio de la cuarta; H. Altura; H/D. Relación entre la altura y el diámetro de la concha; LW. Última vuelta; PrD. Diámetro de la protoconcha; S. Espira; U. Ombligo; W. Vueltas de espira; WPr. Vueltas de la protoconcha.

LW	S	ApD	ApH	U	PrD	W	WPr	ETW	BLW	ELW
–	–	–	–	1.77	–	–	–	–	–	–
5.7	1.0	5.4	4.9	2.25	1.1	5¼	1½	16	11	6
5.1	0.6	5.1	4.4	2.25	1.15	5¼	1¼	21	7	5
4.7	1.0	4.8	4.4	2.0	1.0	5	1¼	18	6	6
4.4	1.1	4.35	3.8	2.0	0.95	5½	1¼	21	8	7
5.1	1.4	5.15	4.2	2.25	1,0	5⅞	1¼	14	4	4
4.4	0.7	5.15	4.2	2.0	0.95	5	1¼	20	8	8
4.4	1.1	4.9	3.9	2.25	0.9	5¼	1¼	25	6	6
4.6	0.8	4.8	3.8	2.0	0.9	5⅞	1⅜	11	5	6
4.8	0.7	5.2	4.35	2.35	0.95	5¼	1⅜	13	7	7
5.1	0.6	5.2	4.2	2.15	1.0	5	1¼	15	5	4
5.3	1.2	5.15	4.5	1.8	1.0	5¼	1⅜	18	8	6
5.2	1.1	5.0	3.95	1.9	1.05	5⅞	1½	22	8	8
5.4	1.0	5.15	4.35	2.2	1.15	5¼	1½	16	6	8
5.4	0.8	5.3	4.7	2.0	1.1	5¼	1⅜	13	7	5
5.1	1.0	4.95	4.25	2.15	1.1	5¼	1½	21	7	5
5.3	1.2	5.2	4.75	2.05	1.05	5⅞	1¼	18	10	8
4.7	0.9	4.85	4.2	1.6	1.1	5	1½	22	7	7
5.7	0.4	4.75	4.1	1.65	1.05	5¼	1¼	14	6	9
5.4	1.1	5.1	4.5	2.0	1.05	5⅞	1¼	14	6	6
5	0.7	4.75	4.2	2.0	1.0	5½	1½	16	6	6
4.1	0.6	4.35	3.7	1.75	1.0	4	1¼	23	9	11
4.2	0.6	4.25	3.6	2.0	1.05	4⅞	1⅞	29	9	11
4.8	0.7	4.9	3.9	1.55	1.25	4⅞	1½	20	9	10
4.2	0.5	4.35	3.6	1.5	1.0	4¾	1½	21	11	7
4.1	1.4	3.4	3.4	1.7	1.0	5¼	1¼	28	7	9
5.8	0.7	5.2	4.85	2.25	0.95	5½	1¼	28	11	11
5.1	0.7	5.0	4.75	2.5	0.95	5½	1¼	25	13	9
5.3	0.5	5.1	4.65	2.3	1.0	5½	1½	29	10	8
4.7	0.8	5.0	4.3	2.25	0.95	5¼	1⅜	20	9	7
5.1	0.6	5.2	4.75	2.7	1.0	5¼	1⅞	24	10	5
5.4	1.0	5.0	4.7	2.25	0.95	5½	1½	20	8	7
5.6	1.0	5.6	5.1	2.75	1.0	5½	1¼	17	7	9

Annex. (Cont.)

	Taxa	Locality	Coll	D	H	H/D
34	<i>X. m. delicatula</i>	"	Bros	10.4	5.8	0.557
35	<i>X. m. delicatula</i>	"	Bros	14.0	8.2	0.585
36	<i>X. m. delicatula</i>	"	Bros	11.7	7.0	0.598
37	<i>X. betulonensis</i>	<i>Locus typicus</i> , Lectotype; MZB 81–4808	Bofill	9.4	4.6	0.489
38	<i>X. betulonensis</i>	Topotypes	Bros	9.1	5.4	0.593
39	<i>X. betulonensis</i>	"	Bros	8.5	5.0	0.588
40	<i>X. betulonensis</i>	"	Bros	9.1	5.2	0.571
41	<i>X. betulonensis</i>	"	Bros	8.2	4.8	0.585
42	<i>X. betulonensis</i>	"	Bros	8.55	4.5	0.526
43	<i>X. betulonensis</i>	"	Bros	8.0	4.3	0.537
44	<i>X. betulonensis</i>	"	Bros	9.2	5.2	0.565
45	<i>X. betulonensis</i>	"	Bros	8.0	4.8	0.6
46	<i>X. betulonensis</i>	"	Bros	9.1	5.1	0.56
47	<i>X. betulonensis</i>	"	Bros	8.9	5.2	0.584
48	<i>X. betulonensis</i>	"	Bros	8.6	5.1	0.593
49	<i>X. betulonensis</i>	"	Bros	8.4	5.3	0.63
50	<i>X. betulonensis</i>	"	Bros	8.1	5.1	0.629
51	<i>X. betulonensis</i>	"	Bros	9.2	5.8	0.63
52	<i>X. betulonensis</i>	"	Bros	7.1	4.6	0.647
53	<i>X. betulonensis</i>	"	Bros	8.4	5.0	0.595
54	<i>X. betulonensis</i>	Gallifa	Bros	8.0	4.5	0.562
55	<i>X. betulonensis</i>	"	Bros	6.9	4.3	0.623
56	<i>X. betulonensis</i>	"	Bros	7.1	4.0	0.563
57	<i>X. betulonensis</i>	"	Bros	8.4	5.2	0.619
58	<i>X. betulonensis</i>	"	Bros	8.2	4.7	0.573
59	<i>X. betulonensis</i>	"	Bros	8.1	4.6	0.567
60	<i>X. betulonensis</i>	"	Bros	8.5	4.7	0.552
61	<i>X. betulonensis</i>	"	Bros	7.6	4.7	0.618
62	<i>X. betulonensis</i>	"	Bros	9.2	5.1	0.554
63	<i>X. betulonensis</i>	"	Bros	7.9	4.6	0.582
64	<i>X. betulonensis</i>	Sentmenat	Bros	8.2	4.9	0.597
65	<i>X. betulonensis</i>	"	Bros	9.9	6.1	0.616
66	<i>X. betulonensis</i>	"	Bros	6.9	4.6	0.666
67	<i>X. betulonensis</i>	"	Bros	8.2	5.0	0.609
68	<i>X. betulonensis</i>	"	Bros	7.5	4.3	0.573
69	<i>X. betulonensis</i>	"	Bros	7.4	4.1	0.554
70	<i>X. betulonensis</i>	"	Bros	8.4	5.1	0.607
71	<i>X. betulonensis</i>	"	Bros	8.0	4.5	0.562
72	<i>X. betulonensis</i>	"	Bros	8.9	5.0	0.561
73	<i>X. betulonensis</i>	"	Bros	7.6	4.4	0.578

Annex. (Cont.)

LW	S	ApD	ApH	U	PrD	W	WPr	ETW	BLW	ELW
5.0	0.8	5.1	4.7	2.15	0.95	5½	1⅝	21	7	9
6.8	1.4	6.8	6.0	3.1	1.05	5¾	1½	16	8	9
5.4	1.6	5.3	5.0	2.75	1.0	5¾	1½	20	7	5
4.1	–	–	–	1.9	–	4¾	1¼	11	7	4
4.4	1.0	–	–	1.5	1.2	4¾	1⅝	14	7	5
4.2	0.8	4.0	3.45	1.35	1.2	4½	1¾	19	9	7
4.6	0.6	4.0	–	1.4	0.95	4¾	1½	15	8	7
3.8	1.0	4.0	2.75	1.45	1.0	4⅝	1¼	20	11	9
4.0	0.5	4.1	3.45	1.4	1.0	4½	1⅝	21	11	8
3.8	0.5	4.0	2.95	1.25	1.0	4¼	1¼	19	10	11
4.6	0.6	4.65	3.8	1.55	1.0	4½	1¼	16	7	6
4.1	0.7	4.25	3.35	1.9	1.2	4 ⅝	1½	15	6	7
4.2	0.9	4.25	3.6	1.85	1.1	4 ⅜	1½	14	6	5
4.3	0.9	4.4	3.45	1.75	1.2	4 ⅝	1¼	15	6	8
4.8	0.3	4.35	3.5	1.7	1.0	4⅞	1¼	18	7	6
4.4	0.9	3.85	3.5	1.4	1.05	4⅝	1¼	16	6	6
4.2	0.9	4.1	3.25	1.75	1.0	4¾	1¼	14	9	7
4.8	1.0	4.35	3.7	2.5	1.15	4⅞	1⅝	14	8	6
4.2	0.4	4.0	3.15	1.5	1.05	4½	1⅝	14	11	8
4.3	0.7	4.45	3.9	1.65	1.05	4⅝	1⅝	20	10	6
3.9	0.6	4.0	3.3	1.6	1.0	4¾	1⅝	20	9	13
3.7	0.6	4.0	3.25	1.5	1.0	4¾	1½	23	11	13
3.5	0.5	3.6	3.1	1.75	1.0	4⅞	1 ⅜	24	11	8
4.1	1.1	4.24	3.75	1.75	1.05	5	1 ⅜	15	12	9
3.9	0.8	4.0	3.35	1.85	0.95	5⅝	1¼	22	13	13
3.9	0.7	4.0	3.3	1.75	0.95	5⅝	1¼	20	15	10
4.1	0.6	4.4	3.7	1.85	1.05	4⅞	1½	23	10	8
4.2	0.5	3.85	3.4	1.75	1.0	5	1⅝	21	11	9
4.5	0.6	4.6	3.85	2.1	1.05	5	1½	33	10	7
3.9	0.7	4.15	3.6	1.65	1.05	5	1½	25	12	10
4.3	0.6	4.75	3.7	1.5	1.0	4⅞	1½	21	12	10
5.1	1.0	5.0	4.25	1.75	0.95	5¼	1¼	16	8	8
3.8	0.8	3.4	3.0	1.45	1.15	5	1½	17	12	9
4.4	0.6	4.25	3.75	1.55	1.0	5	1¼	15	7	11
3.6	0.7	4.0	3.4	1.25	1.0	4¾	1¼	20	11	10
3.5	0.6	3.7	3.1	1.6	1.0	4⅞	1½	20	17	14
4.1	1.0	4.1	3.6	1.7	1.0	5	1⅝	21	10	10
3.8	0.5	4.1	3.7	1.75	0.95	4¾	1¼	18	14	13
4.2	0.8	4.35	3.8	1.75	1.0	5	1½	24	13	11
3.8	0.6	3.85	3.1	1.75	1.0	4¾	1¼	24	13	10

