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Bivalve mollusc exploitation in Mediterranean coastal communities: an historical approach

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The aim of this work was to survey the early history of bivalve mollusc exploitation and consumption in the Mediterranean coastal areas as recorded in the classical works of Greek antiquity. All bivalve species mentioned in the classical texts were identified on the basis of modern taxonomy. The study of the works by Aristotle, Hippocrates, Xenocrates, Galen, Dioscorides and Athenaeus showed that out of the 35 exploited marine invertebrates recorded in the texts, 20 were molluscs, among which 11 bivalve names were included. These data examined under the light of recent information on bivalve exploitation showed that the diet of ancient Greeks included the same bivalve species consumed nowadays in the coastal areas of the Mediterranean. The habitats of the exploited bivalves and consequently their fishing areas were well known and recorded in the classical texts. Information on the morphology and various aspects of the biology of certain edible species was given mostly in Aristotle's zoological works, while Xenocrates and Athenaeus presented instructions and recipes on how bivalves were cooked and served. Hippocrates and Galen gave detailed information on the dietary value of bivalve molluscs, their consumption for treatment or prevention of certain diseases, and their use for the production of drugs from their shell or flesh. The data on bivalve use derived from the classical texts is in accordance with archaeological evidence of the geometric and archaic periods from Greek coastal localities.

Key words: Aegean Sea, Greek antiquity, food, medicine.

INTRODUCTION

The use of animals by humans goes back to dawn of human development. Palaeoethnozoologists study the human-animal interactions in the past using iconographic, textual, architectural and artifactual, as well as faunal sources of information. Zooarchaeology and Archaeozoology are increasingly exploring such sources as aids to the interpretation of faunal remains (Ellis, 2000). Very interesting information on the knowledge and use of animals during Greek antiquity is embedded in the works of classical authors (Voultsiadou & Tatolas, 2005; Voultsiadou, 2007; Voultsiadou & Vafidis, 2007). Specifically, the use of animals in human food and medicine in the ancient world has been studied by some authors who attempted to review the diets and medical practices of the Greeks and Romans (e.g. King, 1998; Grant, 2000; Nutton, 2006; Wilkins & Hill, 2006).

The ancient Greek civilization which developed around the Aegean was oriented towards the sea. Fishing was the primary activity of the inhabitants of most areas that developed along the coasts of the Greek mainland, Asia Minor and the numerous islands of the Aegean and Ionian Seas. Fish have been the most studied aquatic animal group among those exploited in ancient marine communities, and it has been demonstrated that what characterized fisheries in ancient Greece was variability both in the nature and abundance of the exploited fish and in the manner of their exploitation (e.g. Mylona, 2007).

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Although fish were the main catch, molluscs and crustaceans where also collected in antiquity. Shellfish were often high-status food and their consumption was connected with the treatment or prevention of various health problems and diseases. It is known that the medical system of Hippocrates and Galen was based on food selection and proper cooking and their writings are a tremendous knowledge resource for the researcher. During the last decades molluscs as archaeological remains have been examined (Theodoropoulou, 2007a, b; Veropoulidou, in press) and an estimation of their value for people of older epochs was attempted.

Nevertheless, as Wilkins & Hill (2006) suggested, terminology has always been a problem in the attempts to understand the diet of ancient people. "*There are many examples in Athenaeus and Galen*" they comment "*where which plant or animal is in question is unclear to them, let alone to us*". Thus, the classification of marine animals mentioned in the classical texts is still far from agreed.

In western society the main marine invertebrates consumed are those groups conventionally termed "shellfish"; that is crustaceans (mainly lobsters, prawns, crabs) and bivalves, and to a lesser extent gastropod molluscs. That is why bivalves have attracted considerable scientific attention concerning their stock availability and genetics (Thorpe *et al.*, 2000 and references therein).

According to the aforementioned, the main goal of this paper was to survey the early history of bivalve mollusc exploitation and consumption in the Mediterranean coastal areas, through a comprehensive investigation of their use in diet and medicine, as recorded in the classical texts of Greek antiquity. Emphasis was given on the identification of the bivalve species on the basis of modern taxonomy, while their present commercial interest and population status in the Greek Seas has been considered. This study is part of a broader research on the use of marine invertebrates by humans in Greek antiquity.

MATERIALS AND METHODS

An investigation of the records concerning bivalve molluscs in all written documents of Greek antiquity was first conducted. This search was initially based on the bivalve names recorded in the zoological works of Aristotle (*History of animals*, *Generation of animals*, *Parts of animals*, *Progression of animals*, *Movements of animals*), as these have been identified by Voultsiadou & Vafidis (2007) and gradually comprised all terms found in the works of Greek literature. This was achieved using the search engine of the Thesaurus Linguae Graecae digital library (TLG, Edition 2007), in which the University of California offers a comprehensive library of the Greek literature.

Of the records found, those referring to the use of bivalves in human diet were selected and studied in detail. In addition to the information given by Aristotle, evidence on marine bivalve consumption in antiquity was found in: i) several of the works by Hippocrates, who is considered the father of medicine (*On the diseases of women, Regimen I-III, Regimen in acute diseases, On the sight, On the nature of the woman, On unfruitful women, On superfoetation, On the excision of the foetus, Of ulcers, Of haemorrhoids and fistulas, Diseases I-III, Epidemics I-VI, Internal affections*; ii) the work *On food derived from aquatic animals* by Xenocrates, a physician who lived in the 1st c. BC in Aphodisiada of Asia Minor; iii) several works by the great physician Galen (*De alimentorum facultatibus, De victu attenuante, De compositione medicamentorum per genera, De purgantium medicamentorum facultate*); iv) the *Materia medica* by Dioscorides a survey on the pharmaceutical use of plants and animals in antiquity, and v) the well known *Deipnosophistes* by Athenaeus, focusing on the 3rd book concerning mainly seafood.

The collected bivalve names were critically examined and each of them was finally assigned to a modern species of the class Bivalvia (phylum Mollusca). This was accomplished by consulting various monographs and articles on molluscs and edible European and Mediterranean bivalves (e.g. D' Angelo & Gargiullo, 1978; Poutiers, 1987; Zenetos, 1996; Poppe & Goto, 2000; Delamotte & Vardala-Theodorou, 2001; Davidson, 2002; Doneddu & Trainito, 2005). Comments on the collection, cooking and population status of the studied species in modern times were also included. If not otherwise indicated, population status information was extracted from Koutsoubas *et al.* (2007) and Katsanevakis *et al.* (2009).

For each species presented, the classical name (Greek and Latinized) is followed by the common English and Greek names, as well as by the valid Latin scientific name as this was identified in the present study. In certain cases two or more scientific names of very closely related species are proposed. This is either because it is difficult to recognize the exact species among them on the basis of the existing information, or because we claimed that classical names cor-

responded to more than one species in antiquity; the latter is also true for modern common names.

RESULTS AND DISCUSSION

Bivalve molluscs in classical zoology

The animals called molluscs and classified by modern taxonomists in the phylum Mollusca have been paid special attention by Aristotle (Koutsoubas, 1992; Voultsiadou & Vafidis, 2007). He classified them into *anhaima* meaning bloodless animals. Bloodless animals are called invertebrates today. Aristotle distinguished the cephalopods, calling them *malakia*, from *ostracoderma* in which he classified recent gastropods (which he called *stromvode*) and bivalves (*dithyra*). The name *dithyra* (meaning to have two valves) was given by him for the first time and is still used by modern zoologists for these animals.

The prominent position of molluscs in the biological knowledge of Aristotle's time is obvious due to their large number of species (totally 85 according to Voultsiadou & Vafidis, 2007) and to their high frequency of appearance in Aristotle's works, in comparison to other invertebrate groups (Voultsiadou & Vafidis, 2007). According to these authors, more than 40% of the invertebrate species recorded by Aristotle were identified as modern molluscs, and more than 60% of the total invertebrate records found were assigned to molluscs. Among Aristotle's molluscs, bivalves are the dominant group with 42%, followed by gastropods with 33% and cephalopods with 25%.

Exploited bivalves in antiquity

Out of the 35 exploited marine invertebrates reported in the studied texts, 20 are molluscs. They make up 58% of the total exploited invertebrates, followed by crustaceans, sponges, sea squirts, sea anemones, and sea urchins. Among the 20 mollusc species, 11 edible bivalves are included, the remaining being mainly cephalopods (like squids, octopuses and sepias) and only a few gastropods (like the purple dye gastropods).

An annotated presentation of the bivalve species identified (Fig. 1) is given below. It should be mentioned that the frequently reported names κόγχη (*conche*) and κογχύλιον (*conchylion*) were not identified as certain bivalve species, since they most probably refer to the bivalve shell in contradiction to the animal inside (Thompson, 1947), or, according to Hippocrates, generally to the different bivalve species.

Ὄστρεον or **Λιμνόστρεον** (*Ostreon* or *Limnostreon*)

European flat oyster / Stridi

Ostrea edulis (Linnaeus, 1758)

Oyster is the most frequently appearing bivalve in the classical texts. Aristotle calls it "*limnostreon*" (limne = lake), suggesting by this name that it was also found in brackish and fresh waters as it is proved by its recent distribution in European Transitional Waters (Guelorget & Perthuisot, 1992). It was so common, that Aristotle called "*ostracoderma*" or "*ostrea*" all marine animals bearing a hard shell around their body. Besides Aristotle, Xenocrates also supported that they thrived in areas where fresh water mixed with sea water. This was the reason why the best of them were growing in the estuaries of the rivers Nile (Egypt) and Kaistros (Asia Minor). In such places, oysters became sweet, juicy and fleshy, and they were kept in rearing sites in order to grow like seeds. This is a clear reference to the oyster culture of that age.

In modern time the species *O. edulis* (Fig. 1E) has been the basis for oyster production in many European countries in the northeast Atlantic and the Mediterranean (Poutiers, 1987). However, since the early 1970s, many flat oyster populations in these areas suffered massive mortalities due to infection by pathogenic protozoan parasites (Koutsoubas *et al.*, 2007), even if oyster beds overfishing has been considered the major reason for the collapse of the natural populations in certain areas (e.g. Thermaikos Gulf, see Galinou-Mitsoudi & Sinis, 2000).

According to Galen, oysters were in great demand due to their very soft flesh, being the softest among bivalves. Thus, they could be eaten fresh, although some people preferred to eat them fried. However, he advised people who wanted to lose weight to avoid eating oysters. Hippocrates says that fresh oysters were laxative, while cooked they lost their juice and caused constipation and intestinal gas production. Nowadays, in certain areas, especially in small fishery villages in the coasts of the north Aegean (e.g. Kavala coasts and Lesvos island), the species constitutes a delicious plate and is consumed either fresh with lemon juice or even grilled.

Hippocrates mentions that the ashes of burned and pulverized oyster shell, mixed with honey, were used as a medicine for wound and sore healing. Their ashes were also recommended for cleaning and polishing the teeth as well as for firm and healthy gums. Furthermore, oyster soup was used as an antidote for the poisonous secretion of a plant named "*doryknion*".

Κτείς (*Kteis*)

Scallop / Chteni

Chlamys glabra (Linnaeus, 1758) – Smooth scallop

Pecten jacobaeus (Müller, 1776) – Jacob scallop

The scallop is the second most frequently reported bivalve in the studied texts. It was a prized delicacy at that time.

Most authors report the high quality of the scallops coming from Lesvos island, which were distinguished for their large size and their tasty flesh and soup. Aristotle comments twice on their fishing. In one case he mentions that scallops vanished from Kaloni Bay due to the fishing method, since fishermen used an instrument which scratched the bottom of the sea. In another case he says that scallops move very rapidly, sometimes jumping out of the gear used for their collection. Xenocrates mentions that they were abundant in the Ionian Sea, Chios and other islands, and in Egypt, while in the Black Sea they were small and difficult to grow.

Athenaeus considered white scallops more delicate, while among black and reddish ones, the bigger in size were of better quality and taste. They were a mild food, very easy to digest, eaten with pepper and cumin.

According to Xenocrates scallops were more elegant and easy to digest than oysters. They became tastier when cooked with unwatered wine. They had a laxative effect cooked with vinegar and "*Kyrenaikos opos*" (a food dressing made of fruit juice) rather than grilled. Grilled inside their own shell they became more nutritious and digestible. The white scallops were diuretic. They were preserved in salt keeping in this way their natural taste. Scallop consumption was considered helpful in healing sore bladder.

The classical name "*kteis*" corresponds to the genera *Chlamys* and *Pecten*, most possibly *C. glabra* and *P. jacobaeus*. *Chlamys glabra* (Fig. 1B) is a Mediterranean species, living in sand and biogenic sediments down to 40 m of depth. In the Greek Seas it is mainly collected nowadays on the continental shelf of the north Aegean, i.e. Thermaikos Gulf and Lesvos island. In Lesvos it has been a major fisheries target for the local fishermen (in particular the Gulf of Kalloni) through centuries (mean annual production over 50 tns up to the 2nd World War, 20 tns between the mid 1970s and late 1980s) being, along with sardines, the most popular biological resource of this area (Koutsoubas *et al*., 2007). It is worth mentioning that the major fishing tool for its collection has been for centuries the traditional dredge gear "argalios" or "lagamna" (Fig. 2A), an instrument scratching the bottom of the sea as Aristotle mentioned, followed more recently by Scuba diving. Unfortunately, similarly to what Aristotle had reported for his age, smooth scallop stocks in the Gulf of Kalloni have recently collapsed (production is negligible from 2003 onwards), due to intensive harvesting and lack of any rational management. Over the last years most of the production of this bivalve (less than 10 tns yr^{-1}) is mainly derived from the populations thriving in Thermaikos Gulf. *Pecten jacobaeus* (Fig. 1C) is widespread in the Greek Seas (Zenetos, 1996), but its density is generally too low to support a cost-effective fishery. It is usually caught as a by catch by fishing trawls and dredges or collected by divers (Koutsoubas *et al*., 2007).

Scallops constitute an important component of the cuisine offered in certain areas of Greece (e.g. Thessaloniki, Kavala, Volos, Evvoia and Lesvos islands) and are consumed in many ways: fresh with lemon juice, with olive oil poured over and cooked in the oven, cooked in a casserole sauté with onions, parsley and white wine to form a sauce for spaghetti.

Μῦς or **Μύαξ** (*Mys* or *Myax*)

Mediterranean mussel / Mydi

Mytilus galloprovincialis (Linnaeus, 1758)

According to Athenaeus, they were served with other shellfish, they were a pleasant food, but the sharp edge of their shell might hurt.

Xenocrates says that they were salty and had a bad smell, which could be improved by the addition of "*Kyrenaikos opos*" and vinegar. He further suggested that they should be cooked with strong spices like mustard, rocket and cress. He says that they were hard to digest, especially when grilled and they caused thirst.

Dioscorides and Galen described the use of mussels in the treatment of various diseases. They say that the ashes of burned mussel shells could cure dental problems in children. Their cleaned flesh was used with honey in the preparation of compresses to heal eye problems or dog bite injuries.

The empty shells of mussels, together with those of sea urchins, were used as recipients for medicines or to carry small quantities of liquids from one jar to another.

Mytilus galloprovincialis (Fig. 1I) is distributed from the intertidal zone down to 40 m of depth on all European coasts. It lives (in densities up to 24000 mus-

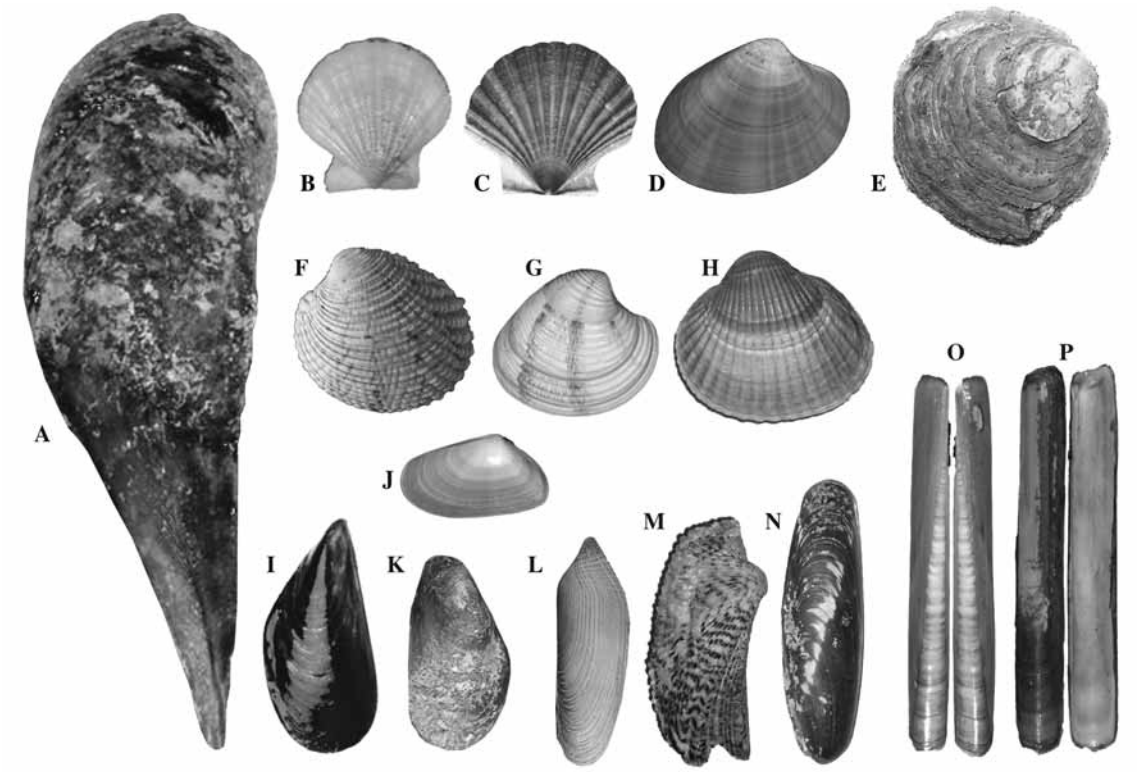

FIG. 1. Bivalve species exploited in early marine coastal areas according to the evidence given in the classical texts: A. *Pinna nobilis*. B. *Chlamys glabra*. C. *Pecten jacobaeus*. D. *Callista chione*. E. *Ostrea edulis*. F. *Venus verrucosa*. G. *Chamelea gallina*. H. *Cerastoderma glaucum*. I. *Mytilus galloprovincialis*. K. *Modiolus barbatus*. L. *Pholas dactylus*. M. *Arca noae*. N. *Lithophaga lithophaga*. O. *Ensis minor*. P. *Solen marginatus*.

sels m^{-2}, see FAO, 2007) attached by byssus threads to hard substrates such as rocks, piers and ropes within sheltered bays, harbors, estuaries, open rocky shores, and even directly on sandy-muddy bottoms in favorable sites. Apart from natural populations, the species is also intensively cultured, mainly in coastal waters from the northeast Atlantic (northwest Spain) to the northern shores of the Mediterranean Sea (FAO, 2007). More than 550 farms are distributed in the Greek Seas, with the majority deployed in gulfs and bays of the north Aegean (almost 90% of the farms are installed in Thermaikos Gulf). Mussel production has increased by 50% over the period 1995-2004 and exceeded 30000 tns yr^{-1}. However, since 2001 harmful algal blooms and biotoxins have occurred in Thermaikos Gulf (Nikolaidis *et al.*, 2005), which have been reported to affect the mussel farms, while the produced mussels are often of a poor quality, with a tendency towards deterioration (Koutsoubas *et al*., 2007). Due to their high production in the north Aegean continental coasts, mussels constitute a common plate offered in almost all types and categories of restaurants and taverns in this part of Greece. They are consumed in various ways (more than 15 recipes have been recorded from that area) the most common of which are the so called "saganaki" (sauté with peppers, cheese, tomato and mustard), fried, steamed with lemon juice and garlic and finally cooked with rice (Galinou-Mitsoudi *et al.*, 2007).

Μυΐσκη (*Myiske*)

Bearded horse mussel / Chavaro

Modiolus barbatus (Linnaeus, 1758)

Xenocrates and Athenaeus knew that *M. barbatus* was distinguished from the common mussel since its shell is hairy and more rounded. Although it had a smaller quantity of flesh inside, due to its smaller size and its different nature, its flesh was sweet and its soup tasty. In case of overconsumption they irritated the mouth cavity and throat, made the voice harsh or caused voice disorders, cough and hoarseness.

In recent times *M. barbatus* (Fig. 1K) is a commercially important mussel in many parts of the

northeast Atlantic and the Mediterranean. The species derives its common name (i.e. "bearded horse mussel") from the long, flat bristles it bears on its periostracum over the posterior half of its shell, as described by the classical writers. In the Greek Seas it is a major target for the local fishermen in the island of Lesvos (and in particular the Gulf of Kalloni), where it is collected by divers (mean annual production over 200 tns for the fishing periods from 2000 onwards). All the production is exported for consumption (most recipes are similar to that of the common Mediterranean mussel *M. galloprovincialis*) either to the northern parts of Greece (mainly the markets of Thessaloniki and Kavala) or abroad (Italy). The species is also heavily exploited (mean annual production > 200 tns) in the north Aegean (mainly Thermaikos Gulf). However, since 2002 *M. barbatus* fishing has been forbidden in the Gulf of Thessaloniki due to excess of permitted quantities of heavy metals (Cd) detected in its edible part (Koutsoubas *et al*., 2007).

Πίννα (*Pinna*)

Fan mussel / Pinna

Pinna nobilis (Linnaeus, 1758)

Aristotle informs us that the largest Mediterranean bivalve lived attached by threads of its byssus in sandy and silty bottoms. Indeed this endemic Mediterranean species occurs in depths between 0.5 and 60 m, mostly in *Posidonia oceanica* meadows, but also in bare sandy bottoms consisting of biogenic detritus in their greatest part (Katsanevakis, 2006). It is not only the largest Mediterranean bivalve but one of the largest worldwide, attaining lengths up to 120 cm and it may exceed 20 years of life (Galinou-Mitsoudi *et al*., 2006).

Xenocrates considered as more delicate the fan mussels collected in shallow marine areas, protected from the wind action, and receiving fresh water. Small and medium sized fan mussels had a whiter, softer and tastier flesh than the large ones. Their adductor muscle (the main edible part) was very tough, hard to separate from the shell and difficult to digest. Grilled they were even harder than stewed. They were cooked in oil, honey and wine, and as with other bivalves their soup was laxative.

The Mediterranean population of *P. nobilis* (Fig. 1A) has been greatly reduced during the past few decades as a result of recreational and commercial fishing for food (fried or grilled), use of its shell for decorative purposes, and incidental killing by trawls, bottom nets, or anchoring. Until early in the 20th century, *P. nobilis* was also exploited for its byssus, from

FIG. 2. Traditional dredges for bivalve fishing: A. "argalios" or "lagamna" used for the collection of scallops in the Gulf of Kalloni, island of Lesvos, North Aegean. B. "pinologio" used for the collection of fan mussels in the Greek Seas. Photos were taken at the Museum of Traditional Fisheries and Shells in Moudania (Chalkidiki, Greece) by D. Koutsoubas.

which an extremely fine and valuable fabric was produced, called "sea silk". The traditional fishing gear in the Greek Seas used for the collection of fan mussels from a fishing boat – called "pinologio" (Fig. 2B) – is an iron made apparatus capable to fit on the wide part of the shell and pull out the whole shell from the soft bottom. Although *P. nobilis* has become rare in many parts of the Mediterranean, important local populations still exist in the Greek Seas especially in Korinthiakos, north Evvoikos, and Thermaikos Gulfs, the islands of Chios and Lesvos (north Aegean), as well as the Ionian Sea (Katsanevakis *et al.,* 2008 and references therein). Nowadays it has been declared an endangered species under protection (92/43/EC Directive – Annex IV, Protocol of the Barcelona Convention – Annex II, Hellenic Presidential Decree 67/1981) and its exploitation has been banned.

Σωλήν or **Αὐλός** or **Δόναξ** (*Solen* or *Aulos* or *Donax*)

Razor shell / Solinas

Solen marginatus (Linnaeus, 1758) – European razor clam

Ensis minor (Chenu, 1843) – Giant razor clam

Xenocrates claimed that there was an apparent difference between male and female razor shells. The males bore multicolored strips and were diuretic. They were safely consumed with salt and vinegar, but they might cause vomiting with salt and oil. Females were monochromatic and tastier than males. The longest among them were tastier when grilled. The preserved razor shells, though, had an unpleasant taste.

Athenaeus and other authors were making a joke saying that razor shells were a great delicacy for widows, apparently due to their elongate shape.

Both species (Fig. 1O, P) have a wide distribution in the northeast Atlantic from Mauritania to the North Sea and in the Mediterranean. The species are also common in particular areas of the Greek Seas (e.g. Peloponnese, Amvrakikos, Saronikos, Pagasitikos and Thermaikos Gulfs, northeast Aegean islands). They are exploited locally, their fishing being regulated by the Hellenic Presidential Decree 109/2002 (Katsanevakis *et al.*, 2008), both for human consumption (often served grilled, but also offered in a soup along with olive oil, garlic and herbs) and as fishing bait.

The evidence given in the studied classical texts on the next 6 shellfish is not adequate in order to safely identify the modern bivalve species. However, we took the risk to suggest the most probable bivalve names, based also on their exploitation in the Mediterranean, and more specifically in the Greek Seas, in recent times.

Χήμη τραχεῖα or **Γλυκυμαρίς**
(*Cheme tracheia* or *Glycymaris*)

Venus clam / Kydoni

Venus verrucosa (Linnaeus, 1758) – Warty venus

Chamelea gallina (Linnaeus, 1758) – Stripped venus

Xenocrates characterized these bivalves using the adjective "*tracheia*" (meaning coarse) presumably due to the coarse surface of their shell. He claims that they became very tasty when cooked with spices. Both their flesh and soup were very good for the stomach, they were laxative and diuretic. Their flesh hardened when grilled. Those having a sea smell, implying they were fresh, were suitable for patients with various diseases, while those growing in the port of Alexandria (Egypt) were sweet, producing a tasty soup.

Venus verrucosa (Fig. 1F) is found from Norway to South Africa and is common in the Mediterranean on biogenic sandy bottoms, gravel substrates, as well as in *Posidonia oceanica* meadows, usually down to a depth of about 30 m. It is fished intensively off the coasts of Normandy and Brittany and sustains commercial fisheries in certain Mediterranean areas (Koutsoubas *et al*., 2007). In the Greek Seas it constitutes a major target species (mean annual yield over 4000 tns at the beginning of the 1990s) and it is mainly collected by professional divers in Evvoikos Gulf, the northeast Aegean islands, and the continental shelf of Greek mainland. However, intensive harvest and lack of any rational management have led to dramatic reduction of natural populations in many parts of Greece (e.g. yield from Thermaikos Gulf has been reduced to 250 tns yr^{-1} over the last decade versus more than 2000 tns yr^{-1} before the 1980s). It constitutes a delicious – though expensive due to reduction of yield – plate and is mostly consumed fresh or slightly steamed with olive oil and lemon juice.

Chamelea gallina (Fig. 1G) is widespread in the Greek Seas (Zenetos, 1996), but its density is generally too low to support a cost-effective fishery (it is rather sporadically met in the fish market of the continental coasts of the north Aegean). However, the species, which is collected mostly by dredges, is among those legally exploited (fisheries regulated by the Hellenic Presidential Decree 86/98 and EU Regulation 1967/2006, see Koutsoubas *et al*., 2007). It is consumed

fresh, slightly steamed with olive oil and lemon juice or cooked in a casserole sauté with onions, parsley and white wine to form a sauce for spaghetti.

Χήμη λεία (*Cheme leia*)

Smooth callista / Gialisteri

Callista chione (Linnaeus, 1758)

Some information is given about this species by Xenocrates, who says that it was much different than the coarse cheme mentioned above. It was tasty, nutritious and easy to digest. It was eaten with "*Kyrenaikos opos*", mustard, fresh or grilled and its soup was good for the stomach.

Callista chione (Fig. 1D) is among the most abundant bivalve species inhabiting shallow soft-bottomed Mediterranean shores (Zenetos, 1996) and is economically important in several countries (e.g. Spain, Italy, Croatia, Greece). The extensive clam fishery is carried out by the artisanal fleet and in the western Mediterranean the most commonly used fishing method is dredging, while in the eastern part of this Sea it is mostly collected by divers (Metaxatos, 2004). Populations in the Greek Seas are mostly found in the Evvoikos, Saronikos and Thermaikos Gulfs as well as the Cretan Sea (Delamotte & Vardala-Theodorou, 2001) and in the Gulf of Patras (Ionian Sea, see Zenetos, 1996). Despite the decline in the landings over the last decade, the species still retains a considerable production (over 10 tns yr^{-1}) in Greek Seas (Koutsoubas *et al*., 2007). It is mostly consumed fresh with lemon juice or grilled with olive oil, lemon juice and herbs.

Πελωρίς (*Peloris*)

Lagoon cockle / Pourlida, Katourlithra

Cerastoderma glaucum (Poiret, 1879)

According to Xenocrates, the best among them were growing in calm waters and shallow, muddy bottoms, especially in places where fresh water mixed with sea water, just like the oysters. They seldom grew in deep waters and when they did they had a bad taste. Their soup was very laxative, while their flesh was not very easy to digest.

Nowadays, thriving populations (>368 cockles m^{-2}) of *C. glaucum* (Fig. 1H) inhabit the sandy and muddy bottoms of the upper sublittoral zone in coastal areas and particularly various types of Transitional Water Ecosystems such as estuaries, lagoons, saltmarshes, saltworks distributed in the Mediterranean Sea and the eastern Atlantic (D'Angelo & Gargiullo, 1978). In the Greek Seas it is a common species in similar type ecosystems (e.g. Amvrakikos Gulf, Gialova, Mesolonghi, Nestos and Vistonis lagoons as well as Evros Delta, see Leontarakis *et al*., 2007). It is collected by local fishermen in certain areas (e.g. Nestos and Vistonis lagoons – approximate production of 5 tns) over a limited period of the year (before Easter) for human consumption. The usual recipes are steamed with lemon juice, or as a soup with olive oil, lemon juice and herbs.

Βάλανος (*Valanos*)

Date mussel, Piddock, Noah's arc

Lithophaga lithophaga (Linnaeus, 1758) –
European date mussel / Petrosolinas

Pholas dactylus (Linnaeus, 1758) –
Common piddock / Daktilo, Folada

Arca noae (Linnaeus, 1758) –
Noah's arc / Kalognomi

Under the name *valanos*, more than one bivalve species were probably known: the European date mussel, the common Piddock, and the Noah's arc.

According to Xenocrates, those collected during summer were the best and the more suitable to eat. Nutritious and sweet were the ones growing inside rocks. They were generally tasty and easy to digest, they produced a thick soup and they were very diuretic.

Arca noae (Fig. 1M) is an epifaunal bivalve of hard substratum. Its distribution covers the Atlantic Ocean, the Mediterranean and Black Seas. It lives on rocks and shells, either solitary or in clumps at depths ranging from approximately the low tide level to over 100 m (Poppe & Goto, 2000). In some localities it is commercially important as seafood resource and natural populations are harvested by local fishermen and divers. In the Greek Seas (mean annual production over the last decade > 10 tns) it is mainly collected in the Evvoikos Gulf, the islands of the northeast Aegean, the continental shelf of the north Aegean (mainly Thermaikos, Ierissos, Strymonikos and Kavala Gulfs) and the Ionian Sea. It is consumed usually after boiling for few minutes with lemon juice.

The European date mussel *L. lithophaga* (Fig. 1N) is endemic to the Mediterranean Sea and it lives on hard substrates of the midlittoral and upper sublittoral zones (D'Angelo & Gargiullo, 1978). It is distributed in many localities of the Greek Seas even if thriving populations are mostly located in north Evvoikos Gulf (Galinou-Mitsoudi & Sinis, 1994, 1995).

It is worth mentioning that while in various Greek localities the species is known under the name "*petrosolinas*" (due to its capability to penetrate the hard substrate), in the island of Lesvos it is called "*valani*", as it is recorded in the classical texts. In the past, *L. lithophaga* was extensively exploited in the Greek Seas and it was found in seafood markets and fish restaurants in many localities. The over-exploitation of the species resulted in the dramatic reduction of its populations and nowadays it is under strict protection according to the 92/43/EC Directive (Annex IV), the Bern Convention (Annex II), and the Protocol of the Barcelona Convention (Annex II). It is a delicious food resource, eaten usually grilled or cooked as a soup with garlic, olive oil, lemon juice and herbs, especially in Evvoia and Lesvos islands.

Pholas dactylus (Fig. 1L) lives in midlittoral and shallow sublittoral areas boring into soft rocks such as, shale, peat, chalk, sandstone, stiff clay, or wood. It creates a conical burrow, which has a narrow entrance and a larger rounded chamber. The species has a wide distribution (east Atlantic, Mediterranean and Black Seas, Red Sea) and has been reported from many areas of the Greek Seas (e.g. Thermaikos, Maliakos, Evvoikos, Saronikos, Amvrakikos and Argolikos Gulfs, Ionian coasts, northeast Aegean islands) (Katsanevakis *et al*., 2008). *Pholas dactylus* was once prevalent across the entire Mediterranean and on the Atlantic coast of Europe, but it has disappeared from most sites due to human collection for food and bait and/or as a result of marine pollution. Nowadays the species is under strict protection according to the Bern Convention (Annex II), and the Protocol of the Barcelona Convention (Annex II).

Τελλίνη ή ξιφύδριον (*Telline* or *Xiphidrion*)

Truncate Donax / Tellina, Fasolaki

Donax trunculus (Linnaeus, 1758)

Xenocrates says that they grew in sandy bottoms at coastal areas exposed to the wind action. Their flesh became sweeter when cooked and their soup was laxative. They were eaten with oil and lemon juice, spearmint and rue (*Ruta*). They were flourishing and best to consume in spring.

Donax trunculus (Fig. 1J) is a common inhabitant of the sandy bottoms of the upper sublittoral zone in the European Seas (eastern Atlantic and the Mediterranean, see D'Angelo & Gargiullo, 1978). In the Greek Seas it is included in the bivalve species list with major commercial value (Hellenic Presidential Decree 223/03), even though it is sporadically met, mostly in the coasts of Thracean Sea where it is harvested by dredges (Koutsoubas *et al.*, 2007). Unlike the ancient Greeks, modern Greeks do not appreciate this species as a food resource, with the exception of small fishermen villages in the aforementioned area, and the whole production is exported to Italy. It is consumed either raw or cooked in a pan with olive oil, garlic, tomatoes, parsley, black pepper to make a delicious soup ("Zuppa di Telline", see Davidson, 2002).

Past and present of bivalve exploitation in the Eastern Mediterranean

Summarizing, we can say that the diet of ancient Greeks included the same main bivalve species consumed nowadays in the Mediterranean coastal areas. The identification of the bivalve species was mainly based on information regarding their morphology and various aspects of their biology given mostly by Aristotle in his zoological works (Voultsiadou & Vafidis, 2007) and secondarily in Xenocrates' *On food derived from aquatic animals*.

All bivalves identified in the classical texts are still collected and consumed today along the coastal areas of Greece and more generally the Mediterranean Sea. Ten of the bivalves mentioned in the classical texts (*Arca noae*, *Callista chione*, *Cerastoderma glaucum*, *Chlamys glabra*, *Donax trunculus*, *Modiolus barbatus*, *Mytilus galloprovincialis*, *Ostrea edulis*, *Pecten jacobaeus*, *Venus verrucosa*) are today of major commercial interest, making up 90% of the total shellfish production in the Aegean and Ionian Seas (Koutsoubas *et al.*, 2007). Almost the same species of commercial bivalves are exploited along the coasts of Asia Minor (Dogan *et al.*, 2008) and Egypt (Farag *et al.*, 1999), and generally all over the Mediterranean (Poutiers, 1987). Four of the species consumed by ancient Greeks (*Lithophaga lithophaga*, *Pholas dactylus*, *Pinna nobilis*, *Solen marginatus*) are today of minor commercial interest but well known as delicious food resources (Katsanevakis *et al.*, 2008).

Important information on the use of molluscs in earlier eras has been brought to light by archaeologists through the study of shell assemblages from different localities of the Paleolithic, Neolithic and Bronze Age Aegean (see Veropoulidou, in press). Moreover, archaeological remains of the geometric and archaic periods suggest that bivalves were used as food, decorative material, recipients-tools, and ornaments, while some of them were found in funerary and ritu-

al contexts (Theodoropoulou, 2007b and references therein). Interestingly, the use by ancient Greeks of almost all bivalve species found in the classical texts by the present study has been illustrated in the archaeological record of the Bronze Age, the geometric and archaic periods, according to the above authors: they were primarily consumed by humans, as a secondary source of food, or simply a "spicing" of their everyday diet; the shells of some species, such as *A. noae*, *C. glaucum*, *O. edulis* and *P. nobilis*, were used as recipients or tools, e.g. spoons or pestles, while some shells (e.g. *P. jacobaeus*) were collected as items of aesthetic value. In addition, the bivalve *Spondylus gaederopus* (Linnaeus, 1758), which was not recognized in the classical texts, seems to have been of great interest for early human societies as was testified by the huge amounts of its shells found in northern and central Greece suggesting that *Spondylus* ornaments were exported to early communities of the Balkans and central Europe (see Papa & Veropoulidou, in press; Veropoulidou in press). It is remarkable, however, that the important information given by molluscs and other archaeological remains has begun to interest Greek archaeologists only during the last decades, since most excavations have focused on other important features such as architecture or ceramics (Theodoropoulou, 2007b).

Xenocrates and Athenaeus presented a variety of instructions and recipes on how bivalves were cooked and served, while Hippocrates and Galen gave detailed information on the dietary value of bivalve molluscs, their consumption for treatment or prevention of certain diseases, and their use for the production of drugs from their shell or flesh. Atheanaeus, speaking about the role of bivalves in the meals of ancient Greeks, considered them as a good starter: "*before one started drinking, he should eat the proper food, such as oysters, razor shells, mussels, cockles and scallops; eating them from time to time during the meal, they help cleaning the stomach of the wine residues that might cause pains*". Nowadays bivalves are a highly appreciated food and most are served in Greek restaurants fresh, steamed, or in paella, while more than 15 recipes have been recorded from the Aegean Sea only for mussels (Galinou-Mitsoudi *et al.*, 2007).

The habitats of the exploited bivalve species and consequently their fishing areas were well known and recorded in the classical texts. The areas with the largest and better stocks of certain species were recognized, for instance Lesvos island was famous for scallops and the River Nile for oysters. In the Aegean Sea, there are nowadays areas of high, medium and low shellfish production; bivalve fishery is regulated by law and for most species there are national and European regulations concerning minimum size and the closed fishery period (Koutsoubas *et al.*, 2007). However, despite the existing regulations, a sharp decreasing trend in bivalve production appeared from 1997 onwards, due both to overfishing and in some cases to mass mortalities of bivalve populations (Koutsoubas *et al.*, 2007). The over-exploitation of some species, such as the date mussel (*Lithophaga lithophaga*), the piddock (*Pholas dactylus*) and the fan mussel (*Pinna nobilis*) resulted in the dramatic reduction of their populations and they are under strict protection according to the Conventions of Bern and Barcelona.

The north Aegean constitutes today one of the most significant areas in the Eastern Mediterranean for bivalve production, concerning both fishery and aquaculture, yielding more than 80% of the total shellfish production (Koutsoubas *et al.*, 2007); among the high production areas the Bay of Kaloni in Lesvos island is included, as Aristotle reported 2300 years ago.

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