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MIDDLE BRONZE AGE AND HELLENISTIC MOLLUSK MEALS FROM SOÚRPI BAY (THESSALY, GREECE)

Wietske Prummel[1]

Mollusk shells from three sites at Soúrpi Bay in Thessaly, Greece, were studied. These are the Middle Bronze Age site of Magoúla Pavlína, the Hellenistic town of New Halos, and Hellenistic dwellings at the former Southeast Gate of this town. The mollusks of all sites were collected in Soúrpi Bay and in the lagoon that existed just inland from the bay during the Middle Bronze Age. Mollusks from shallow water with a soft floor prevailed at the three sites, among which the Mediterranean lagoon cockle, *Cerastoderma glaucum,* was most numerous. Significant differences in valve wall thickness were found that presumably can be explained by the change in habitat: the Middle Bronze Age cockles from the lagoon had thick valves, the cockles from the Hellenistic period, which grew in river estuaries, had thinner walls. The inhabitants of the large town of New Halos consumed small as well as large cockles, whereas the inhabitants of the Magoúla Pavlína and the Southeast Gate could be more choosy and consume larger cockles almost exclusively. The deep-water species *Spondylus gaederopus* was gathered by divers more often in the Middle Bronze Age than in the Hellenistic period.

Key words: Cerastoderma glaucum, cultural preferences, ecology, mollusks, valve wall thickness

Marine mollusk shells have been found in large numbers at three sites at Soúrpi Bay in Thessaly, Greece, that date to the Middle Bronze Age (one site) and the Hellenistic period (two sites) (Fig. 1; Table 1). Soúrpi Bay is in the southwest corner of the Pagasitikós Gulf. The present town of Vólos is situated in the northeast corner of this gulf.

The western and southern shores of Soúrpi Bay are composed of gravel, sand, and mud. The floor of Soúrpi Bay falls gradually from west to east. A depth of 5 m is reached at 150 m from the western shore, that of 10.8 m at 550 m. At the southern end of the bay, which is even shallower, a depth of 5 m is reached at 325 m from the shore, that of 10.8 m at 1125 m.

The eastern shore of Soúrpi Bay along the Mitzéla peninsula is rocky and steep and has small gravel beaches. A depth of 10.8 m is reached here about 55 m from the coast. The deepest point of Soúrpi Bay, 27.5 m, is found at the outlet of the bay into the Pagasitikós Gulf, close to the eastern shore of the bay.

During the Middle Bronze Age a lagoon was situated behind the western and southern shore of Soúrpi Bay (Fig. 1, right, shaded area). The lagoon was protected from the bay by a spit (van Straaten 1988). The Middle Bronze Age site that is discussed in this paper is the Magoúla Pavlína (MP), situated on the lagoon (Fig. 1, right). The human population of MP was about 200-400 (H. R. Reinders, personal communication).

In the Late Bronze Age the spit completely closed, after which the lagoon was replaced by a salt marsh along the open bay (van Straaten 1988). Several river estuaries emptied into Soúrpi Bay (Fig. 1, right). The first Hellenistic site discussed in this paper is the town of New Halos (NH), then 1.5 km from the west shore of Soúrpi Bay. (The west shore has moved some 10 m since the Hellenistic period.) Founded ca. 302 B.C., this large town of 1440 houses with an estimated population of 8,000 to 9,000 people, mainly soldiers and their families, was abandoned ca. 265 B.C. (Reinders 1988; Reinders and Prummel 2002). The second Hellenistic site studied consisted of a small number of dwellings at the former Southeast Gate (SEG) of the town of New Halos, dated at ca. 260-220 B.C. (Reinders and Kloosterman 1998) (Fig. 1). The population occupying these dwellings was, at most, only several tens.

The three sites allow the study of the influence of culture (Middle Bronze Age versus Hellenistic Period), environment (a lagoon versus open sea and river estuaries) (Claassen 1998: 126-129), and human population density (low in MP and SEG, high in NH) on the marine shellfish that was collected and consumed. Strong differences in strength and size of the most common species, the lagoon cockle (*Cerastoderma glaucum*), at the three sites became obvious during the examination of the mollusk materials. Studies of modern Mediterranean lagoon cockles

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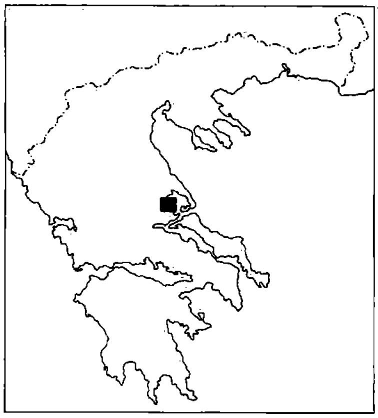

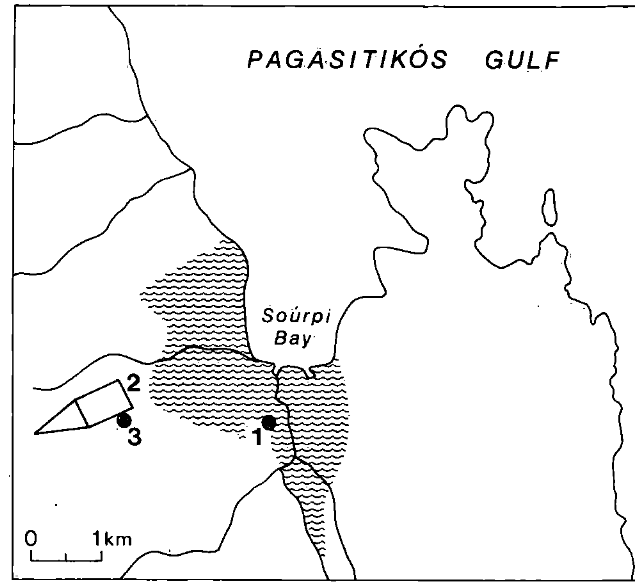

Figure 1. Map of Greece with the area of the studied sites in black (left) and the current situation of the Pagasitikós Gulf and Soúrpi Bay (right). 1) Magoúla Pavlína (MP: Middle Bronze Age); 2) town of New Halos (NH: Hellenistic period); 3) dwellings at former Southeast Gate of New Halos (SEG: Hellenistic period). The wavy shading represents the area that was a lagoon during the Middle Bronze Age and a salt marsh during the Hellenistic period. Drawings by H. Zwier.

(Ivell 1979; Nicolaidou et al. 1988; Trotta and Cordisco 1998) were used to try to explain these differences.

MATERIALS AND METHODS

During a surface survey on MP in June 1996, students and staff of the Groningen Institute of Archaeology collected all visible finds: pottery, flints and other worked stone, bones, and mollusk shells. With a few later exceptions, the pottery was all of Middle Bronze Age date (Dijkstra et al. 1997; Reinders et al. 2001).

The almost complete homogeneity in date of the pottery is seen as a guarantee that the bones of humans (3), animals (124), and marine mollusk shells (285) that were collected during the surface survey date to the Middle Bronze Age. This was confirmed by the ^{14}C dates of two cattle bones (GrA-16888: 3580 ±40 B.P. and GrA-16889: 3675 ±40 B.P.), calibrated (95.4% confidence level) 2033-1989, 1987-1873, 1843-1811, 1799-1775 and 2195-2175, 2143-1943 cal B.C., respectively. These dates place the occupation at the middle of the Middle Bronze Age.

During excavation, Hellenistic materials NH and SEG were collected. Animal remains were sampled carefully by hand. Sieving was done at both sites, but no subfossil bone or shell was recovered. The NH deposits were 0.4 m deep at maximum. In these deposits, 899 mammal bones, 13 tortoise bone fragments, 1 fish vertebra, 504 marine mollusk shells, 20 shells of terrestrial mollusks, half of them the edible *Helix figulina*, plus one echinoderm endoskeletal fragment were found. Although preservation of bone and shell in the soil of the town of New Halos was good due to the high lime content of the soil and the low precipitation, remains of groups with more fragile skeletons, such as echinoderms, were very rare or, in the case of birds and crustaceans, absent (Prummel 2003).

The slightly younger SEG deposits were up to 1.5 m in depth. The excavation of these dwellings and the identification of the animal remains are in progress. At present (May 2001), 2884 mammal bones, 1827 marine mollusk shells, 120 terrestrial gastropod shells (most of them *Helix figulina*), 39 tortoise bone fragments, 6 fish bones, 76 bird bones, and 7 crab fragments (crustaceans) have been studied. The better representation of fish and the presence of bird bones and crustacean remains suggest slightly better preservation conditions in the SEG than in the NH deposits. Still, echinoderm remains have not been found in the SEG deposits, and fish bones are rare. This could suggest that fish was not much consumed in the two Hellenistic sites at Soúrpi Bay.

SAMPLING, IDENTIFICATION, MEASURING

All marine mollusk remains were identified with a reference collection that was assembled for this purpose from beach finds of Soúrpi Bay and the Pagasitikós Gulf. Identifications of the reference material were made with Poppe and Goto (1991; 1993) and Delamotte and

Vardala-Theodorou (1994) and checked by Rob Moolenbeek of the Zoological Museum of the University of Amsterdam (the Netherlands).

The numbers (N) for the bivalvia in Table 1 are the sums of left and right valves. Minimum numbers of individuals (MNI) are the numbers of gastropod shells (N) and the numbers of bivalvia valve fragments divided by two and raised to the nearest integers (Table 1).

The *Cerastoderma glaucum* valves were measured to an accuracy of 0.1 mm according to standards for bivalvia (length: from anterior to posterior margin; height: from umbo to midline). The shells and valves of MP and SEG were weighed to an accuracy of 0.1 g and those of NH to an accuracy of 1 g. Graphs and statistics of *Cerastoderma glaucum* valves were processed using SPSS 8.0.

RESULTS

Most mollusk shells and shell fragments from the three sites are from animals that were collected with the living animal in it, and thus come from mollusks consumed by humans. Few shells were dead beach finds. Damage by opening the shells with a stone knife is visible on many MP spiny oyster (*Spondylus gaederopus*) valves (Prummel 2001). Evidence, such as large numbers of small shell fragments of *Hexaplex* and *Bolinus*, that would indicate purple dye production (Becker 2001) does not exist. A *Luria lurida* from SEG had a hole in the shell and obviously had been used as a pendant. A bead made of mollusk shell was found in NH (Prummel 2002).

The Middle Bronze Age site differs from the Hellenistic sites by the small number of recovered marine mollusk species: 7 as opposed to 25 and 22 (Table 1). Species with fragile shells, such as *Patella* sp., *Mactra stultorum*, *Donacilla cornea*, *Tapes decussatus*, and *Solen marginatus*, are lacking in the MP material, which had been plowed to the surface and therefore may be underrepresented. Excavation is needed to ascertain whether or not fewer mollusk species were consumed in MP than NH and SEG.

Slight differences in preservation conditions between the two Hellenistic sites are illustrated by the absence of *Solen marginatus* valves in the NH material. The much deeper SEG deposits may have preserved the fragile valves of this species better than the shallow NH layer.

Even if the fragile species are under-represented in MP, the strong representation of *Spondylus gaederopus* in the material of this Middle Bronze Age site (22.4% of MNI) is obvious. In the two Hellenistic sites, the proportion of spiny oyster valves is no higher than 1.7 and 0.9% of MNI (Table 1). The species lives cemented to rock bottoms in 7 to 50 m of water (Poppe and Goto 1993: 68) and was procured by diving. With this species, the deep, rocky habitat is much better represented in the total mollusk MNI of MP than in the Hellenistic sites NH and SEG (Table 2).

The lagoon cockle of the Mediterranean (*Cerastoderma glaucum*) (Fig. 2), a species of shallow, soft-bottomed lagoons and river estuaries, is better represented in MP and SEG than in NH. In NH, however, it also is the most common mollusk. The shallow, soft habitat is best represented in each site (Table 2). Limpets (*Patella* sp.), species of hard substrate shallow-water habitats, oyster (*Ostrea edulis*), a species of hard or soft substrate habitats of shallow waters up to 90 m deep, and Noah's ark, (*Arca noae*), a species of hard substrates in shallow to 119 m water, are more common in NH than in the two other sites (Table 1). In NH, also, hard surfaces under shallow water (14.7% of MNI) and soft or hard surfaces under shallow or deep water (17.7% of MNI) are well represented (Table 2).

The MP lagoon cockle valves differ from those of NH and SEG in two aspects. First, the MP valves are on average much heavier than those from NH or SEG (Table 3, Fig. 3). While the weight of mollusk valves may change during their stay in the soil, the good preservation conditions for bones and shells in MP soil at the three sites would not change the diameter of the valve wall. Nonetheless, this diameter is difficult to measure because the shell sculpture has radiating ribs and furrows. Moreover, cockle-valve wall thickness decreases from the umbo to the bottom of the valve and from the anterior to the posterior margin. The pallial line halfway between the anterior and posterior margin was chosen to measure the valve wall thickness (Fig. 2).

MP lagoon cockles had thicker walls than the NH and SEG cockles. As might be expected, wall diameter increases with valve height (Fig. 4). MP valves of 25-40 mm in height had wall thicknesses between 3 and 4 mm, whereas NH valves of the same height had wall thicknesses between 2 and 3 mm. Shell height and valve wall thickness were measured on the same valves for only part of the SEG lagoon cockles. The SEG valves of 25-40 mm height had wall thicknesses between 1.7 and 2.9 mm (Fig. 4), about the same as the NH valves.

Second, valve size, the mean of valve length and height, differs considerably (Fig. 5, Table 3). Because the lagoon cockle is equivalve, left and right valve measurements have been combined. The ranges and

Table 1. The numbers (N) of shell and valve fragments of marine mollusks in three sites near the coast of Soúrpi Bay, their minimum numbers of individuals (MNI) and the proportions for MNI. The sites are Magoúla Pavlína (Middle Bronze Age), the Hellenistic town of New Halos and some dwellings at the former Southeast Gate of New Halos (Fig. 1). The habitat column indicates where the species lives; the first character refers to the substratum: H - hard substrata, S - soft substrata, A - hard or soft substrata (all); the second character refers to the depth of water: S: shallow water (to 6 m), D: 6 m or more deep water, A: shallow and deeper water (habitat data: Poppe and Goto 1991; 1993).

	Magoúla Pavlína			New Halos			Southeast Gate			
	N	MNI	MNI%	N	MNI	MNI%	N	MNI	MNI%	Habitat
Marine gastropoda										
Patella caerulea Linnaeus, 1758	-	-	-	41	41	14.0	21	21	2.1	H/S
Patella rustica Linnaeus, 1758	-	-	-	-	-	-	1	1	0.1	H/S
Monodonta articulata Lamarck, 1822	-	-	-	-	-	-	1	1	0.1	H/S
Gibbula divaricata (Linnaeus, 1767)	-	-	-	1	1	0.3	-	-	-	H/S
Gibbula cf. *umbilicaris* (Linnaeus, 1767)	-	-	-	-	-	-	2	2	0.2	S/S
Gibbula albida (Gmelin, 1791)	-	-	-	2	2	0.7	-	-	-	A/A
Cerithium vulgatum (Bruguière, 1792)	13	13	6.5	10	10	3.4	43	43	4.3	S/S
Luria lurida (Linnaeus, 1758)	-	-	-	1	1	0.3	1	1	0.1	H/A
Tonna galea (Linnaeus, 1758)	-	-	-	1	1	0.3	-	-	-	A/D
Bolinus brandaris (Linnaeus, 1758)	-	-	-	8	8	2.7	75	75	7.5	S/A
Hexaplex trunculus (Linnaeus, 1758)	10	10	5.0	19	19	6.5	33	33	3.3	S/A
Buccinulum corneum (Linnaeus, 1758)	1	1	0.5	1	1	0.3	-	-	-	H/S
Fusinus syracusanus (Linnaeus, 1758)	-	-	-	-	-	-	1	1	0.1	A/A
Conus ventricosus Gmelin, 1791	-	-	-	2	2	0.7	1	1	0.1	H/A
Unidentified marine gastropod	-			4			1			
Marine bivalvia										
Arca noae Linnaeus, 1758	8	4	2.0	38	19	6.5	3	2	0.2	H/A
Glycymeris insubrica (Brocchi, 1814)	-	-	-	4	2	0.7	2	1	0.1	S/S
Mytilus galloprovincialis Lamarck, 1819	-	-	-	1	1	0.3	-	-	-	H/A
Pinna nobilis Linnaeus, 1758	-	-	-	3	2	0.7	7	4	0.4	S/A
Chlamys cf. *glabra* (Linnaeus, 1758)	-	-	-	2	1	0.3	-	-	-	S/D
Spondylus gaederopus Linnaeus, 1758	89	45	22.4	9	5	1.7	17	9	0.9	H/D
Ostrea edulis Linnaeus, 1758	8	4	2.0	50	25	8.5	56	28	2.8	A/A
Psoedochama gryphina (Lamarck, 1819)	-	-	-	1	1	0.3	-	-	-	H/D
Acanthocardia tuberculata (Linnaeus, 1758)	-	-	-	22	11	3.8	16	8	0.8	S/A
Cerastoderma glaucum (Poiret, 1789)	248	124	61.7	188	94	32.1	1480	740	73.8	S/S
Mactra stultorum (Linnaeus, 1758)	-	-	-	3	2	0.7	3	2	0.2	S/A
Donacilla cornea (Poli, 1795)	-	-	-	4	2	0.7	-	-	-	S/S
Solen marginatus Pulteney, 1799	-	-	-	-	-	-	25	13	1.3	S/A
Callista chione (Linnaeus, 1758)	-	-	-	1	1	0.3	2	1	0.1	S/A
Tapes decussatus (Linnaeus, 1758)	-	-	-	31	16	5.5	14	7	0.7	S/S
Venus verrucosa Linnaeus, 1758	-	-	-	50	25	8.5	18	9	0.9	A/A
Unidentified marine bivalve	-			3			3			
Unidentified marine mollusc	-			4			1			
Total	377	201	100.0	504	293	100.0	1827	1003	100.0	

histograms (Fig. 6) of valve length and height show that minimum values for length and height in NH are much lower than those in MP and SEG. SEG has slightly larger maximum values for valve length and height than MP or NH.

Because the distributions of valve length and height of the NH and SEG lagoon cockle valves strongly differ from the normal distribution (Fig. 6), nonparametric tests were used to test whether the lagoon cockles from MP, NH, and SEG could come from the same or identical populations of lagoon cockles collected for consumption.

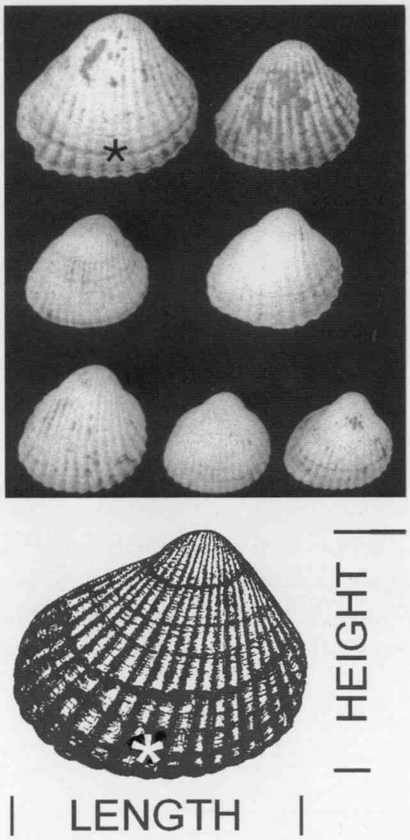

Figure 2. Above: right valves of *Cerastoderma glaucum* from the Middle Bronze Age site Magoúla Pavlína. The star marks the place where valve wall diameter was measured. Scale in cm. Below: the measurements taken (length, height, valve wall diameter).

(It should be noted that the descriptive statistics of cockles that were collected for consumption will differ from those of populations not selected for consumption). The Kruskal-Wallis H test for three independent samples (the length and height valve measurements for MP, NH, and SEG) gave Chi-squares for length and height of 40.992 and 71.424, respectively. The asymptotic significance of these two Chi-square values (with df = 2) is 0.000. Thus, MP, NH, and SEG are not significantly homogeneous in valve length and height.

Results of Mann-Whitney-Wilcoxon tests for three sets of two independent samples (MP-NH, MP-SEG, NH-SEG) of lagoon-cockle valve lengths and heights showed that the lagoon cockles from these three sites came from three different populations of collected cockles (Table 4). The lagoon cockles from SEG were significantly larger in length and height than those from NH, whereas those from MP were significantly larger than those from either NH or SEG (Fig. 5).

DISCUSSION

Mollusks were consumed in quantity at the three sites studied, the Middle Bronze Age site, MP, and the two Hellenistic sites, NH and SEG. In the Hellenistic sites, a wide variety of mollusks was consumed. Because the MP material was collected during a surface survey, it is not possible to state whether the choice of species was really more restricted at this Middle Bronze Age site than in the Hellenistic sites (Table 1). For all sites, we cannot determine the potential consumption of cephalopod species, which lack shells.

Mollusks living in shallow water with a soft floor were the most consumed species in each of the three sites (Table 2). The main species in this group was the lagoon cockle (*Cerastoderma glaucum*). Shallow water with soft bottoms was present at short distances from the sites. The Middle Bronze Age lagoon, the west and south shores of Soúrpi Bay, and the river estuaries all had this type of marine bottom. The lagoon that was in existence during the Middle Bronze age was a very good habitat for *C. glaucum* (Ivell 1979; Nicolaidou et al. 1988; Trotta and Cordisco 1998). During the Hellenistic period the species lived in the estuaries of the rivers flowing into Soúrpi Bay. In the bay itself, fish predation restricted the species.

The east coast of Soúrpi Bay (Fig. 1) was rocky

Table 2. Magoúla Pavlína, Hellenistic New Halos and Southeast Gate of New Halos. Proportions of MNI of mollusks living on (columns): hard habitats (H), soft habitats (S) and hard or soft habitats (A) and below (rows): shallow water (S), shallow and deep water (A) and deep water (D) (for the preference habitats of the mollusk species see Table 1).

	% living in soft habitats (S)	% living in soft or on hard habitat (A)	% living on hard habitat (H)
Shallow water (S)			
Magoúla Pavlína	68.2	-	0.5
New Halos	42.3	-	14.7
Southeast Gate	79.1	-	2.3
Shallow and deep water (A)			
Magoúla Pavlína	5.0	2.0	2.0
New Halos	14.7	17.7	7.8
Southeast Gate	13.6	3.8	0.4
Deep water (D)			
Magoúla Pavlína	-	-	22.4
New Halos	0.3	0.3	2.0
Southeast Gate	-	-	0.9

Table 3. Number, range, mean, and standard deviation (Std.Dev.) of length, height and weight of *Cerastoderma glaucum* valves (left and right valves taken together) from the Magoúla Pavlína, New Halos and the Southeast Gate. The weight was only measured for complete valves. Length and height in mm, weight in g.

Length	N	Range	Mean	Std.Dev.
Magoúla Pavlína	92	18.0-48.0	33.2	6.11
New Halos	49	12.2-48.8	26.3	7.03
Southeast Gate	323	14.4-54.4	29.9	6.22
Height				
Magoúla Pavlína	144	17.2-45.5	31.6	5.30
New Halos	68	14.6-40.3	24.9	5.28
Southeast Gate	338	13.9-47.7	27.8	5.54
Weight				
Magoúla Pavlína	93	0.7-18.2	7.0	3.60
New Halos	54	0.9-11.0	2.6	1.86
Southeast Gate	265	0.5-16.4	3.5	2.65

and suitable for human collection of mollusks. For MP and NH, mollusks collected on coastal rocks were of some importance (Table 2). In MP, the main species collected from rocks was the spiny oyster (*Spondylus gaederopus*). In NH, limpets (*Patella* sp.), and Noah's Ark (*Arca noae*) were the most common species collected from rocks (Table 1).

Mollusks from shallow to deep water with soft or hard bottoms were collected rather often by or on behalf of the inhabitants of NH (Table 2). These species, of which *Bolinus brandaris*, *Hexaplex trunculus*, *Ostrea edulis*, *Venus verrucosa*, and *Acanthocardia tuberculata* are the most common (Table 1), may have been collected along the west and south shores of Soúrpi Bay. *Bolinus brandaris* and *Hexaplex trunculus* shells are also common in SEG. Remains of *Ostrea edulis*, *Venus verrucosa*, and *Acanthocardia tuberculata* in NH suggest that, for the large human population of this town, all types of mollusks were collected, whereas the

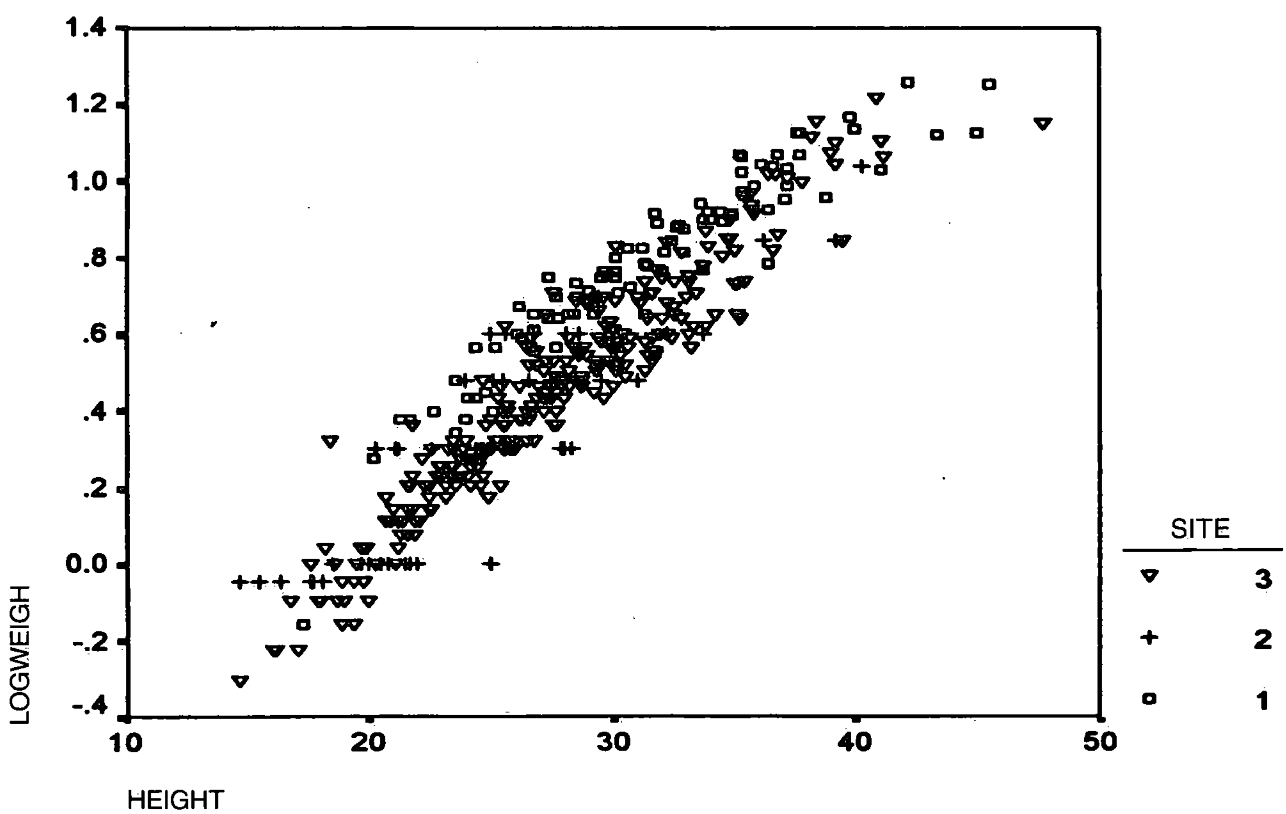

Figure 3. Scatterplot of ^{10}log of weight (in g) (LOGWEIGH) against height (in mm) of complete *Cerastoderma glaucum* valves from 1. Magoúla Pavlína (Middle Bronze Age), 2. New Halos (Hellenistic period), 3. Southeast Gate (Hellenistic period).

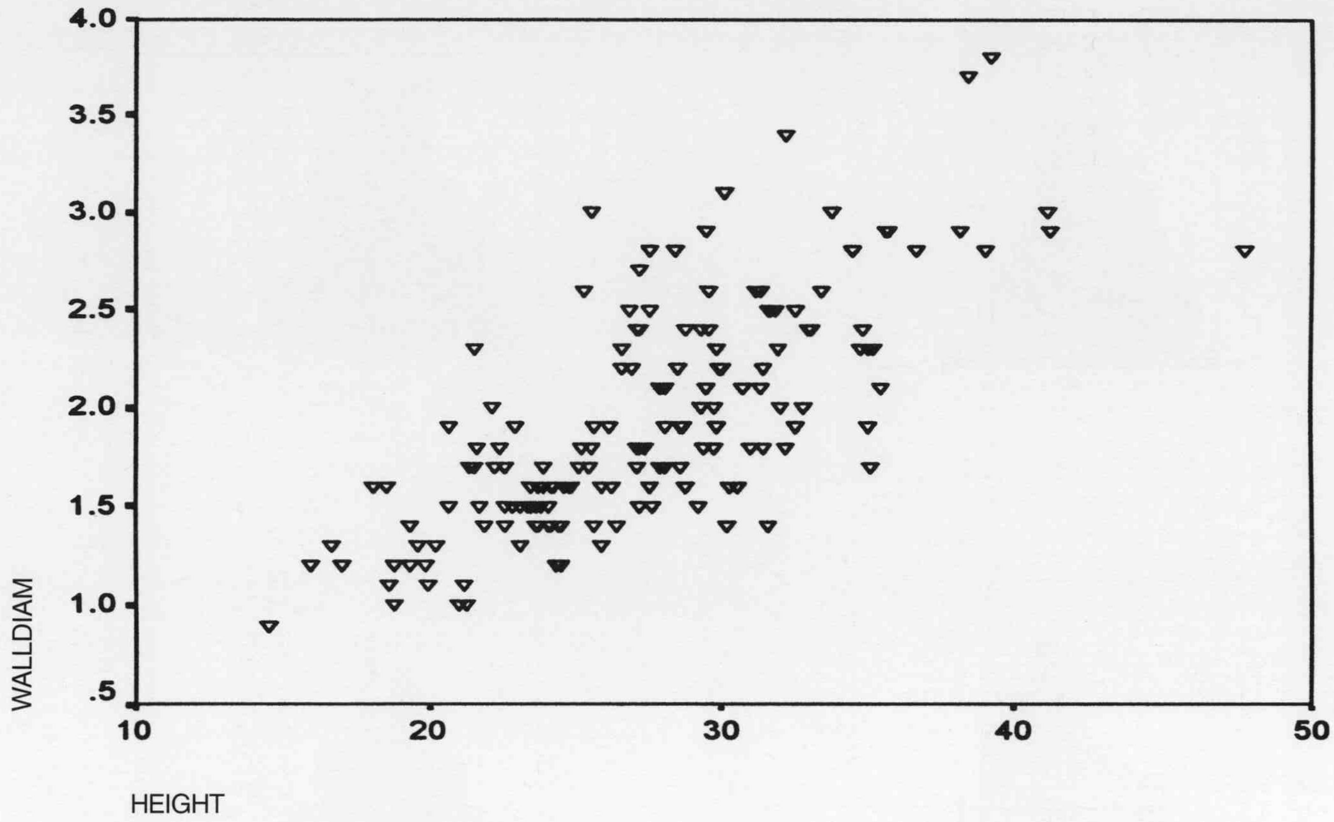

Figure 4. Scatter plot of valve wall diameter (WALLDIAM) against height of *Cerastoderma glaucum* valves from the Southeast Gate site (SEG). Scales in mm.

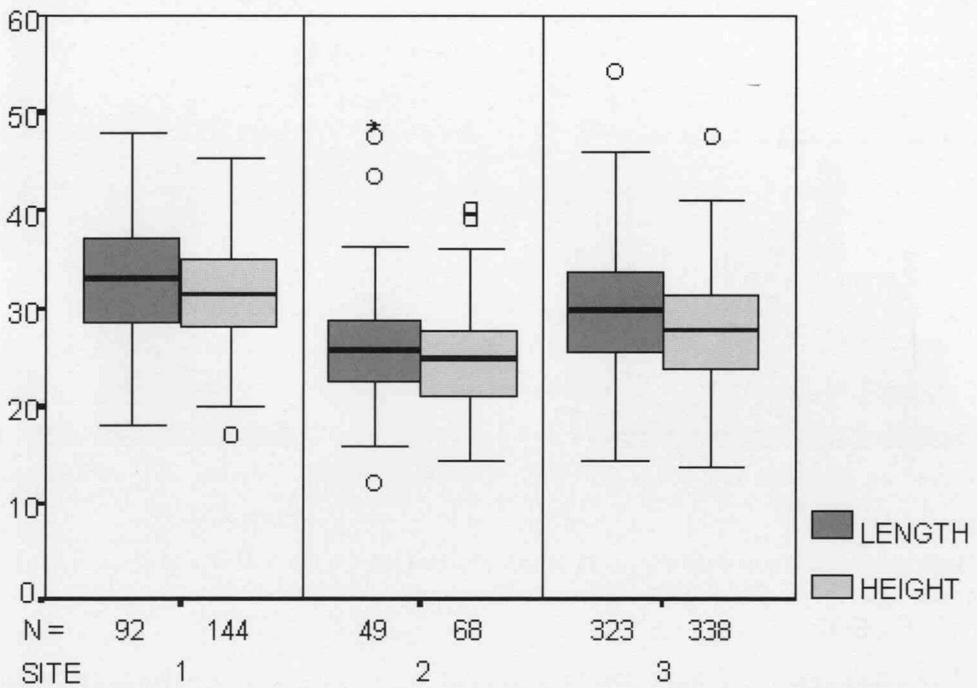

Figure 5. Box plots of length and height of *Cerastoderma glaucum* valves from 1. Magoúla Pavlína (Middle Bronze Age), 2. New Halos (Hellenistic period), 3. Southeast Gate (Hellenistic period). Scale in mm.

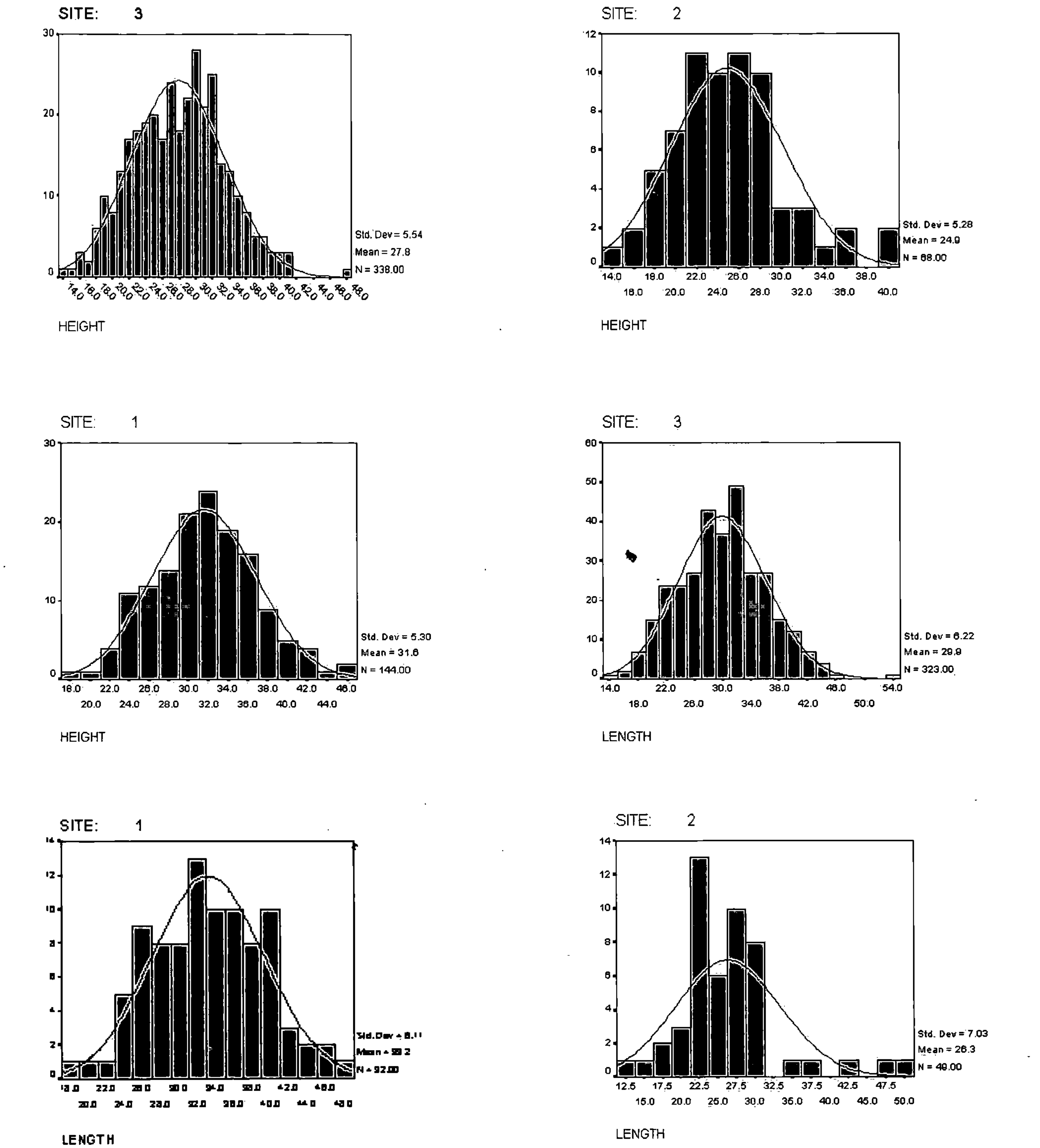

Figure 6. Histograms and the normal curves of length and height of *Cerastoderma glaucum* valves from 1. Magoúla Pavlína (Middle Bronze Age), 2. New Halos (Hellenistic period), 3. Southeast Gate (Hellenistic period). Scale in mm.

MP and SEG inhabitants were more selective in their choice of mollusks and hardly consumed these species (see below). All mollusk species that were consumed in the three sites could have been collected in Soúrpi Bay.

Spondylus gaederopus is far more common in MP than in NH and SEG (Table 1). That the taste for this delicious species was lost from the Middle Bronze Age to the Hellenistic period is improbable. A second possible explanation is that the Hellenistic inhabitants less often took the trouble to dive for this deep-water species. A third explanation is that the consumption of spiny oysters in the Pagasitikós Gulf during the Neolithic (Reinders et al. 1997) and the Bronze Age (Falkner 1975; Prummel 2001) and the ring, bead, and button production from spiny oyster valves during the Neolithic (Tsuneki 1989:8-13) gradually decreased the stocks of spiny oysters. It is clear that this last aspect needs further study.

For *Cerastoderma glaucum* from the Middle Bronze Age site MP, the much thicker valve walls than those from the Hellenistic sites may be caused by environmental factors. At Lago Lungo, a brackish lagoon in Italy, Ivell (1979) studied the biology and ecology of lagoon cockles (*C. glaucum*) from a lake and freshwater mouth of a river and a seawater mouth that all fed Lago Lungo. The freshwater mouth showed a much larger community of lagoon cockles than the seawater mouth. The same result was found by Trotta and Cordisco (1998), who observed much larger densities (782 g/m^2) of lagoon cockles in the Lesina Lagoon on the Italian Adriatic coast than in the nearby Fortore River estuary (417 g/m^2). The preference of the species for confined lagoon waters that are protected from open sea was also found by Nicolaidou et al. (1988) in the Messologhi lagoonal system on the west coast of Greece. Predators that enter from the open sea in more exposed areas of the lagoonal system heavily reduce lagoon cockle densities.

Ivell (1979: 371 and his Fig. 4) found that growth in valve height was greater in the freshwater mouth community than in the seawater mouth community of Lago Lungo. Freshwater-mouth cohorts (the lagoon cockle may have three to four cohorts yearly; also see Trotta and Cordisco 1998) increased from 7 to 25 mm in valve height in 7 months, or from 11 to 22 mm in 5 months, while a typical seawater-mouth cohort in this lagoon increased in valve height from 10 to 22 mm in 11 months. Correspondingly, the amount of $CaCO_3$ and the dry organic content of the shell attained higher absolute values in less time in the freshwater mouth than in the seawater mouth.

The rates of shell growth and wall thickness of species of *Cerastoderma* are influenced by temperature, temperature fluctuations, trophic state, pH, oxygen content, bottom type, and other factors (Eisma 1965). While the influence of environmental factors on valve wall thickness of the Mediterranean lagoon cockle has not been studied yet, we conclude that one or several ecological factors caused the differences in valve wall thickness between the lagoon cockles from the Middle Bronze Age, that were collected in the lagoon, and those from the Hellenistic period, that were collected in the river estuaries.

Table 4. Mann-Whitney-Wilcoxon Test for two independent variables of three samples of valve length and valve height of *Cerastoderma glaucum*.

Length	N	Mean rank	Sum of ranks
Magoúla Pavlína (MP)	92	85.77	7891
New Halos (NH)	49	43.27	2120
Mann-Whitney U	895		
Wilcoxon W	2120		
Z	-5.884		
Asymp. Significance (2-tailed)	.000		
Length			
Magoúla Pavlína (MP)	92	254.35	23400
Southeast Gate (SEG)	323	194.80	62920
Mann-Whitney U	10594		
Wilcoxon W	62920		
Z	-4.201		
Asymp. Significance (2-tailed)	.000		
Length			
New Halos (NH)	49	125.20	6135
Southeast Gate (SEG)	323	195.80	63243
Mann-Whitney U	4910		
Wilcoxon W	6135		
Z	-4.282		
Asymp. Significance (2-tailed)	.000		
Height			
Magoúla Pavlína (MP)	144	128.38	18486
New Halos (NH)	68	60.18	4092
Mann-Whitney U	1746		
Wilcoxon W	4092		
Z	-7.556		
Asymp. Significance (2-tailed)	.000		
Height			
Magoúla Pavlína (MP)	144	304.14	43796
Southeast Gate (SEG)	338	214.81	72607
Mann-Whitney U	15316		
Wilcoxon W	72607		
Z	-6.445		
Asymp. Significance (2-tailed)		.000	
Height			
New Halos (NH)	68	148.97	10130
Southeast Gate (SEG)	338	214.47	72491
Mann-Whitney U	7784		
Wilcoxon W	10130		
Z	-4.200		
Asymp. Significance (2-tailed)	.000		

The differences in shell size (height and length) (Fig. 5, tables 3-4) can be explained partly by environmental factors and partly by the strong differences in human population size at the sites and, thus, in the degree of exploitation of the lagoon cockle populations. The large size of the MP lagoon cockles may be correlated to a degree with the high shell-growth rate of the communities that lived in the lagoon. The lagoon cockles in the less confined, more open estuaries will have shown a lower shell growth rate than those in the lagoon. The inhabitants of the Hellenistic sites had to wait longer before the lagoon cockles attained a good size.

No environmental differences in the estuaries would have existed between the occupation periods of NH and SEG. The size differences between the lagoon cockles from these sites have to be explained by the differences in human population size. Whereas the few inhabitants of the last site could be choosy in the size of selected lagoon cockles, the many of the first site had to accept smaller lagoon cockles as well.

The enormous reproductive potentiality of the Mediterranean lagoon cockle would have prevented over-exploitation of the species, even by the inhabitants of NH, the large town. Lagoon cockle populations have seeds at almost all times of the year (Trotta and Cordisco 1998). Should humans harvest 90% of the lagoon cockles, the remaining 10% are able to replenish the stock in a short period (Ivell 1979: 378).

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