

The freshwater mussel collection (Bivalvia: Unionida) of the Museo Nacional de Ciencias Naturales (Madrid, Spain)

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ABSTRACT

A review of the freshwater mussel collection housed at the Museo Nacional de Ciencias Naturales of Madrid (Spain) (MNCN) including complete specimen data for the 3,270 lots is provided. The 10,009 specimens (single valves not included) represent species from five continents and Oceania, with 342 species in 110 genera belonging to 6 currently recognized families of the Order Unionida. This collection contains 42.9 % and 60.7 % of the total currently recognized unionoid species and genera respectively. There are 152 lots with 30 species from Africa, 1,359 lots containing 245 species from the Americas, 125 lots including 55 species from Asia, 1,472 lots representing 18 European species and 28 lots of 7 species from Oceania. The Iberian Peninsula has the greatest representation with 1,233 lots (114 Margaritiferidae and 1,119 Unionidae). The alcohol-preserved collection includes 456 lots of European and 39 lots of North African mussels, and represents a significant contemporary collection of freshwater mussels from these areas. We also present an historic description of the collection, with special emphasis on the South and Central American mussels collected by the Comisión Científica del Pacífico (1862–1866), and updated data on the presence of threatened and endangered species following the Endangered Species Act (USA) and the Habitats Directive (Europe). According to the International Union for the Conservation of Nature [IUCN] Red List, there are 30 % of the Vulnerable species, 36 % of the Endangered species, 44.5 % of the Critically Endangered and the 34.5 % of today's Extinct freshwater mussels represented.

INTRODUCTION

Biological specimen collections, conserved in natural history museums and other institutions, provide a rich source of data essential for numerous areas of research including biogeography to phenological or evolutionary studies. These collections comprise samples collected during the period of accelerated anthropogenic habitat destruction, climate warming and freshwater habitat destruction. These specimens and their associated data, document baseline conditions before the major impact of these factors (Nicholson, 1991; Allmon, 1994; Shaffer, Fisher and Davidson, 1998; Lister et al., 2011; Suárez and Tsutsui, 2004). Museum collections are essential for the future documentation of the abundance and distribution of species (Lips, 2011). In order to achieve this goal, it is necessary to curate existing specimens and their corresponding data in museums and make sure this data is well organized and available for scientists (Solem et al., 1981) and others on the World Wide Web.

The objective of this paper is to update the data associated with each lot (taxonomic, faunistic, storage, number of specimens, etc.) in the freshwater mussel collection (order Unionida) (Bouchet and Rocroi, 2010; Carter et al., 2011) of the Museo Nacional de Ciencias Naturales (Madrid, Spain) (MNCN), providing a comprehensive overview of this material, as well as documenting the association of classic studies on taxonomy and distribution with the specimens. Dry specimens may be used for studies on shell ultrastructure, trace element analyses, sclerochronology or climate change, while alcohol-preserved specimens can be the source of anatomical and molecular markers used in systematic, phylogenetic or evolutionary research. We present an

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historical description of this collection, with special emphasis on the freshwater mussels collected by the “Comisión Científica del Pacífico”, a natural history expedition made between 1862 and 1866, and provide updated data on the presence of Threatened, Endangered and Extinct species following the IUCN Red List, the United States Endangered Species Act and the Habitats Directive.

The mollusk collection of the MNCN houses around 100,000 lots of the eight known mollusk classes: Solenogastrea, Caudofoveata, Polyplacophora, Monoplacophora, Gastropoda, Cephalopoda, Bivalvia, and Scaphopoda. Although specimens have been collected from around the world, the best represented areas are the Iberian Peninsula, Philippines, Cuba, Equatorial Guinea, and South America. The terrestrial mollusk collections from the Philippines, Cuba and Equatorial Guinea are probably among the best in the world. There is an important historical representation of the South and Central American fauna coming from the Comisión Científica del Pacífico.

The core historical material of the collection is from three Spanish malacologists: Paz (P. M. Paz y Membiela, 1808–1874) with 40,000 specimens representing 12,000 species and subspecies, Hidalgo (J. González Hidalgo, 1839–1923) with 8,000 species, and Azpeitia (F. Azpeitia, 1859–1934) with 80,000 specimens of 8,171 species (6,594 gastropods and 1,577 bivalves) (Barreiro, 1992). Other historical material comes from the founder of the Museum, P. Franco Dávila (1711–1786), and from M. Graells (1809–1898), who was director of the museum between 1845 and 1867. More recently, the collections have grown with the additions of A. Ortiz de Zárate (1887–1964) with 4,500 lots, A. Cobos (1922–1998) with 4,390 lots, and J. Conde with approximately 20,000 lots. The type collection including primary and secondary types, contains 1,192 lots corresponding to 946 taxa, all are computerized, arranged in taxonomic order, and housed in all steel cabinets with metal drawers that meet conservation standards and are locked (Templado et al., 1993; Villena et al., 1997). Currently, only 50% of the general collection is computerized.

The Comisión Científica del Pacífico (the Comisión) collected 38,755 specimens belonging to 816 different species (Almagro, 1866). Most of them were collected by the President of the Comisión, (P. M. Paz y Membiela), and by F. P. Martínez y Saez, but other members of the expedition like Jiménez de la Espada, Isern and Almagro also collected mollusks. Zameron, Barreiros, Philippi and Richardson donated 767 specimens of 43 species, and 37 specimens of 19 species were purchased (Almagro, 1866). All of the Comisión specimens were studied by Martínez y Saez, who was responsible for mollusks during the expedition, and by J. González Hidalgo (Hidalgo, 1900; Calvo, 1994). Martínez y Saez and Hidalgo wrote the three volumes set *Moluscos del viaje al Pacífico*, which included marine bivalves (Martínez, 1869), terrestrial gastropods (Hidalgo, 1872) and marine

gastropods (Hidalgo, 1879). The freshwater bivalves were studied by Isaac Lea (1792–1886) (Lea, 1866a, b, 1867, 1869a, b) and Fritz Haas (Haas, 1886–1969), who published “*Náyades del viaje al Pacífico*” (Haas, 1916).

Of the 60 new mollusk species described from the material collected by the Comisión, 18 were freshwater bivalves: 2 were described by Hidalgo (Calvo, 1994), 14 by Lea (1866a, b, 1867, 1869a, b) and 2 by Haas (1916). The 14 species described by Lea (1866a, b, 1867, 1869a, b) lacked exact locality data, reporting only South or Central America, but were probably collected by Paz in the Uruguay River (Salto Oriental, Uruguay) and were sent to Lea at the end of the expedition (Haas, 1916). It was uncertain if Lea’s types were included in the MNCN or in the Lea collection at the USNM (Smithsonian Institution, Washington, DC) (Haas, 1916).

RESULTS

Detailed locality, taxonomic and historical on all the freshwater mussel (Unionida) lots in the MNCN collection can be found at the Global Biodiversity Information Facility (GBIF). There are 10,009 specimens (single valves not included) in 3,270 lots representing 342 species of 110 genera belonging to the currently recognized 6 families: Margaritiferidae, Unionidae, Mycetopodidae (= Mulleriidae), Etheriidae, Iridinidae and Hyriidae (Bouchet and Rocroi, 2010; Carter et al., 2011). The collection contains representative lots and specimens of 60.7 % and 42.9 % of the total number of described unionoid genera and species respectively (Graf and Cummings, 2007; Bogan, 2008) (Table 1). There are 587 alcohol-preserved lots and 2,683 dry lots. Among these specimens are glochidia, optical microscopical slides of soft parts and shell thin sections.

Summarizing the geographical information on specimens in the unionoid collection (Table 2), there are 134 lots without locality information, including the continent of origin. The area represented by the most specimens is Europe, with 18 species (including the exotic *Sinanodonta woodiana* (Lea, 1834)) in 1,472 lots, and 29 lots without country identification. The largest number of lots comes from the Iberian Peninsula, with 1,233 lots (114 Margaritiferidae and 1,119 Unionidae): 1,131 from Spain and 102 from Portugal. During the past 12 years (Soriano et al., 2001), the Iberian material in the family Unionidae in the collection has grown by 754 lots. Other European lots by country are: Albania (3), Austria (7), Belgium (11), England (14), Croatia (6), Czech Republic (1), Denmark (1), Estonia (2), France (69), Finland (1), Germany (37), Greece (32), Hungary (7), Ireland (5), Italy (58), Latvia (2), Netherlands (1), Poland (11), Romania (2), Russia (12), Slovakia (10), Slovenia (4) and Switzerland (5). Of the 152 African lots, 42 come from Morocco, 19 from Egypt, 18 from Senegal and 18 from Tunisia; the rest come from Algeria (1), Burkina Faso (3), Burundi (7), Democratic Republic

Table 1. Total number of genera and species in families of freshwater mussels in the MNCN collection in comparison with the whole described taxa. * We consider all the living Margaritiferidae belonging to the genus *Margaritifera*. (1) Graf & Cummings (2007). (2) Bogan (2008).

	Species MNCN	Genera MNCN	Described species (1)	Described species (2)	Described genera (2)
Etheriidae	1	1	4	1	1
Hyriidae	34	9	71	83	17
Iridinidae	12	6	43	41	6
Margaritiferidae	7	1*	12	12	3
Mycetopodidae	24	7	36	39	12
Unionidae	264	86	674	621	142
TOTAL	342	110	840	797	181

of the Congo (6), Ethiopia (1), Gabon (1), Guinea (1), Ivory Coast (2), Libya (2), Mauritania (1), Niger (1), Nigeria (1) and South Africa (6). The alcohol-preserved collection, with 456 European and 39 lots of North African naiads is one of the most significant contemporary collections of freshwater mussels for these areas. There are 1,358 American lots, which include 973 from the United States of America, and 53 lots from Cuba, 44 collected by Poey already included in the Paz y Membiela collection (Barreiro, 1992), and the aforementioned specimens collected by the Comisión Científica al Pacífico (see below). The number of lots by country is: Argentina (14), Bolivia (4), Brazil (60), Canada (2), Chile (17), Colombia (2), Ecuador (18), Guatemala (1), Mexico (10), Nicaragua (8), Paraguay (1), Peru (3), Uruguay (103) and Venezuela (1). There are 78 North American lots without a country listed. The best represented Asiatic countries, with a total of 125 lots, are Japan with 33 and China with 21. Other Asiatic lots by country are: Cambodia (1), Philippines (8), India (15), Indonesia (5), Iraq (6), Israel (2), Laos (3), Malaysia (1), Myanmar (2), Singapore (2), Sri Lanka (2), Taiwan (1), Thailand (7), Turkey (9) and Vietnam (7). There are 28 lots from Oceania, 8 from Australia and 20 from New Zealand.

HISTORICAL OVERVIEW

Among the freshwater mussel historical material, it is important to document the presence of mid-nineteenth century specimens collected in South America by

the Comisión Científica al Pacífico (1862–1866), which included the Paraná and Amazon basins, Chile and the Pacific coast of Ecuador. The information about these specimens comes from three different sources: (1) Almagro (1866, page 162) published the list of the freshwater mussels collected in the Comisión, detailing the localities (15), number of species (44), number of specimens (300) and the name of the collectors. (This information was based on specimens exhibited after the Comisión Expedition); (2) Lea (1866a, b; 1867, 1869a, b) described 14 new species from South America, procured by Paz during the Comisión but failed to include any reference as to the origin of the specimens. Following Lea (1866a), some of the material sent by Paz was preserved in alcohol; (3) Haas (1916), who, during his obliged stay in Spain due to the unfavorable political climate in Germany (Haas, 1915), was invited to the MNCN where he studied the mussels collected during the Comisión. Haas (1916) listed 32 different taxa from the Comisión collection, two he described as new species (*Diplodon hidalgoi* and *Mycetopoda bolivari*). He added a summary organizing the species by river basin and included some biogeographic remarks and observations. Most of this material is in the MNCN collection and has the original Haas label (Fig. 1). In his paper, Haas mentioned that some specimens were sent by Paz to Lea, who published several new species based on this material (Lea, 1866a, b, 1867, 1869a, b) and Lea did not return part of it. This included four types of species Lea described, and Haas supposed they were in the Lea collection at the United States National Museum, Washington, DC (Haas, 1916).

Table 2. Number of lots in families of freshwater mussels at the MNCN mollusc collection. In brackets the corresponding number of species.

	Africa	America	Asia	Europe	Oceania	Unassigned
Etheriidae	6 (1)					1
Hyriidae		142 (26)			28 (7)	4
Iridinidae	41 (12)	1 (1)				
Margaritiferidae	3 (1)	4 (2)	3 (2)	136 (3)		4
Mycetopodidae		148 (23)				
Unionidae	102 (16)	1,064 (193)	122 (53)	1,336 (15)		125
TOTAL	152 (30)	1,359 (245)	125 (55)	1,472 (18)	28 (7)	134

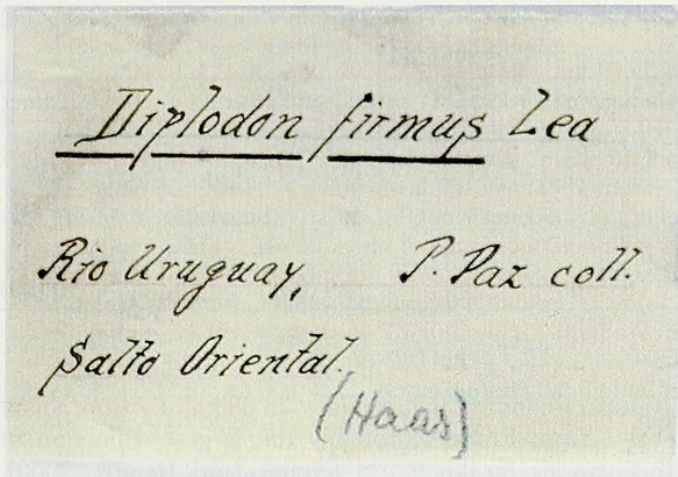


Figure 1. Handwriting of Fritz Haas on the labels of the Comisión specimens.

We located 51 lots of mussels collected by the Comisión (**Table 3**. Freshwater mussels from the Comisión Científica al Pacífico in the MNCN mollusk collection. Posted online at <http://nautilus.shellmuseum.org>); they include 223 specimens of 22 species belonging to 2 different families. We verified that the specimens sent to Lea by Paz were indeed absent; at least those corresponding to the following seven species described by Lea (1866a, 1869) are not in the MNCN. We have found them at the mollusk collection of the Smithsonian Institution, National Museum of Natural History (Washington, USA): *Unio ampullaceus* Lea, 1866. Type: USNM 85614 (= *Diplodon wymanii* (Lea, 1860)), *Unio locellus* Lea, 1866. Type: USNM 85189 (= *Rhipidodonta variabilis* (Maton, 1811)), *Unio parvus* Lea, 1866. Type: USNM 85198 (= *Rhipidodonta charruana* (Orbigny, 1835)), *Unio acutirostris* Lea, 1866. Type: USNM 85930 (= *Diplodon parallelopipedon* (Lea, 1834)), *Unio apprimus* Lea, 1866. Type: USNM 85167 (= *Diplodon wymanii* (Lea, 1860)), *Unio rugososulcatus* Lea, 1866. Type: USNM 84392 (= *Pachynaias rugososulcata* (Lea, 1866)), and *Unio rufofuscus* Lea, 1865. Type: USNM 84101 (= *Rhipidodonta grata* (Lea, 1860)). Another part of the Paz material is separated between the Smithsonian and the MNCN (**Table 3**. Freshwater mussels from the Comisión Científica al Pacífico in the MNCN mollusk collection, posted online at <http://nautilus.shellmuseum.org>): *Unio paraguayensis* Lea, 1866. Type: USNM 85068 (= *Diplodon delodontus* (Lamarck, 1819)), *Unio peculiaris* Lea, 1866. Type: USNM 85190 (= *Diplodon wymanii* (Lea, 1860)), *Unio firmus* Lea, 1866. Type: USNM 85113 (= *Diplodon delodontus* (Lamarck, 1819)), *Monocondylaea lentiformis* Lea, 1866. Type: USNM 86335 (= *Monocondylaea corrientesensis* (Orbigny, 1835)), *Monocondylaea pazii* Lea, 1866. Type: USNM 86342 (= *Monocondylaea minuana* (Orbigny, 1835)) and *Anodonta pazii* Lea, 1866. Type: USNM 86703 (= *Anodontites trapezea* (Spix and Wagner, 1827)). Haas (1916), cited Simpson (1914), noting the type of *Anodonta napoensis* Lea, 1868 was

also sent by Paz to Lea and it was present in the Lea collections in the Smithsonian Institution, Washington, DC. This was an error by Haas (1916) because Simpson (1914) did not cite Paz as donor but the name of Prof. Orton; therefore, the type specimen of this species at the Smithsonian (USNM 25429) did not come from Paz but from Dr. G. Strebel (Graf and Cummings, 2013). Other material from the Comisión can be found at the Senckenberg Museum of Frankfurt (Haas, 1916; Zilch, 1967; Graf and Cummings, 2013).

The two species described by Hidalgo, *Castalia crosseana* Hidalgo, 1865 and *Castalia pazi* Hidalgo, 1868, have been synonymized under *Castalia ambigua* Lamarck, 1819 and *Rhipidodonta hylaea* (Orbigny, 1835) by Bonnetto (1965) and Simone (2006), respectively. One specimen of each was sent by Hidalgo to the Senckenberg Museum (Frankfurt am Main, Germany) (Haas, 1916). Synonymized by Haas (1969) are the two species described by himself (Haas, 1916), *Diplodon hidalgoi* and *Mycetopoda bolivari*, as *Rhipidodonta charruana* (Orbigny, 1835) and *Mycetopodella falcata* (Higgins, 1868).

It is worth noting the presence of some specimens from the Comisión preserved in fluids (currently in 70% ethanol) at the MNCN collection that were probably overlooked by Haas (1916): 7 specimens of *Anodontites trapesialis* (Lamarck, 1819), 6 specimens of *Anodontites trapezea* (Spix and Wagner, 1827) and 2 specimens of *Diplodon delodontus* (Lamarck, 1819). The remaining 208 specimens are all dry.

We note some differences in the number of specimens recorded by Almagro (1866), Haas (1916) and this paper. For instance, regarding *Anodontites patagonica* (Lamarck, 1819), Haas (1916) cited two lots at the MNCN, one lot of 3 specimens from Río de la Plata and another lot with 2 specimens from Miguelete River, and we have found only one lot, labelled as Río de la Plata, but with 6 specimens, four of them with "Río de la Plata" written inside the shell. This maybe explained because some material may have been lost or mixed during the last 150 years, or because the data from Almagro (1866) might not be accurate. Almagro's book was written in the last year of the Comisión, so the historical number of species and corresponding number of specimens may be inexact. Another reason could be the loaning or gifting of specimens between different collections and/or the loss of old labels, as occurred among the Paz, Hidalgo, and Azpeitia collections. We have not found the specimens from Montevideo, Negro River, Aguano and Otavalo (Almagro, 1866).

Some years after the end of the Comisión, Paz sent Lea his collection of North American freshwater mollusks for expert identification (ACN0252/002; ACN0259/013). Lea returned the identified specimens (451 gastropods and 287 bivalves) in 6 parcels to La Habana (Cuba), where they were shipped again to Cádiz (Spain) arriving on 12 July 1872. On 22 August 1872 they were moved by train to Madrid where they arrived on 4 September. One year later, in 1873, the Paz mollusk collection,

Table 4. Number of freshwater mussels species included in the IUCN in the MNCN collection. Number total of species included in each category in brackets.

	Near threatened	Vulnerable	Endangered	Critically endangered	Extinct
America	35 (40)	7 (14)	10 (34)	24 (50)	10 (27)
Africa	0 (1)	0 (9)	3 (5)	2 (4)	0 (2)
Asia	0 (2)	0 (6)	3 (9)	1 (8)	
Europe	1 (1)	3 (4)	2 (2)	1 (1)	
Oceania					
TOTAL	36 (44)	10 (33)	18 (50)	28 (63)	10 (29)

including this material, was sold to the Museo Nacional de Ciencias Naturales (Barreiro, 1992).

ENDANGERED SPECIES

Freshwater bivalves are among the most imperiled animal groups on the planet, declining due to pollution, modified or disturbed habitat and reduced numbers of host fish (Lydeard et al., 2004; Strayer et al., 2004). In cases of imperiled fauna, the role of natural history collections is essential, being the last repositories where scientists can study extinct or endangered species (Nicholson, 1991; Shaffer, Fisher and Davidson, 1998). The MNCN collection has 82 % of all the Near Threatened freshwater bivalve species, 30 % of the Vulnerable species, 36 % of the Endangered species, 44.5 % of the Critically Endangered and 34.5 % of the today's Extinct naiads recognized by the International Union for the Conservation of Nature (IUCN) (Table 4). It also has nearly 60 % of the North American Endangered species (Endangered Species Act) and numerous lots of all the European species protected under the Habitats Directive: *Margaritifera margaritifera*, *M. auricularia*, *U. elongatulus*, and *U. crassus* (Tables 5, 6; **Table 6**. Freshwater bivalve species in the MNCN collection included in the IUCN, the Endangered Species Act and the Habitats Directive. Posted online at <http://nautilus.shellmuseum.org>).

Margaritiferidae represents one of the most imperiled naiad families. The MNCN mollusk collection contains

Table 5. Number of freshwater mussels species included in the Endangered Species Act and in the Habitats Directive in the MNCN collection. Number total of species included in each category in brackets. * We consider *Unio mancus* and *U. ravoisieri* under the same Annex (III and IV) as *U. elongatulus*, and *U. tumidiformis* under the same Annex (II and IV) as *U. crassus* (Araujo et al., 2009).

	America	Europe
Endangered	43 (73)	-
Threatened	1 (10)	-
Annex II	-	4 (3)*
Annex IV	-	2 (2)
Annex V	-	4 (2)*

169 specimens of *M. auricularia* in 68 lots, 67 from Spain and 1 from France, probably the largest collection of this species in the world (Araujo and Ramos, 2000), 69 lots of *M. margaritifera*, 3 lots of the North African *M. marocana*, 3 of *M. monodonta*, 1 of *M. dahurica*, 2 of *M. laevis* and 1 lot of the Asiatic *M. laosensis*. *Margaritifera laosensis* is quite rare in collections and has only recently been collected alive in the northern region of the Lao People's Democratic Republic (S. Schneider, Personal Communication).

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