INTRODUCTION

The Thermaikos Gulf (NW Aegean Sea) comprises one of the most complicated and multi-used ecosystems of the Eastern Mediterranean Sea. For such an ecosystem, although there are numerous environmental investigations, only a few are referred exclusively to its fauna and even to its bivalve molluscs (e.g. Sakellariou, 1957; Zenetos, 1996; Zenetos et al., 2005; Manousis et al., 2010). As alien species are rapidly changing the marine ecosystems (Por, 1978, 1990; Galil & Zenetos, 2002; Zenetos et al., 2003; Pancucci-Papadopoulou et al., 2005; Streftaris et al., 2005; Streftaris & Zenetos, 2006; Zenetos et al., 2007) and as the Thermaikos Gulf has not been intensively searched, a more thorough investigation of its malaco fauna could lead to new findings. Apparently, Thermaikos Gulf is a marine basin on the navigation line to the second largest port of Greece with recorded traffic of more than 3000 ships per year; therefore, it is expected that alien species occur continuously. A dynamic evidence of this fact is the recent record of six alien bivalve species from the same area (Manousis et al., 2010). Thus, the main purpose of this study is: a) to further contribute to the knowledge of (mainly small in size) bivalve biodiversity of Thermaikos Gulf and re-describing and comparing its significant systematic characteristics, b) to compare the present biological diversity of the area with that recorded in publications of the past, and c) to improve the knowledge on the distribution and expansion of alien bivalve species.

MATERIALS AND METHODS

The sampling of specimens was conducted from October 2008 to June 2013 in E Thermaikos and Thessaloniki Gulfs (Fig. 1) by methods describe in Manousis et al. (2012) with the addition of a fourth sampling approach, i.e. the searching of only fresh trawled...
and discarded material from small scale fishing nets taken from the vessels. Wood-eaters were dissected out of submerged infested wood by means of fine scalpels and a pair of tweezers. After cleaning with fresh water, shells were treated with 25% glycerin in ethanol and examined under a stereoscope with a magnification of up to \( \times 80 \). For each species collected, the following data have been recorded: location, depth, type of habitat and size (length, unless otherwise stated). The species recognition was based on literature provided in Manousis et al. (2012). For the species nomenclature update (30 June 2013), the Marine Biodiversity and Ecosystem Functioning EU Network of Excellence – The European Register of Marine species (MarBEF – ERMS) (www.marbef.org) and the CLEMAM (www.somali.asso.fr) were used. The taxonomic order followed the guides provided in CLEMAM. In addition, the Ellenic Network on Aquatic Invasive Species (ELNAIS, https://services.ath.hcmr.gr/) was used for the alien species status in the Hellenic Seas.

The specimens are deposited in the premises of the Alexander Technological Educational Institute of Thessaloniki and those of Dr. T. Manousis. Scientists are welcome to have access to the biological material at will.

RESULTS

As a result of this investigation, approximately 700 specimens were collected and 46 species belonging to 23 families were identified. They are listed in phylogenetic order within families in Table 1, with their last recorded distribution and mode of life. Among the identified species, nine are new for the Eastern Mediterranean Sea, 15 are referred for the first time for the Hellenic fauna (Table 2), three of which are alien and 39 species are new for Thermaikos Gulf (five of which are alien). In the study area, three known alien species (Fulvia australis, Fulvia fragilis and Pinctada imbricata radiate) and six of West Mediterranean or Atlantic origin are recognized. Brief text with information and discussion for each species within families follows:

NUCULIDAE

*Nucula* sp. (Fig. 2A). One right valve (0.7 mm) and one left valve (1.0 mm) were found in discarded material brought to the surface from about 25 m depth at station 3. The almost ovate right valve has a prominent and flat umbo (as if cut), smooth margin, weak growth lines and microscopic radial striae. Internally it is glossy, with a trigonal chondrophore under the prodissoconch. The hinge of the right valve bears four large trapezoidal anterior teeth as well as one posterior, while that of the left valve four anterior and two posterior teeth. Externally, the valves resemble those of *Austronucula perminima* (Monterosato, 1875) in their overall shape, the flat prodissoconch and the axial striation but internally they lack the characteristic for *A. perminima* two types of hinge teeth (Gofas et al., 2011). Moreover, comparing the samples with same size juveniles of the sympatric species *N. nitidosa* Winckworth, 1930, *N. nucleus* (Linnaeus, 1758) and *N. sulcata* Bronn, 1831 it was found out that none of them shares the same type of prodissoconch and shell’s shape with our specimens.

*Ennucula aegeensis* (Forbes, 1844) (Fig. 2B). One left valve (1.2 mm) was found in rocky material trawled from silty bottom at a depth of 70 m of station 7 (central Thermaikos Gulf). The fragile, grey-white and transparent shell is equivalent, inequilateral and tumid with a trapezoidal oval outline. Its anterior dorsal margin is slightly rounded and slopes gently, while its posterior dorsal margin is slightly rounded and slopes steeply. The anterior margin is widely rounded, while the ventral margin is deeply rounded. The escutcheon is broad, raised, elliptical and long, and the lunule is elliptical, long and raised. The umbos are broad and prominent as they project above the dorsal margin. The outer surface is smooth with fine concen-
<table>
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<tr>
<th>Family</th>
<th>Species</th>
<th>Record type</th>
<th>Zone/Depth</th>
<th>Habitat</th>
<th>Mode of life</th>
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<td><strong>Habitat</strong></td>
<td><strong>Mode of life</strong></td>
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<td>+</td>
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<tr>
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<td>0.2 m</td>
<td>Zostera bed</td>
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tric growth lines. The prodissoconch is also smooth, prominent and well defined. The shell’s inner margin is smooth. The ligament is internal, opisthodetic and inserted in a deep and wide resilifer. The taxodont hinge is formed on a wide and continuous hinge plate bearing 3 anterior and 2 posterior short and blunt teeth. A deep water species recorded from all the Hel- lenic Seas and now from Thermaikos Gulf. The species is common in the Mediterranean Sea (Cachia et al., 2004; Repetto et al., 2005; Zenetos et al., 2005) and this is the first record from Thermaikos Gulf.

ARCIDAE

Asperarca secreta La Perna, 1998 (Fig. 2E). Two live specimens (2.4 mm and 2.9 mm) and a shell (2.3 mm) was collected from discarded material of a small scale fishing boat fishing at 15-20 m depth of mixed bottom at station 3. The shell is sub rectangular, equiva- lence and inequilateral. The umbos are situated at the ante- rior area of the shell. The light brown scaly periostra- num becomes more wide and extended at the posterior- ventral area. The hinge bears large teeth, 4 anterior and 6 posterior. The species is found for the first time in Greece and it is already known from the Central Mediterranean Sea (Cachia et al., 2004; Repetto et al., 2005; Cossignani & Ardovini, 2011).

Bathyarca pectunculoides (Scacchi, 1834) (Fig. 3A). One shell (2.0 mm) and several valves (2.0-3.0 mm) were found in rocky material trawled from 70 m at station 7. The species is common in the Mediterranean Sea (Cachia et al., 2004) and this is the first record from Thermaikos Gulf. The species has been re- ferred from all the Hellenic Seas by Tenekidis (1989), Zenetos (1996) and Zenetos et al. (2005) as B. gren- phia (Risso, 1826).

Bathyarca philippiana (Nyst, 1848) (Fig. 2E). One live individual (5.0 mm) and one left valve (4.5 mm) were found in two different instances in rocky mate- rial trawled from 70 m depth at station 7. The species has a similar outline with that of B. pectunculoides but is more oblique rectangular, the margin is finely crenulated and the sculpture is reticulated with fine radiating and concentric ribs that are slightly stronger in the posterior area. The taxodont hinge line is wide bearing 6 anterior strong teeth and 10 also strong po- sterior plus one vestigial tooth at the posterior end of the hinge. The species which is referred as rare (Dog- an et al., 2009) or rather uncommon (Repetto et al., 2005) is also known from the Aegean and Medi terranean Seas (Zenetos et al., 2005; Dogan et al., 2009; Cossignani & Ardovini, 2011).

MYTILIDAE

Crenella arenaria Monterosato, 1875 (Fig. 3B). Several live specimens, shells and valves (1.0-2.5 mm) were found in detritus material trapped in small scale fishing nets at 20 m depth from mixed bottom at station 3 and in trawled material from the muddy bottom of
FIG. 2. A. *Nucula* sp.; B. *Ennucula aegeensis*; C. *Nuculana cf. pella*; D. *Saccella commutata*; E. *Asperarca secreta*; F. *Bathyarca philippiana*.
FIG. 3. A. *Bathyarca pencunculoides*; B. *Crenella arenaria*; C. *Dacrydium hyalinum*; D. *Idas* sp.
station 7 at 70 m depth. The convex shells with smooth margins are oval, glossy, semi-transparent, white to cream in color and with fine growth lines. The hinge is finely crenulated. The species has been recorded from the S Aegean Sea (Zenetos et al., 2005) while it is also known from the Central and W Mediterranean Sea (Cachia et al., 2004; Repetto et al., 2005; Cossignani & Ardovini, 2011).

*Dacrydium hyalinum* (Monterosato, 1875) (Fig. 3C). One live specimen (1.7 mm) and several valves (1.8-2.5 mm) were found in trapped detritus material from 20 m depth in small scale fishing nets from mixed bottom at station 3 and also several valves of the same lengths in trawled material from muddy bottom and 70 m depth at station 7. The rather large umbos are situated almost at the middle area of the hinge. The external surface is smooth or with conspicuous growth lines. Hinge with a narrow ligament beneath the umbos. Small teeth are situated on both sides of the ligament followed after a toothless interval by a series of 12-13 larger teeth on the two thirds of the dorsal butiment followed after a toothless interval by a series of small teeth are situated on both sides of the ligament. A species is referred as

Internally, it is shiny and bears a septum across the umbonal cavity. The sculpture consists of many strong radial ribs, occasionally bifurcating and crossed by finer concentric lines showing a nodulous appearance. Hinge with 3 large teeth under the umbo and 8 large teeth behind the ligament. Inner margin crenulate. The light brown periostracum bears scattered simple long fine hairs. The species is known from S Greece since 2010 (ELNAIS, https://services.ath.hcmr.gr/; Zenetos et al., 2011) and this is the first record from the N Aegean Sea.

**PTERIIDAE**

*Pinctada imbricata radiata* (Leach, 1814) (Fig. 4B). Since the last recorded reference of the species in Thermaikos Gulf (Manousis et al., 2010), the species is now recorded further north in E Thessaloniki Gulf and its abundance seems to rise rapidly as 20 live specimens of different sizes (0.5-7 cm in length) were collected in December 2011. The majority (15 individuals) of small size shells (<3 cm) were attached to fished *Flexopecten glaber* shells and the rest five were bigger (3-7 cm). Dead animals of a length ranging from 2 to 5 cm were found in a long beach of E Thessaloniki Gulf after a medium storm in January 2012, some of which with remnants of the soft parts of their body.

**PROPEAMUSSIIDAE**

*Cyclopecten brandisii* Smriglio & Mariottini, 1990 (Fig. 4C). Three left valves (1.7-2.1 mm) were collected from trapped detritus material in small scale fishing nets at 25 m depth from mixed bottom of station 3. The external surface of the valves bear a number of 17 primary, secondary and tertiary radial ribs densely covered with convex scales. The bases of the scales extend on both sides in a form of down curved lirae, which in combination with the radial ribs give the shell’s surface an imbricate appearance. The large and almost equal ears bear ribs, with a similar sculpture as of the rest of the shell. The species is referred from the Gulf of Lion as well as from the Central Mediterranean Sea (Ligurian, N Adriatic Sea and Sicily) (Cachia et al., 2004; Repetto et al., 2005; Cossignani & Ardovini, 2011), while the current reference is the first from the E Mediterranean Sea.

*Cyclopecten hoskynsi* (Forbes, 1844) (Fig. 4D). One right valve (2.45 mm) was collected from trapped detritus material in small scale fishing nets at 25 m depth from mixed bottom of station 3. The sub circular valve is fragile and transparent. The valve in-between
FIG. 4. A. Septifer cumingii; B. Pinctada imbricata radiata; C. Cyclopecten brandisiensis; D. Cyclopecten hoskynsi; E. Spondylus cf. multisetosus; F. Monia squama.
the com-marginal granulated lines is decorated by very fine radial lines. The anterior ear is wider and longer than the posterior decorated with evenly spaced co-marginal lirae which turn into weak co-marginal ridges of a very fine granular aspect. The species has been referred from S and W Greece (Zenetos et al., 2005) as well as, as a rare species, from the Mediterranean Sea (Repetto et al., 2005; Gofas et al., 2011) while it is known from N Atlantic (Dijkstra et al., 2009), N and W Europe (MarBEF, www.marbef.org).

SPONDYLIDAE

*Spondylus cf. multisetosus* Reeve, 1856 (Fig. 4E). One live specimen (58.0 mm length, 88.0 mm height) was found on a rock at 5 m depth in the sublittoral zone of station 5. The specimen was cemented to the substrate by a small area of its right (lower) valve. The sculpture of the left (upper) valve consists of numerous dominant radial ribs with regularly spatulate dark orange upstanding spines that are hollow underneath. In between these ribs, there are finer ribs with smaller sharp spines. The external color of the shell is burgundy red and the internal is dull cream-yellow with vivid orange upstanding spines that are hollow underneath. The umbo of the right (lower) valve distances away from the umbo of the left one leaving behind a large, ivory white and triangular cardinal area. The current reference is the first from Greece. The species was referred from Israel and Turkey by Zenetos et al. (2003), Repetto et al. (2005) and Cossignani & Ardovini (2011), while its presence in the Mediterranean Sea is disputed as its shell’s characteristics are similar to those of *Spondylus spinosus* (Zenetos et al., 2003).

ANOMIIIDAE

*Monia squama* (Gmelin, 1791) (Fig. 4F). Two live specimens (14.0 mm and 7.0 mm) attached to bivalve shells were collected from 6 m depth at station 3. The main distinguishing characteristic among Anomiidae species is the position to each-other of the adductor muscle scars of their left (upper) valve (Poppe & Gotto, 2000). The two unequal adductor muscle scars of *M. squama* left (upper) valve are completely coalescent to form one large impression. The species is referred from the Central and the Western Mediterranean Sea (Repetto et al., 2005; Cossignani & Ardovini, 2011) and this is a confirmed reference from Greece.

LIMIDAE

*Limatula gwyni* (Sykes, 1903) (Fig. 5A). One right valve (2.2 mm) was found in trapped detritus material in small scale fishing nets at 20 m depth from mixed bottom of station 3. The valve bears 30 radial riblets the two central of which are thicker. The hinge plate on either side of the triangular wide resilifer is smooth with a narrow but distinct sinus behind the ears. The species is similar to *L. subovata* but the late has much more radial riblets (about 50) (Marine Bivalve Shells of the British Isles, www.naturalhistory.museumwales.ac.uk) in contrast to *L. gwyni* which has 30 (Gofas et al., 2011). *Limatula gwyni* is referred from all over the Mediterranean Sea (Repetto et al., 2005; Zenetos et al., 2005) and now, for the first time, from Thermaikos Gulf.

*Limatula subauriculata* (Montagu, 1808) (Fig. 5B). One right valve (2.9 mm) was found in trapped detritus material in small scale fishing nets at 20 m depth from mixed bottom of station 3. The valve is ovate, translucent, with one central thicker rib and 30 radial riblets. The hinge plate is smooth with a triangular less wide than *L. gwyni* resilifer on the cardinal area. The species is known from all over the Mediterranean Sea (Repetto et al., 2005; Zenetos et al., 2005) and now from Thermaikos Gulf.

*Limatula subovata* (Monterosato, 1875) (Fig. 5C). A right valve (2.0 mm) was found in rocky material trawled at 70 m from station 7. The valve bears 40 fine radial riblets and a thicker one at the center. Some of these riblets do not start from the umbones. The hinge plate is situated over an arc and bears a triangular smooth resilifer for the ligament on its cardinal area. The species is similar to *L. gwyni* but the late has 30 radial riblets (Gofas et al., 2011) and wider resilifer in contrast to *L. subovata* which has about 50 radial riblets (Marine Bivalve Shells of the British Isles, naturalhistory.museumwales.ac.uk) and smaller resilifer. The species is distributed all over the Mediterranean Sea (Repetto et al., 2005; Zenetos et al., 2005) while this is the first record from Thermaikos Gulf. Allen (2004) redescribing the species refers that the distribution depths of the species in the Mediterranean Sea is unknown.

*Notolimea crassa* (Forbes, 1844) (Fig. 5D). A live specimen (2.2 mm) and two valves, one right (2.0 mm) and one left (1.5 mm), were found in rocky material trawled at 70 m from station 7. The shell is tumid, ovate, with rather small ears. The ribs are thicker at the middle area and with laminate ridges. The hinge bears eight teeth on both sites of a triangular pit. The
FIG. 5. A. Limatula gwyni; B. Limatula subauriculata; C. Limatula subovata; D. Notolimea crassa; E. Crassostrea gigas; F. Thyasira alleni; G. Thyasira biplicata.
species is considered as common in Malta (Cachia et al., 2004) and rare in the Mediterranean Sea (Repetto et al., 2005), while it is also distributed in the Hellenic Seas (Zenetos et al., 2005).

OSTREIDAE

Crassostrea gigas (Thunberg, 1793) (Fig. 5E). A live specimen (39 mm) was collected from an anchor rope at station 1 at 2 m depth. According to Minchin & Gollasch (2008), this alien species has expanded in the S Aegean and the Ionian Sea. According to Zenetos et al. (2003) and ELNAIS database (https://services.ath.hcmr.gr), the species is established in the Ionian Sea and particularly in Patraikos and Korinthiakos Gulfs. This is the first documented record from the N Aegean Sea. There is unconfirmed information that the species was imported for aquaculture into Thermaikos Gulf in 2007 (Katsanevakis et al., 2008).

THYASIRIDAE

Thyasira alleni Carrozza, 1981 (Fig. 5F). One live specimen (1.2 mm) was collected at 5 m from mixed bottom of station 5. The shell outline is subequilateral-rhombooidal and weakly sinuate posteriorly. The external surface is rough with visible growth lines. The lunule is well demarcated, sung below the umbones and with two creases. The lanceolate escutcheon and the auricle are distinct with a shallow sub-marginal sulcus and a weak posterior sulcus. The ligament is sunken below the umbones. The anterior fold is prominent and the posterior sulcus well developed. The broad lunule is weakly excavated. The escutcheon is lanceolate and well marked. The hinge plate of the right valve bears a single cardinal tooth and a single thin lateral just over the ligament, while the left one bears two cardinals: the tuberculous anterior and the sphenoid posterior. The overall appearance of the hinge is very similar to that of Vasconiella jeffreysiana shown clearly by Coney (1990), but the right valve does not show the typical notch known for the species. Vasconiella jeffreysiana is a rare species known from the northern part of the Gibraltar straight (Coney, 1990; Repetto et al., 2005; Cossignani & Ardovini, 2011) and from the SW Mediterranean Sea according to Repetto et al. (2005).
the characteristic notch of the RV is not present in juveniles of *V. jeffreysiana*, the specimen presented here is the first collected *V. jeffreysiana* from the rest (Central and East) of the Mediterranean Sea.

**LEPTONIDAE**

*Litigiella glabra* (Fischer P in de Folin & Périer, 1873) (Fig. 6C). Three live specimens (1.0-6.8 mm) and several individual valves (0.9-5 mm) were collected at stations 5 and 6 from 0.2 m and 8.0 m depth, respectively. The species is common in the Mediterranean Sea and these must be the first records from the Aegean as Zenetos *et al.* (2005) only refer the species in detail from the Ionian and S Aegean Seas.

**LASAEIDAE**

*Lepton squamosum* (Montagu, 1803) (Fig. 7A). One right valve (1.2 mm) was collected from material trapped in nets at approximately 35 m and brought to the surface from the mixed bottom of station 4 and one left valve (4.5 mm) was trawled from 70 m at station 7. The right valve is white, transparent, thin and fragile, sub equilateral and with the beak just in front of the midline. It is compressed, rhomboidal in its outline, with its dorsal and ventral margins parallel. The anterior and posterior margins slope obliquely with the anterior slightly more narrow. The outer surface is densely punctuate and bears prominent growth lines and fine co-marginal lines. The inner margin is smooth. The hinge has a paired anterior and posterior lateral teeth and a very small cardinal. The left valve, which is partially damaged, is also thin and fragile with small umbo just anterior to the midline. The sculpture of its outer surface consists of fine concentric lines, most conspicuous close to the distinct growth lines, and dense punctuations showing through from

![Fig. 6. A. Thyasira flexuosa; B. Vasconiella cf. jeffreysiana; C. Litigiella glabra.](image_url)
FIG. 7. A. Lepton squamosum; B. Coracuta obliquata; C. Devonia perrieri; D. Kelliopsis jozinae.
the inside. The hinge bears two small cardinal teeth and single anterior and posterior laterals. An Atlantic and Mediterranean rare species (Repeto et al., 2005; Marine Bivalve Shells of the British Isles, http://naturalhistory.museumwales.ac.uk), already known from the Ionian and the N Aegean Sea (Zenetos et al., 2005) and now reported for the first time from Thermaikos Gulf.

**MONTACUTIDAE**

*C. obliquata* (Chaster, 1897) (Fig. 7B). Six valves (1.2 mm to 2.2 mm) were collected from material brought to the surface trapped in nets at approximately 35 m from mixed bottom at station 4. The inequilateral valve (left) bears beaks situated at approximately the 2/3 of the shell, is obliquely subovate, with anterior margin prominent sloping gently and slightly angled at the junction with the anterior margin which is rounded. The ventral margin is gently curved and the posterior one subtruncate. The posterior dorsal margin is short, steeply angled and slightly convex. The outer surface bears fine, concentric and occasionally dichotomous ridges. The valve bears no laterals but dorsal margins extended as marginal flanges in contrast to those of the right valve which are narrow, elongate and separated from the shell margin. The color is creamy, the inner surface glossy and the prodissoconch smooth. This rare species (Repeto et al., 2005) is referred from Greece as *Neolepton obliquatum* (Monterosato in Chester, 1897) (Zenetos et al., 2005).

*Devonia perrieri* (Malard, 1904) (Fig. 7C). One live specimen (1.9 mm) was found in sandy-muddy bottom of station 5 at 0.2 m depth. The shell is sub quadrate, compressed, with the beaks close to the posterior end. There are distinct co-marginal and indistinct radial lines. The ligament is small, internal, on a shallow resilifer in the proximity of a faint tubercle. The thin and transparent periostracum covers the ivory white shell, while the umbos are tinted light brown. The species is referred from the NE Atlantic, the W Mediterranean (www.marbef.org) and now from the E Mediterranean Sea.

*Kelliopsis jozinae* (van Aartsen & Carrozza, 1997) (Fig. 7D). One live specimen (1.7 mm) partially filled with a mass of larvae in the ontogenetic stage of D shape was collected from material trawled from sandy-muddy bottom at station 7. In addition, two live juveniles (both 0.9 mm), one shell (1.9 mm) and one left valve (1.0 mm) were found in rocky material trawled from 70 m at station 7. The prosogyrate, thin and translucent shell is equivale, subequilateral, with prominent beaks situated just behind the midline. The shell is tumid, sub circular, posteriorly narrow, with dorsal margin slightly depressed and bears thin pale brown periostracum. Externally the shell’s surface is decorated with fine co-marginal lines. The ligament is internal on a shallow resilifer. The hinge is weak, with a small cardinal tooth, a short anterior lateral flange and a longer posterior lateral tooth behind the resilifer of the right valve. The left valve bears a posterior long groove, a poorly differentiated cardinal tooth and an anterior distinctive lateral tooth. The species has been referred from the NE Atlantic (van Aartsen & Carrozza, 1997; Marine Bivalve Shells of the British Isles, http://naturalhistory.museumwales.ac.uk) and the West and Central Mediterranean Sea (Cachia et al., 2004; Repeto et al., 2005; Cossignani & Ardovini, 2011). This record seems to be the first for the E Mediterranean Sea.

*Kurtiella tumidula* (Jeffreys, 1866) (Fig. 8A). One live specimen (1.5 mm) as well as two left valves were collected from material brought to the surface trapped in nets at approximately 35 m from mixed bottom at station 4. The thin and fragile shell, is equivale and inequilateral with light brown prodissoconch in its posterior 1/4. It is sub-ovate in its outline and expanded anteriorly with the anterior dorsal margin long and straight while the anterior area is widely rounded. The posterior dorsal margin is straight sloping steeply to the rounded posterior. It bears fine, co-marginal lines on its surface and its inner margin is smooth. The ligament is internal in a wide pit beneath the beaks and inserted deep inside the umbos. The hinge consists of two diverging lateral teeth in each valve; those in the right valve are narrow, elongate, separated from the shell margin and with an angle of divergence of approximately 110° while those of the left valve appear as extensions of the shell margin, with an angle of divergence of approximately 130°. The pallial line is entire, the periostracum is light yellow and the color is whitish. The inner surface of the valves is highly shiny. The species, already referred from Greece (Koukouras, 2010) and known from the Aegean Sea as *Mysella tumidula* (Jeffreys 1866) (Zenetos et al., 2005), is now reported from Thermaikos Gulf.

*Montacuta goudii* (van Aartsen, 1997) (Fig. 8B). One live specimen (1.3 mm) as well as two right valves (both 1.2 mm) were collected from a shallow Zostera bed at station 5. The transparent, convex and smooth shell is trapezoidal in shape, fragile and has large beaks situated close to its anterior end. The prominent prodissoconches are of light chestnut brown color.
FIG. 8. A. Kurtiella tumidula; B. Montacuta goudi; C. Montacuta phascolionis; D. Acanthocardia deshayesii.
The hinge plate is very narrow with tooth-like tuberculate projections. This rather recently described species is known only from the Central Mediterranean Sea (Cachia et al., 2004; Associazione Naturalistica Malachia, www.malachia.it).

Montacuta phascolionis Dautzenberg & H. Fischer, 1925 (Fig. 8C). Two live specimens (1.9 mm and 2.4 mm) were collected from fine sand and mud bottom at station 5 and seven individual valves (1.5-3.0 mm) were found in shallow (0.2 m) Zostera beds at the same station. The white, thin and rather fragile shell is almost equivalent and equalateral (with shorter the posterior part) with the left valve slightly smaller and fitting within the right valve. The posterior and anterior sides are rounded and the ventral edge straight or even concave. Each valve bears a single anterior cardinal tooth with that of the right one obliquely elongated. Shell surface smooth with fine concentric growth lines and faint radials. Known from the E Atlantic Ocean and the W and Central Mediterranean Sea (Cachia et al., 2004; Repeto et al., 2005; Cossignani & Ardovini, 2011) it is now reported from the E Mediterranean Sea.

CARDIIDAE

Acanthocardia deshayesii (Payraudeau, 1826) (Fig. 8D). One live specimen (30.8 mm) was collected from material brought to the surface trapped in nets at approximately 10 m from mixed bottom at station 3. The shell bears 22-23 radial ribs with spatulate tubercules, mainly by the margin area, and the interspaces in between the radial ribs with wavy concentric striae. The species which is considered as rare according to Poppe & Goto (2000), Cachia et al. (2004) and La Perna & D‘Abramo (2009), is distributed all over the Mediterranean Sea and has been generally referred from the N Aegean Sea (Zenetos et al., 2005) and Evoikos Gulf (W Central Aegean Sea) (Tenekidis, 1989; Zenetos, 1996).

Fulvia fragilis (Forsskål in Niebuhr, 1775) (Fig. 9B). One live individual (30.6 mm), one shell (17.0 mm) as well as one broken right valve with intact hinge were collected from a depth of 5 m at Station 2 (NE Thermaikos Gulf) in December 2010 after a severe NW wind of 10 Bf during 10 and 11 December 2010 (National Observatory of Athens, www.meteo.gr) and in the same area where the species was also recorded by Angelidis (2013) on February 2012. Moreover, a left valve was collected at the beach of Palioura (Station 3) (E Thermaikos Gulf). The beige fragile shells are slightly longer than high with 35-39 smooth ribs bearing small calcareous spines in the posterior part, are in morphological accordance with the described form of the specimens from Izmir Gulf by Öztürk & Poutiers (2005). Radial periostracum lamellae arise from the mid-line of the ribs, becoming more prominent towards the anterior part of the valves. Internally, the margin is evidently crenulated and the color is creamy white at the anterior part, yellowish pink with a longitudinal blotch under the umbo and violet across the posterior part. Fulvia fragilis is an already established alien species in Saronikos and Evoikos Gulfs (Zenetos et al., 2003; ELNAIS, https://services.ath.hemr.gr/; Angelidis, 2013).

Parvicardium hauniense (Peterson & Russel, 1971) (Fig. 9C). One live juvenile specimen (1.5 mm) was collected from shallow (0.2 m) Zostera beds at station 5. The reddish brown shell is thin, equivalent, inequilateral, slightly inflated, with prosogyrate beaks in front of the midline. It is oval in its outline and a little expanded posteriorly. Its sculpture consists of 23 radial low ribs of the same width as that of the interspaces. A few blunt spines decorate the posterior dorsal ribs. The margin is crenulated and the parivincular short ligament sits on a prominent nympha. The hinge is rather weak and bears on the right valve one anterior and a pair of posterior laterals as well as two small cardinals and on the left valve single almost marginal laterals and two small cardinal teeth. A North Atlantic species restricted to the Baltic Sea (Marine Bivalve Shells of the British Isles, http://naturalhistory.museumwales.ac.uk) but was recorded for the first time from the W Medi-
FIG. 9. A. *Fulvia australis*; B. *Fulvia fragilis*; C. *Parvicardium hauniense* bearing an epibiont on the beak area of its right valve; D. *Coralliophaga lithophagella*. 

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terranean Sea (The Conchological Society of Great Britain and Ireland, www.conchsoc.org) and now is referred for the first time from the Greek waters.

**TRAPEZIDAE**

*Coralliophaga lithophagella* (Lamarck, 1819) (Fig. 9D). One live specimen (11 mm) and a shell (7 mm) were dissected out of a calcareous block trawled at 20 m from mixed bottom at station 3. The equivale and strongly inequilateral prosogyrate shell is solid and modioliform with anterior end reduced and rounded and posterior end expanded and slightly truncated. The ventral line is rather straight while the dorsal one is almost straight. The sculpture consists of concentric lines, growth stops and ridges. The inner margin is smooth and the ligament is external, behind the beaks and set on a shallow nymph. A pale yellow periostracum covers a white shell. Already known from the Greek seas, it is now referred for the first time from Thermaikos Gulf.

**MYIDAE**

*Sphenia binghami* Turton, 1822 (Fig. 10A). Three live specimens (1.5 mm, 2.0 mm and 2.1 mm, respectively) were collected from sandy muddy bottom of station 4 at 0.2 m and several individual valves (0.9-3.2 mm) were found in shallow *Zostera* beds at station 4. Moreover a valve (3.0 mm) was collected from trawled bottom material from 70 m at station 7. The rather thin and brittle shells are equivale, inequilateral with prosogyrate beaks situated at the middle of the anterior part. Their outline varies; they are irregular, roughly rectangular and longer than high. The anterior part slopes steeply towards a rounded anterior ventral margin. The posterior dorsal line is long and sub parallel to the ventral sloping to a broad or narrow subtruncate posterior. The posterior area is defined by an angular ridge running from the umbo to the posterior ventral junction. The sculpture consists of irregular undulations and co-marginal lines. The inner margin is smooth and the ligament is internal lying on a shallow and small chondrophore. Hinge without teeth. The periostracum is persistent, of straw yellow color and the shell itself is white. It is an uncommon inhabitant of the Mediterranean Sea (Gofas et al., 2011) and the Greek waters (Zenetos et al., 2005).

**TEREDINIDAE**

*Bankia carinata* (J.E. Gray, 1827) (Fig. 10B). Several live specimens (2.2-3.5 mm) were dissected out of submerged wood from 7 m depth at station 5. The main characteristic of the species are its pallets which consist of a long white cylindrical stylet with a series of cones covered with a brown unserrated periostracal sheath. The species is cosmopolitan (Gofas et al., 2011), it has been recently collected in Thermaikos Gulf (www.shellauction.net, but with no figure available) and now its occurrence is documented from E Thermaikos Gulf for the first time for Greece.

*Lyrodus pedicellatus* (de Quatrefages, 1849) (Fig. 10C). Several live specimens (3.2-6.4 mm) were dissected out of submerged woods beached at the stations 3, 4 and 6. The pallets consist of a white cylindrical stylet connected with a suture to a blade of equal length which is elongate, oval and with a brown periostracal sheath on its tip. This cosmopolitan species (Gofas et al., 2011) is distributed all over the Mediterranean Sea (Repetto et al., 2005). Recently it was collected in Korinthiakos Gulf, S Greece (www.shellauction.net, but with no figure available) and now its occurrence is documented from E Thermaikos Gulf for the first time.

*Nototeredo norvagica* (Spengler, 1792) (Fig. 10D). Several live specimens (4.0-12.2 mm) were dissected out of submerged wooden poles of fish traps from 7 m depth at station 3. The shell outline and sculpture are very variable. Nevertheless, the pallets are quite distinct with a more or less oval blade, obscurely segmented, having a ribbed or striated appearance and a short stylet (1/3-1/4 the length of the blade). The species is known from the Atlantic Ocean and Mediterranean Sea (Shipway et al., 2011; Borges et al., 2012) and has also been referred for Greece from the Aegean Sea (Natuurhistorich Museum Rotterdam, http://nlbif.eti.uva.nl/nmr).

**XYLOPHAGIDAE**

*Xylophaga dorsalis* (Turton, 1819) (Fig. 11A). Several live specimens (7.5-9.2 mm) were dissected out of a submerged old wooden door found at station 5. The species has been referred from S and W Greece (Zenetos et al., 2005) and this is the first record from the N Aegean Sea.

**THRACIIDAE**

*Thracia* sp. (Fig. 11B). Two live specimens (1.94 mm and 1.50 mm) and 8 valves (1.55-2.10 mm) were collected at 0.2 m from a *Zostera* bed at station 5. The shell is equilateral, slightly inequivalve, with the dorsal margins of the left valve fitting inside those of the
FIG. 10. A. Sphenia binghami; B. Bankia carinata; C. Lyrodus pedicellatus; D. Nototeredo norvagica.
FIG. 11. A. Xylohaga dorsalis; B. Thracia sp.; C. Cardiomya costellata; D. Arcopella balaustina.
right valve, and compressed. It is subtrigonal in its outline and truncated posteriorly. The beaks are prominent and the anterior dorsal margin is straight sloping steeply towards the narrowly rounded anterior margin. The ventral margin is straight, the posterior margin is broadly truncate while the posterior dorsal margin is straight with a slope less steeply than the anterior dorsal margin. Its posterior dorsal area is developed as a flat escutcheon and its anterior dorsal area is slightly cleft. The hinge is weak with the right valve bearing a well-developed anterior tooth which continuous with a weak ridge more prominent at the anterior end of the dorsal slope, and a weaker posterior tooth. The left valve bears no teeth. The ligament is internal and attached to a poorly developed sub-umbonal plate. The prodissococonch, of 190 μm in diameter, is simple with a well-demarcated rim. Seen from the inner surface it gives the impression of sugar grains stack together to form the valves, while the outer surface under high magnification seems to consist of uneven series of fine papillae (8-10 μm in diameter) to form ridges interrupted usually every three or two papillae. When compared with the relevant photographs of Oliver & Holmes (2004), the shell strongly resembles in its outlook and the umbo type and size that of *Thracia arianatoma* Oliver & Holmes, 2004 and *T. myopsis* Møller, 1842 with photographs shown in Coan (1990) and World Register of Marine Species (WoRMS) (www.marinespecies.org), while in its outer surface microsculpture it is closer to that of *T. myopsis* Møller, 1842 (Coan, 1990) or *T. kowiensis* Turton, 1932 (Oliver & Holmes, 2004).

**CUSPIDARIIDAE**

Cardiomya costellata (Deshayes, 1833) (Fig. 11C). Three shells (1.5-5.5 mm) and two broken left valves were found in rocky material trawled from 70 m at station 7. The very thin, fragile and rather inflated shell is slightly inequivalent with the left valve overlapping the right valve. The beaks are situated slightly behind the midline. The body of the shell is ovate, oblique, with its ventral extremity well in front of the line through the beaks and with the anterior dorsal margin sloping steeply. The rostrum is short, slightly turned upwards, triangular and with its dorsal margin concave. The ventral margin is weakly concave corresponding to a weak sulcus at the junction between the rostrum and the body. The shell body bears several radial riblets increasing in size posteriorly. Already known from the Greek seas (Zenetos et al., 2005) it is now referred for the first time from Thermaikos Gulf.

**DISCUSSION**

**The new records**

The last list of the known species of bivalves from Thermaikos Gulf (Manousis et al., 2010) included 188 species. This survey increases that number by >20%, as it adds 39 new species, brings the total number to 227 and presents new data on the biodiversity of the area. At the same time, it reveals the presence of 15 new species from the Hellenic Seas. The current addition of those new records (Table 2) increases the bivalve biodiversity of the Hellenic fauna from 319 (Zenetos et al., 2005, 2007; Manousis et al., 2010) to the total number of 334 species, or by approximately 5.5%. As the majority of all those new species are of small size (<5 mm), their finding is attributed to the intensive, frequent and thorough sampling effort as well as to the careful sorting under magnification and the appropriate and delicate handling of the material.

Out of the two nuculanid species recorded, *Nuculana cf. pella* (Linnaeus 1767) comprises a temptation to be considered as a variant of the known in the area *Nuculana pella* (Linnaeus 1767) but as the members of this family separate from each other often on the basis of minor morphologic differences, such a “variant” should be kept separate from its close relative.

The finding of a number of minute and rare montacutids reported in this work for the first time from Greece, namely, *Devonia perrieri* (Malard, 1904), *Kelliopsis jozinae* (van Aartsen & Carrozza, 1997), *Montacuta goudi* (van Aartsen, 1997) and *M. phascolionis* Dautzenberg & Fischer H., 1925, as well as the small and fragile species *Cyclopecten brandisiiens* Smirglio & Mariotti, 1990, *Monia squama* (Gmelin, 1791) and *Thyasira biplicata* (Philippi, 1836), known inhabitants of the West and/or Central Mediterranean Sea, indicates that the sorting of delicate bivalve fauna necessitates the appropriate handling in order to survive treatment.

It should be pointed out that a considerable number of the presented miniature bivalve species are collected from the station 5 and particularly from 10 m² of a *Zostera* bed (protected from the waves, not exciding the 20 m² in its total surface). This is reminiscent of another great biodiversity “hot spot” harboring a remarkable association of, similar to those of this publication, miniature bivalves of the Lower Pliocene in Peloponnesus, Greece (Schneider & Hochleitner, 2006).

Among the wood eating members of the family TEREDINIDAE, the presence of *Bankia carinata* (Je Gray, 1827) and *Lyrodes pedicellatus* (de Quatrefages,
1849) in the Greek waters is now documented. Their identification is mainly based on the morphological characteristics of their pallets which are only present in live and intact biological material. After the death of the wood inhabiting organisms, their pallets are lost (either due to drifting or they are cemented in the wooden substrate) and thus complicate the systematic study these xylophages organisms.

The alien species status

From the three new alien species for Greece, *Fulvia australis* seems to have started expanding from the coasts of Israel towards the NW Aegean (Thermaikos Gulf) or it has been introduced by shipping as there is no reference from the rest of the Aegean Sea yet, while the congeneric and very similar species *F. fragilis* is well established in Thessaloniki and Thermaikos Gulfs according to the existing information by Zenetos et al. (2003), Angelidis (2013) and the current study.

*Pinctada imbricata radiata* is now successfully established in the S Aegean (ELNAIS, https://services.ath.hcmr.gr). The specimens of this study, with age up to three years, all with a rather high growth rate which is very similar to that of individuals from Israel and the Red Sea (Fig. 12) show establishment and a quick expansion in the E Thessaloniki Gulf (N Aegean, E Mediterranean Sea) perhaps due to appropriate ambient conditions of the area.

Beside *Pinctada imbricata radiata*, *Crassostrea gigas* is another commercial alien that is recorded in the E Thessaloniki Gulf where the alien gastropod *Bursatella leachii* was also found (Manousis et al., 2012) in coincidence with a massive expansion of the alien alga *Caulerpa racemosa* which is recorded in quantities along almost all the eastern littoral zone of Thessaloniki and Thermaikos Gulfs during the current study.

Apart from the different collection stations of the recorded alien species in Thermaikos Gulf (NW part of the Aegean Sea), their successful establishment is also indicated by the collection of live juveniles, live individuals filled with D shape larvae, intact shells and individual valves. This success could be attributed to an adaptability of their populations to the Hellenic marine environment as it was also referred for *Parvicardium hauniense* (Peterson & Russel, 1971) (The Conchological Society of Great Britain and Ireland, www.conchsoc.org) or/and to the fact that the environment in the E Mediterranean Sea has changed during the last decade and became warmer (Saaroni et al., 2003; Hansen et al., 2010) with the N Aegean Sea being more rapidly warmed than the rest of the Mediterranean sea basin (Skiliris et al., 2011).

The goal set in a previous publication (Manousis et al., 2010) to “further research emphasizing on small in size species, symbionts, epibionts and rare species needs to be contacted in order to further explore the present biodiversity of bivalves in the area” seems to be accomplished. The present and the previous findings consist a reference base for any future study of the bivalve malaco fauna of Thermaikos and Thessaloniki Gulfs.

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