

## Recent data on marine bivalves (Mollusca, Bivalvia) of the Cape Verde Islands, with records of six species new to the archipelago

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### ABSTRACT

Based on newly collected samples and data from the literature, an updated list of the marine bivalves of the Cape Verde Islands is presented. From 2004 to 2006, collections were made at 22 sampling points in the islands of Santiago, São Vicente, Santa Luzia, São Nicolau, Boavista and Maio. Using qualitative and direct sampling methods, 39 species of bivalves, belonging to 20 families, were identified. Families most represented were Veneridae (6 species), Cardiidae (5 species), Arcidae (4 species) and Mytilidae (4 species). Islands with the largest diversity of species were São Vicente (30 species) and Santiago (23 species), probably due to the larger number of sample points (64% of total). Six species not previously reported from the archipelago were collected, i.e. *Irus irus*, *Venus declivis*, *Timoclea ovata*, *Diplodonta rotundata*, *Plagiocardium papillosum* and *Tagelus adansoni*. *Corbicula fluminea*, supposedly a man assisted introduction, was also collected.

### RESUMO

Uma nova lista de espécies de moluscos bivalves com ocorrência no arquipélago de Cabo Verde é proposta, a partir de amostras recolhidas e análise da literatura. Entre 2004 e 2006, foram recolhidos bivalves em 22 pontos de amostragem nas ilhas de Santiago, São Vicente, Santa Luzia, São Nicolau, Boavista e Maio. Com base numa amostragem qualitativa e em métodos de recolha directos, foram identificadas 39 espécies de bivalves agrupados em 20 famílias. As famílias mais representativas foram Veneridae (6 espécies), Cardiidae (5 espécies), Arcidae (4 espécies) e Mytilidae (4 espécies). As ilhas com maior número de espécies representadas foram as de São Vicente (30 espécies) e Santiago (23 espécies), o que poderá estar relacionado com o maior número de pontos de amostragem (64% do total). Foram encontradas espécies cuja ocorrência não tinha sido registada até agora para o arquipélago, nomeadamente *Irus irus*, *Venus declivis*, *Timoclea ovata*, *Diplodonta rotundata*, *Plagiocardium papillosum* e *Tagelus adansoni*. Foi também recolhida *Corbicula fluminea*, supostamente introduzida pelo homem.

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## INTRODUCTION

Bivalve mollusks or clams (Mollusca, Bivalvia) are soft-bodied invertebrates that usually produce an exoskeleton (shell) by precipitation of calcium carbonate. The shell consists of two valves, united by a ligament (Ruppert *et al.* 2005). Bivalve mollusks are cosmopolitan, but their distribution is limited by several factors like mode of reproduction, water currents, water temperature, salinity, depth and sediment type (Silva & Mantalverne 1980).

The Cape Verde archipelago is located *c.* 500 km off Senegal, West Africa, between latitudes 14°50'N-17°20'N and longitudes 22°40'W-25°30'W. It is composed of 10 islands and several islets, some of latter being satellites of the main islets, while others are entities of their own. The islands are divided into two groups: the Barlavento (Windward) islands (Santo Antão, São Vicente, Santa Luzia, São Nicolau, Sal and Boavista) and the Sotavento (Leeward) islands (Maio, Santiago, Fogo and Brava). Natural resources are few and terrestrial ecosystems are fragile and sensitive to changes caused by extreme environmental imbalances.

A great diversity of marine organisms exists in Cape Verde and this also applies to bivalve mollusks. They are often collected,

together with the gastropod *Strombus latus* Gmelin, 1791, for decorative purposes, mainly *Glycymeris formosus* (Reeve, 1843), *Lyrocardium aeolicum* (Born, 1780) and *Nodipecten corallinoides* (d'Orbigny, 1834) (Almada & Lopes 1998). So far, the bivalves of Cape Verde have remained little studied. Saldanha (1997) dealt with the underwater fauna of the eastern Atlantic, while Guerreiro & Reiner (2000) listed the mollusks known from São Vicente island. The Second National Report on Biodiversity (SEPA 2001), only mentioned two families of bivalve mollusks from Cape Verde. There exists considerable discrepancy in taxonomic treatment between the publications mentioned above, especially regarding the nomenclature of species level taxa.

The study of mollusks from Cape Verde should make an important contribution to malacological systematics in general and to the conservation of local marine biodiversity in particular. The main objective of the present work was to contribute to the knowledge of marine bivalves of the Cape Verde archipelago by clarifying their taxonomy, establishing spatial distribution of taxa in the islands and to increase the number of species recorded in the archipelago.

## MATERIAL AND METHODS

**SAMPLING** Specimens were collected from April 2004 to July 2006 at 22 sampling sites (Fig. 1) on the islands of São Vicente (Calhau, Matiota, Baía das Gatas, Salamansa, Baía do Porto Grande, São Pedro, Tupim), Santa Luzia (Palmo a Tostão), São Nicolau (Barril, Tedja, Cacimba, Urina D'Ose), Boavista (Ervatão, Cural Velho, Ponta Cosme, João Barrosa), Maio (sand extraction area in the north of the island) and Santiago (Gamboa, Prainha, Praia Baixo, São Francisco, Tarrafal).

Sites were searched qualitatively, with the minimum requirement of collecting the maximum number of species present. Specimens were collected in the intertidal zone (by direct observation at low tide), up to 6 m deep in coral areas (by snorkeling) and up to 30 m deep (by mechanical sand dredgers at 30 m of coastline in the north of Maio).

Sampling sites had different types of substrate, including sand, silt, rocks and gravel.

**IDENTIFICATION** Screening of the collected material was carried out with stereo microscopes to assort it into species or higher taxonomic categories. After screening, the material was stored in labeled plastic bags. Identification of the material was carried out using Fischer *et al.* (1981, 1987, 1990), Schneider (1992), Saldanha (1997), Lloris & Rucabado (1998), Guerreiro & Reiner (2000) and Leal (2002). As a base criterion (cf. Rolán 2005), the morphological characteristics of the shell (grooves, spines) were taken into account. After morphological analysis, the samples were photographed and simple frequency analyses were carried out in an MS® Office Excel sheet.

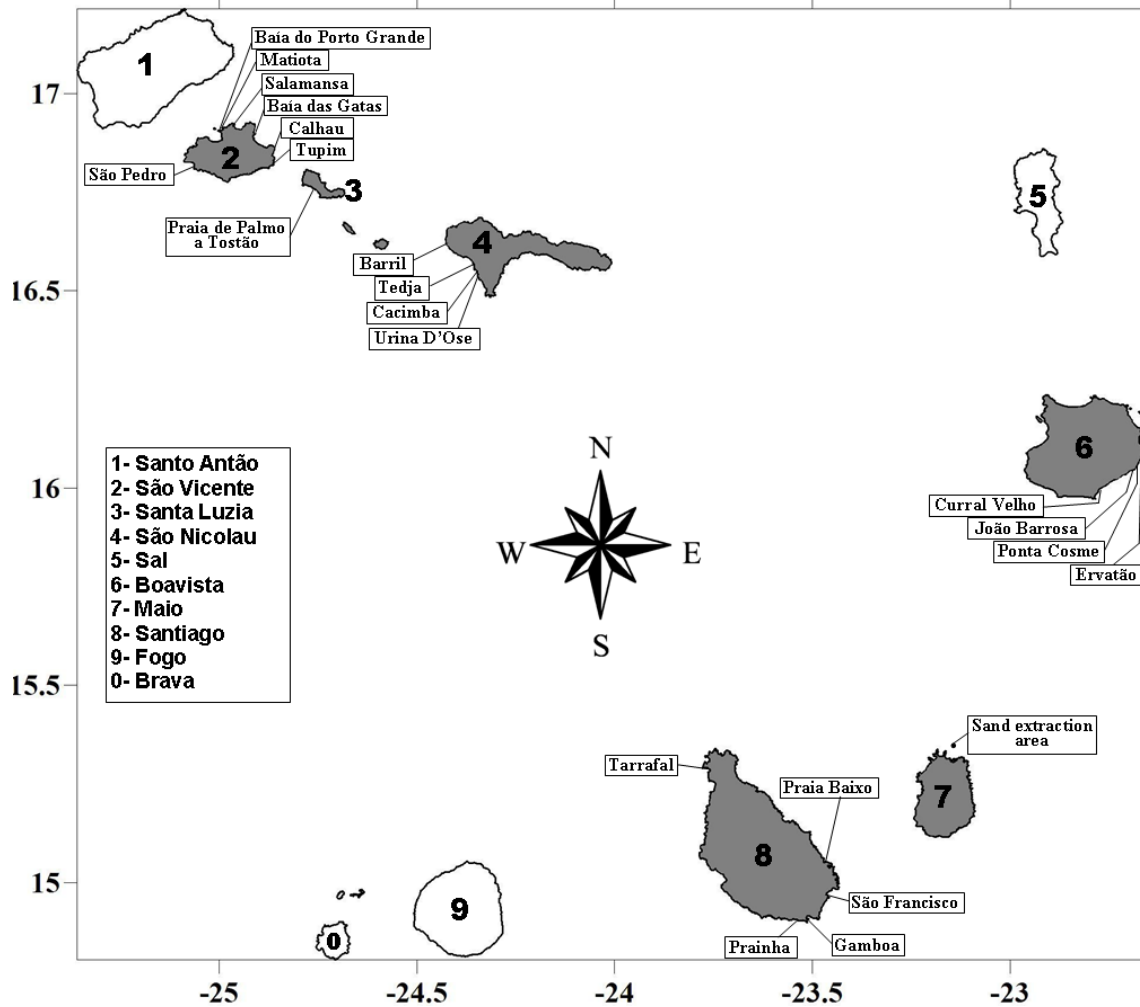


Fig. 1. Map of the Cape Verde Islands, showing sampled islands (grey) and sampling sites.

## RESULTS

The material collected in this study yielded 39 species of bivalves, distributed in 20 families<sup>1</sup>. Of these, 33 had been reported from Cape Verde before, while six species (of the families Veneridae, Ungulinidae, Cardiidae and Solecurtidae) are reported for the first time for the islands. Islands with the largest number of species were São Vicente (30) and Santiago (23), representing 77% and 54%, respectively, of the total number of species identified. In other islands, the number of species was smaller, i.e. 21 in Santa Luzia, 19 in Maio, 15 in Boavista and 13 in São Nicolau (Table 1).

<sup>1</sup> Specimens were deposited at the Laboratory of Cytology and Developmental Biology, Department of Engineering and Marine Science, University of Cape Verde, São Vicente, Republic of Cape Verde.

The most common families were Veneridae (6 species), Cardiidae (5), Arcidae (4), Mytilidae (4), Pectinidae (3), Lucinidae (2) and Ostreidae (2), with the remaining 13 families being represented by a single species. Apart from being the most common, species of Veneridae showed the widest distribution in the archipelago, being found in sandy and muddy sediments. Species of Arcidae, Cardiidae, Chamidae, Lucinidae and Spondilidae were also found in all islands sampled. Families most restricted were Tellinidae, Ungulinidae and Solecurtidae, being found in a single sample only. Spondilidae and Chamidae were each represented by a single species in all islands sampled, i.e. *Spondylus senegalensis* (Schreibers, 1793) and *Pseudochama radians* (Lamarck, 1819). In some cases, such as

specimens of Anomiidae and *Lithophaga* (Mytilidae), identification at the species level was not possible.

Except for the families Mytilidae, Ostreidae and Pinnidae, which were better represented in areas of hard substrate and in coral communities, most species were collected in areas of soft substrate (sand or mud) with little depth and strong hydrodynamics. In the present study, a total of 53 species level taxa (including those not specifically identified) of marine bivalves were collected in the Cape Verde archipelago (Appendix 2).

Six species not previously reported from the Cape Verde Islands were found, i.e. *Irus irus* (Linnaeus, 1758), *Venus declivis* Sowerby, 1853 and *Timoclea ovata* (Pennant, 1777) (Veneridae), *Diplodonta rotundata* (Montagu, 1803) (Ungulinidae), *Plagiocardium papillosum* (Poli, 1795) (Cardiidae) and *Tagelus adansoni* (Bosc, 1801) (Solecurtidae) (Appendix 1). The presence of *Corbicula fluminea* (O.F. Müller, 1774) (Corbiculoidea) in samples from São Vicente and Maio is also worth mentioning.

	Number of species per island					
	São Vicente	Santa Luzia	São Nicolau	Boavista	Maio	Santiago
ANOMIIDAE	1	1	0	0	0	1
ARCIDAE	3	2	2	2	4	3
CARDIIDAE	3	2	2	2	2	2
CARDITIDAE	1	1	0	0	0	1
CHAMIDAE	1	1	1	1	1	1
CORBICULOIDAE	1	0	0	0	1	0
GLYCYMERIDIDAE	1	1	0	1	1	1
ISOGNOMONIDAE	1	1	1	1	0	1
LUCINIDAE	2	1	1	2	1	2
MACTRIDAE	1	1	0	1	1	1
MYTILIDAE	3	1	1	2	0	2
NOETIIDAE	1	1	1	0	1	1
OSTREIDAE	2	1	1	0	1	2
PECTINIDAE	2	2	1	0	1	0
PINNIDAE	1	1	1	1	0	0
SOLECURTIDAE	0	0	0	0	0	1
SPONDYLIDAE	1	1	1	1	1	1
TELLINIDAE	1	0	0	0	0	0
UNGULINIDAE	0	0	0	0	0	1
VENERIDAE	4	3	0	1	4	1
<b>Number of species</b>	<b>30</b>	<b>21</b>	<b>13</b>	<b>15</b>	<b>19</b>	<b>22</b>
<b>Number of sampling sites</b>	<b>7</b>	<b>1</b>	<b>4</b>	<b>4</b>	<b>1</b>	<b>5</b>

Table 1. Number of species per island identified in this study.

## DISCUSSION

Results show a larger number of species in São Vicente and Santiago, which may be due to the larger number of sampling sites in these two islands. Although fewer sites were sampled there (4.5% of total), Maio yielded a

wide variety of species (19). This island has an extensive continental shelf, with small depths, sandy bays and mudflats that support high species diversity (cf. Bravo de Laguna 1985, Almada 1993). The same applies to

Boavista (18% of the total number of sampling sites), where 15 species were identified.

On São Nicolau, a relatively low number of species (13) was obtained. This may be related to the fact that the sampled beaches in São Nicolau contained little sand or mud, without suitable habitats for a number of mollusk species (Guerreiro & Reiner 2000). Beaches on São Nicolau are heavily affected by the collecting of sand for construction, which has led to the degradation of coastal habitats. In contrast, Santa Luzia – with only a single sampling point – shows a considerable diversity of bivalves (21, i.e. 54% of the total number of species). The absence of anthropogenic factors, such as harvesting of species, marine pollution and the fact that the island is uninhabited, may be the reason for this abundance and species diversity.

The families with the largest number of species (Cardiidae and Veneridae) were collected in areas of soft substrate. This is in agreement with the lifestyle of these organisms, which are mostly burying filter-feeders that seek refuge in sand or mud bottoms (Ruppert *et al.* 2005).

The species reported here for the first time for the Cape Verde Islands are distributed throughout the North Atlantic, Mediterranean and along the West African coast (Fischer *et al.* 1981, 1987, 1990, Lloris & Rucabado 1998, Leal 2002). It can be hypothesized that the occurrence of these species in Cape Verde is a result of larval transport (meroplankton, temporary plankton) by ocean currents, especially the cool Canary current, which extends from the North Atlantic to the Cape Verde Islands.

Another species collected – *Corbicula fluminea*, known as the ‘Asian clam’ – is distributed from North America south to Brazil and in Europe and Asia (Poppe & Goto 1993, Abbott & Dance 1998). This

species is characteristic of fresh and brackish waters and estuaries and was not previously reported from West Africa. It is an expansive exotic when introduced in freshwater (Nobre 1940). It is used as an *in situ* biomarker in environmental monitoring studies regarding competition for space with other species (Mersch *et al.* 1996). Since there were several shells of this species in the samples, but none with the shellfish present dead or alive, they were probably introduced by man (Ruiz *et al.* 2000). *Corbicula fluminea* can have reached the Cape Verde Islands by way of ballast water, being discarded by Chinese sailors (who consume them) or by ocean currents, although the latter is rather unlikely because of the large distance they would have to travel. Any of these possibilities should be viewed with caution and evaluated in future studies.

Taxonomy of some species in Appendix 2 diverges from that employed by previous authors, e.g. *Arcopsis afra*, previously included in Arcidae as *Arca afra* Gmelin, 1791 by Guerreiro & Reiner (2000), but now placed in Noetiidae as *Arcopsis afra* (Gmelin, 1791). Other changes in taxonomy have occurred as a result of improved data communication between researchers and the advance of new technologies used in the description, identification and classification of species.

Because of uncertainties in species identification, the present study should be considered as preliminary. As these taxa do not reach high biomass values, cannot be exploited and collection of specimens is more casual than intentional, few studies have been carried out. The material collected in this study forms the basis of a reference collection to be used in future studies on the identification, distribution and taxonomy of bivalves in the Cape Verde Islands.

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APPENDIX 1. Photographs of bivalve species not reported previously from the Cape Verde Islands.



*Irus irus* (Linnaeus, 1758) (L - 12mm)



*Venus declivis* Sowerby, 1853 (L - 30mm)



*Timoclea ovata* (Pennant, 1777) (L - 7mm)



*Diplodonta rotundata* (Montagu, 1803) (L - 20mm)



*Plagiocardium papillosum* (Poli, 1795) (L - 5mm)



*Tagelus adansoni* (Bosc, 1801) (L - 60mm)



APPENDIX 2. Bivalves recorded in the Cape Verde Islands, based on this study and data in Silva & Mantalverne (1980), Saldanha (1997), Abbott & Dance (1998), Guerreiro & Reiner (2000) and Leal (2002). CS = current study; numbers indicate islands where specimens were collected (see Fig. 1).

Class BIVALVIA Linnaeus, 1758

- Subclass PROTOBRANCHIA Pelseneer, 1889
  - ⇒ Order SOLEMYOIDA Dall, 1889
    - Superfamily SOLEMYOIDEA J.E. Gray, 1857
      - \* Family SOLEMYIDAE J.E. Gray, 1857
        - ◆ *Solemya togata* (Poli, 1795)
- Subclass PTEROMORPHIA Beurlen, 1944
  - ⇒ Order ARCOIDA Stoliczka, 1871
    - Superfamily ARCOIDEA, Lamarck, 1818
      - \* Family ARCIDAE Lamarck, 1818
        - Subfamily ARCINAE Lamarck, 1818
          - ◆ *Arca bouvieri* P. Fischer, 1874 (CS 2,3,4,6,7,8)
          - ◆ *Arca noae* Linnaeus, 1758 (CS 2,3,4,7,8)
          - ◆ *Anadara geissei* Dunker in Kobelt, 1891 (CS 2,7,8)
          - ◆ *Senilia senilis* (Linnaeus, 1758) (CS 6,7,8)
        - \* Family NOETIIDAE Stewart, 1930
          - ◆ *Arcopsis afra* (Gmelin, 1791) (CS 2,3,4,7,8)
        - \* Family GLYCYMERIDIDAE Newton, 1922
          - Subfamily GLYCYMERIDINAE Newton, 1922
            - ◆ *Glycymeris formosus* (Reeve, 1843) (CS 2,3,6,7,8)
    - ⇒ Order MYTILOIDA Ferussac, 1922
      - Superfamily MYTILOIDEA Rafinesque, 1815
        - \* Family MYTILIDAE Rafinesque, 1815
          - Subfamily MYTILINAE Rafinesque, 1815
            - ◆ *Brachidontes puniceus* (Gmelin, 1791) (CS 2,3,4,6,8)
            - ◆ *Perna perna* (Linnaeus, 1758) (CS 2)
            - ◆ *Mytilus* cf. *galloprovincialis* Lamarck, 1819 (CS 2)
            - ◆ *Lithophaga* sp. (CS 6)
          - Subfamily CRENELLINAE H. & A. Adams, 1857
            - ◆ *Musculus subpictus* (Cantraine, 1835)
          - Subfamily MODIOLINAE Keen, 1958
            - ◆ *Arcuatula elegans* J.E. Gray, 1828

- ◆ *Modiolus lulat* (Dautzenberg, 1891)
- ◆ *Modiolus verdensis* Cosel, 1995
- Superfamily PINNOIDEA Leach, 1819
  - \* Family PINNIDAE Leach, 1819
    - ◆ *Pinna rudis* Linnaeus 1758 (CS 2,3,4)
    - ◆ *Atrina chautardi* Nicklès, 1953
- Order PTERIOIDA Newell, 1965
  - ⇒ - Superfamily PTERIOIDEA J.E. Gray, 1847
    - Suborder PTERIINA Newell, 1965
      - \* Family ISOGNOMONIDAE
        - ◆ *Isognomon dunkeri* (P. Fisher, 1881) (CS 2,3,4,6,8)
    - Superfamily PECTINOIDEA Rafinesque, 1815
      - \* Family PECTINIDAE Rafinesque, 1815
        - o Subfamily PECTININAE Rafinesque, 1815
          - ◆ *Pecten keppelianus* Sowerby, 1905 (CS 2,3,7)
          - ◆ *Aequipecten commutatus* (Monterosato, 1875)
        - o Subfamily CHLAMYDINAE Korobkov, 1971
          - ◆ *Crassadoma multistriata* (Poli, 1795) (CS 4)
          - ◆ *Nodipecten corallinoides* (d'Orbigny, 1834) (CS 2,3)
          - ◆ *Manupecten pesfelis* (Linnaeus, 1758)
          - ◆ *Argopecten flabellum* (Gmelin, 1791)
      - \* Family SPONDYLIDAE J.E. Gray, 1826
        - ◆ *Spondylus senegalensis* (Schreibers, 1793) (CS 2,3,4,6,7,8)
    - Superfamily ANOMIOIDEA
      - \* Family ANOMIIDAE
  - ⇒ Order OSTREOIDA Ferussac, 1922
    - Suborder OSTREINA Ferussac, 1922
      - Superfamily OSTREOIDEA Rafinesque, 1815
        - \* Family OSTREIDAE Rafinesque, 1815
          - o Subfamily OSTREINAE Rafinesque, 1815
            - ◆ *Ostrea bicolor* (Hanley, 1845) (CS 2,3,4,7,8)
            - ◆ *Dendrostrea folium* (Linnaeus, 1758) (CS 2,8)
- Subclass HETERODONTA Neumayr, 1884
  - ⇒ Order VENEROIDA H. & A. Adams, 1857
    - Superfamily LUCINOIDEA Fleming, 1828
      - \* Family LUCINIDAE Fleming, 1828

- Subfamily LUCININAE Fleming, 1828
    - ◆ *Ctena eburnea* (Gmelin, 1791) (CS 2,3,4,6,7,8)
    - ◆ *Linga adansoni* (d'Orbigny, 1839) (CS 2,6,7)
  - \* Family UNGULINIDAE Fleming, 1828
    - ◆ *Diplodonta rotundata* (Montagu, 1803) (CS 8)
- Superfamily CHAMOIDEA Blainville, 1825
  - \* Family CHAMIDAE Blainville, 1825
    - ◆ *Pseudochama radians* (Lamarck, 1819) (CS 2,3,4,6,7,8)
- Superfamily CARDIOIDEA Lamarck, 1809
  - \* Family CARDIIDAE Lamarck, 1809
    - Subfamily LAEVICARDIINAE Keen, 1936
      - ◆ *Laevicardium crassum* (Gmelin, 1791) (CS 2,3)
    - Subfamily PROTOCARDIINAE
      - ◆ *Lyrocardium aeolicum* (Born, 1780) (CS 2,3,4,6,7)
    - Subfamily TRACHYCARDIINAE Stewart, 1930
      - ◆ *Papyridea lata* (Born, 1778) (CS 2,4,6)
      - ◆ *Plagiocardium papillosum* (Poli, 1795) (CS 8)
      - ◆ *Acanthocardia* sp. (CS 7,8)
- Superfamily CARDITOIDEA Fleming, 1928
  - \* Family CARDITIDAE Fleming, 1928
    - ◆ *Cardita calyculata* (Linnaeus, 1758) (CS 2,3,8)
- Superfamily MACTROIDEA Lamarck, 1809
  - \* Family MACTRIDAE Lamarck, 1809
    - Subfamily MACTRINAE Lamarck, 1809
      - ◆ *Mactra glabrata* (Linnaeus, 1758) (CS 2,3,6,7,8)
    - Subfamily LUTRARIINAE H. & A. Adams, 1856
      - ◆ *Lutraria senegalensis* J.E. Gray, 1837
- Superfamily TELLINOIDEA Blainville, 1814
  - \* Family TELLINIDAE Blainville, 1814
    - Subfamily TELLININAE Blainville, 1814
      - ◆ *Tellina planata* Linnaeus, 1758 (CS 2)
      - ◆ *Arcopagia* cf. *crassa* Pennant, 1777
  - \* Family DONACIDAE Fleming, 1828
    - ◆ *Donax verdensis* Cosel, 1995
  - \* Family SOLECURTIDAE d'Orbigny, 1846
    - ◆ *Tagelus adansoni* (Bosc, 1801) (CS 8)

- Superfamily VENEROIDAE Rafinesque, 1815

\* Family VENERIDAE Rafinesque, 1815

o Subfamily VENERINAE Rafinesque, 1815

- ◆ *Venus declivis* Sowerby, 1853 (CS 2,7)
- ◆ *Venus punctigera* (Dautzenberg & Fischer, 1906)
- ◆ *Venus verdensis* Dautzenberg & Fischer, 1906
- ◆ *Venus cf. verrucosa* Linnaeus, 1758 (CS 2,3,6,7)
- ◆ *Circomphalus foliaceolamellosus* (Dillwyn, 1817) (CS 6)
- ◆ *Timoclea ovata* (Pennant, 1777) (CS 2)
- ◆ *Dosinia exoleta* (Linnaeus, 1758) (CS 3,7)
- ◆ *Venerupis decussata* Philippi, 1836 (CS 2)
- ◆ *Irus irus* (Linnaeus, 1758) (CS 2,3)

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