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Factors affecting the distribution of the bivalve *Donacilla cornea* (Poli, 1795) in eastern Mediterranean sandy beaches

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Donacilla cornea (Poli, 1795) is the characteristic bivalve of the midlittoral sand assemblage in the Mediterranean Sea. In order to acquire information on the factors influencing its distribution, a detailed survey was carried out on 117 sandy beaches in eastern Mediterranean. In each station, samples were taken from the lower midlittoral zone. *Donacilla cornea* was found in 56 beaches moderately exposed to wave action and with a mean particle size ranging from 325 to 1866 μm (medium to very coarse sand). This species was not found in sheltered or extremely exposed beaches. The abundance of this species was correlated with exposure to wave action, mean particle size and sorting index of the sediment. The percentage of $CaCO_3$ and the organic matter in the sediment were not correlated either with the presence or the abundance of this species.

Key words: *Donacilla cornea*, distribution, sandy beaches, exposure, sediment.

INTRODUCTION

In the intertidal zone of sandy beaches, the distribution and the abundance of organisms depend on several factors: tidal level (McLachlan *et al*., 1981), exposure to wave energy (Eleftheriou & Nicholson, 1975), sediment grain size (McLachlan, 1983; Veloso *et al*., 2003), salinity (Lercari *et al*., 2002; Lercari & Defeo, 2003), human activities (Marcomini *et al*., 2002), recruitment success (Crimaldi *et al*., 2002) and species interactions (Defeo *et al*., 1997). Especially for the bivalves that inhabit the intertidal zone of sandy beaches, exposure to wave action and sediment properties are well documented as the main factors that control their distribution (Ansell, 1983; Alexander *et al*., 1993; Huz *et al*., 2002). On the contrary, the information on the factors that control the distribution of organisms in the midlittoral zone of sandy beaches in the Mediterranean (where tidal range is extremely small) is very limited and scattered (Giordani Soika, 1955; Dexter, 1986/87, 1989; Koukouras & Russo, 1991; Deidun *et al*., 2003).

In the Mediterranean Sea, the characteristic bivalve of the "midlittoral sand assemblage" described by Pérès (1967) is *Donacilla cornea* (Poli, 1795). The existing information on this species and the factors which govern its distribution are rather scarce indeed (Giordani Soika, 1955; Băcescu *et al*., 1967; Gomoiu, 1968a, b). Koukouras & Russo (1991), studying two bays in the N. Aegean Sea, found *D. cornea* in exposed beaches of coarse sand, but not in those of reduced salinity or influenced by pollution. The same authors showed that the abundance of *D. cornea* was not correlated with salinity, median grain size, dissolved O_2 in the water or sediment organic matter. Pérès (1967) noted that *D. cornea* avoids calcareous sands, while Gomoiu (1968b) found *D. cornea* in biogenic calcareous coarse sands in the Romanian coast of the Black Sea.

This paper aims at identifying the factors that affect the distribution and abundance of *D. cornea*.

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MATERIALS AND METHODS

Sampling was carried out on an one-off basis at 115 selected beaches along the Greek coast and at two beaches in Cyprus (Fig. 1) from September 2001 to September 2004. Most sampling was carried out during autumn and spring, under calm conditions in order to minimize the effect of seasonal variability on sediment properties. Beaches with muddy sediments were not included in the sampling, as they are inhabited by assemblages where *D. cornea* is always absent (Pérès, 1967).

Two random faunal samples were taken per station from the lower midlittoral zone, where the populations of *D. cornea* have their maximum abundance (Mavidis, 2000). Sampling was carried out during ebb tide by means of a quadrat of 400 cm^2 surface area to a depth of 20 cm. Samples were sieved through a 1 mm sieve (Koukouras & Russo, 1991) and fixed in 5% formalin solution. In each station, three sediment samples were also taken by means of a core sampler (3 cm internal diameter) down to 10 cm depth, one for granulometric analysis, one for mineralogical analysis and one for estimation of the organic content. In the laboratory, the faunal samples were sorted and the mean abundance of *D. cornea* was calculated for each station. Juvenile individuals were not considered for abundance in order to have comparative samples; juveniles are present mainly during the recruitment period, that is in summer (Mavidis, 2000), while some stations were sampled in other seasons. Granulometric analysis was carried out according to the methods described by Buchanan (1984); the central tendency and the sorting index (degree of scatter) of the sediment particles were described by

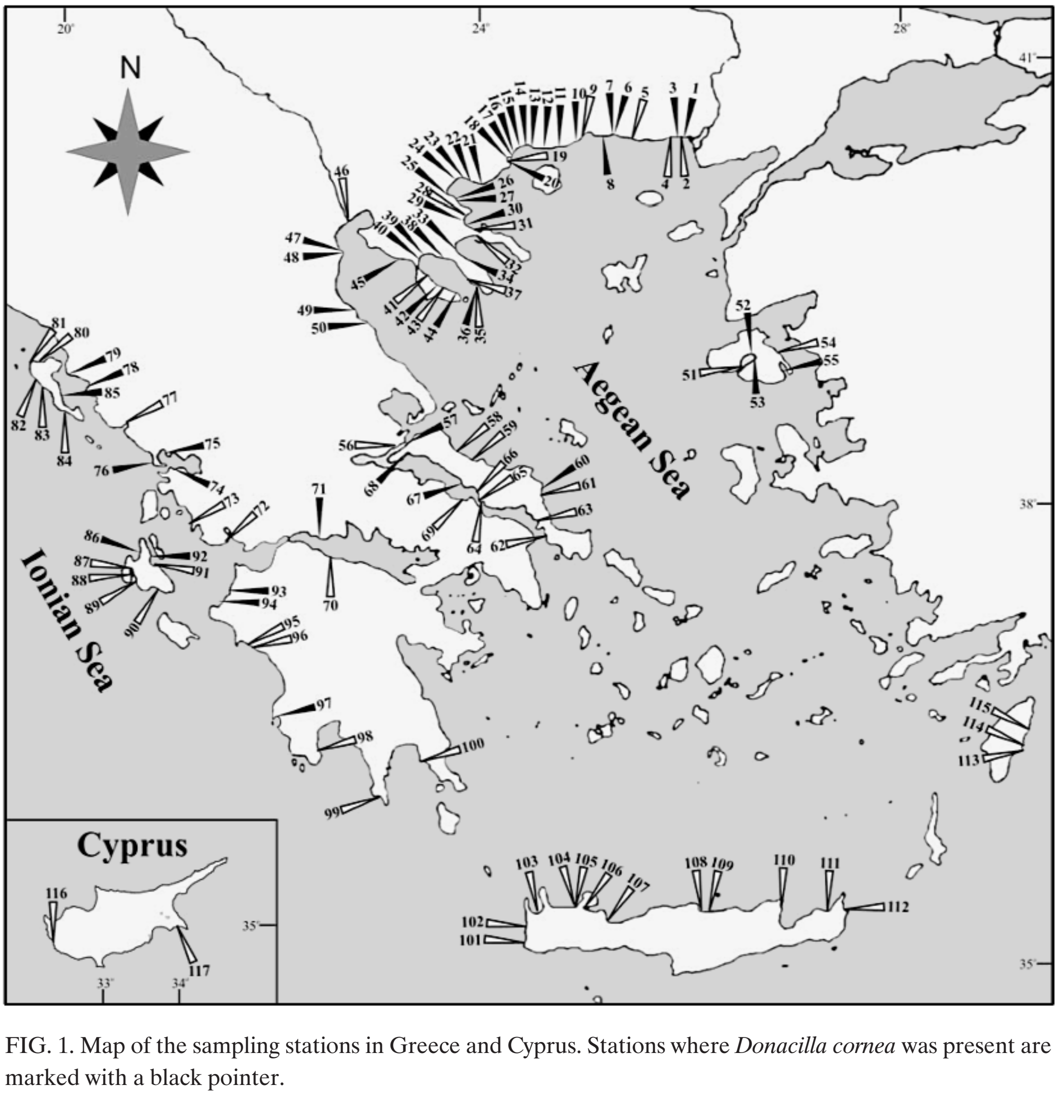

FIG. 1. Map of the sampling stations in Greece and Cyprus. Stations where *Donacilla cornea* was present are marked with a black pointer.

the graphical mean (ME) and the graphical standard deviation (GSD), respectively. Percentage of calcium carbonate in the sediment was estimated as dry sediment weight loss after treatment with HCl (Harris, 1991). The percentage of organic matter content in the sediment was estimated by the loss-on-ignition method after combustion of 2 g of sediment in a muffle furnace for 3 h at 500°C (Luczak *et al*., 1997).

Exposure to wave action was estimated by the adoption of an arbitrary exposure scale (EXP) which was determined on the basis of the fetch length at the direction of the prevailing winds, the duration and intensity of the prevailing winds, and the morphology of the near shore bottom (McLachlan, 1980; Hiscock, 1990; Valesini *et al*., 2003). The fetch length was calculated from map data; wind data were taken from the Hellenic National Meteorological Service, while the near shore bottom morphology was estimated on site during sampling. According to this scale, the studied beaches were separated into the following eight types:

Very sheltered beaches. Completely enclosed coasts or coasts with a fetch less than 10 km facing away from the prevailing winds. Some wave action may occur during storms (Grade scale = 1).

Sheltered beaches. Enclosed coasts with a short fetch facing the prevailing winds. Weak wave action occurs during most of the year (Grade scale = 2).

Sheltered to moderately exposed beaches. Open coasts facing away from the prevailing winds, without a long fetch. Moderate wave action occurs all over the year (Grade scale = 3).

Moderately exposed beaches. Coasts facing away from the prevailing winds, usually having a long fetch. Swells generated by strong prevailing winds in open sea can create relatively high wave conditions. High wave conditions may also occur occasionally when beach faces winds (Grade scale = 4).

Moderately exposed to exposed beaches. Coasts with a usually long fetch facing the prevailing winds. Most of the wave energy is dissipated before waves reach the beach due to the presence of extensive shallow areas offshore (e.g. sand bars) (Grade scale = 5).

Exposed beaches. Open coasts facing away from the prevailing winds but with a long fetch. Strong winds are frequent. Continuous moderate to strong wave action (Grade scale = 6).

Very exposed beaches. Open coasts which face the prevailing winds, without any offshore obstructions for a few hundred kilometers. Storms may prevail for several days (Grade scale = 7).

Extremely exposed beaches. Open coasts which face the prevailing winds without any offshore obstructions for at least 500 km. Both wind-driven waves and swell affect the shore. Storm conditions prevail seasonally (Grade scale = 8).

Ordination of the 117 sampling stations was carried out by Principal Component Analysis (PCA), (Clarke & Warwick, 1994) using the standardized variables EXP, ME (mean grain size), OM (organic matter content), and the fine sand fraction (FSF) which is the sediment fraction with grain size less than 250 μm. The Mann-Whitney U test was employed to assess significant differences in the values of the studied parameters among the groups of stations defined by PCA.

To evaluate the effect of the studied environmental parameters on the abundance of *D. cornea*, a backward stepwise multiple regression analysis was applied to log-transformed data, for the stations where *D. cornea* was present.

RESULTS

The values of the studied abiotic variables as well as the abundance of *D. cornea* in each of the studied stations are given in the Appendix. The whole range from the very sheltered to the extremely exposed beaches was studied. The sediment varied from fine sand to gravels (granules and pebbles) and it was very well to poorly sorted. The percentage of fine sand fraction varied from 0.08% (station 27) to 98.68% (station 72), while the percentage of organic matter in the sediment varied from 0.19% (station 42) to 7.60% (station 101). The entire range from the calcareous sediments (96.53% $CaCO_3$ in station 86) to the quartz sediments (0.87% $CaCO_3$ in station 13) was covered. Spearman's correlation coefficient revealed no high multicolinearity among the studied variables. The highest ϱ value (0.696, $p < 0.01$) was between organic matter and $CaCO_3$.

The ordination of the 117 sampling stations by means of PCA is given in Table 1 and Fig. 2. The ordination of the stations is well described by the first two components in the PCA, since they account for 73% of the sample variability (Table 1; Clarke & Warwick, 1994). According to the values of the eigenvectors, the most important variables for the first component (PC1) were fine sand fraction and mean particle diameter, while the most important variables

TABLE 1. Results of principal components analysis and correlations of principal component values with variables calculated using Spearman's rho [EXP = exposure scale, ME = mean particle size, FSF = fine sand (particles < 250 μm) fraction, OM = organic mater in the sediment]

Factor	Eigenvalues	Percentage variance	Cumulative percentage variance
PC1	1.82	45.6	45.6
PC2	1.09	27.2	72.8
PC3	0.67	16.6	89.4
PC4	0.42	10.6	100.0

Eigenvectors

Factor	EXP	ME	FSF	OM
PC1	–0.346	–0.601	0.640	0.332
PC2	0.703	–0.051	–0.035	0.709

Spearman's correlation coefficient

Factor	EXP	ME	FSF	OM
PC1	0.430*	–0.812*	0.834*	0.397*
PC2	0.815*	–0.036	–0.110	0.571*

* $p < 0.01$

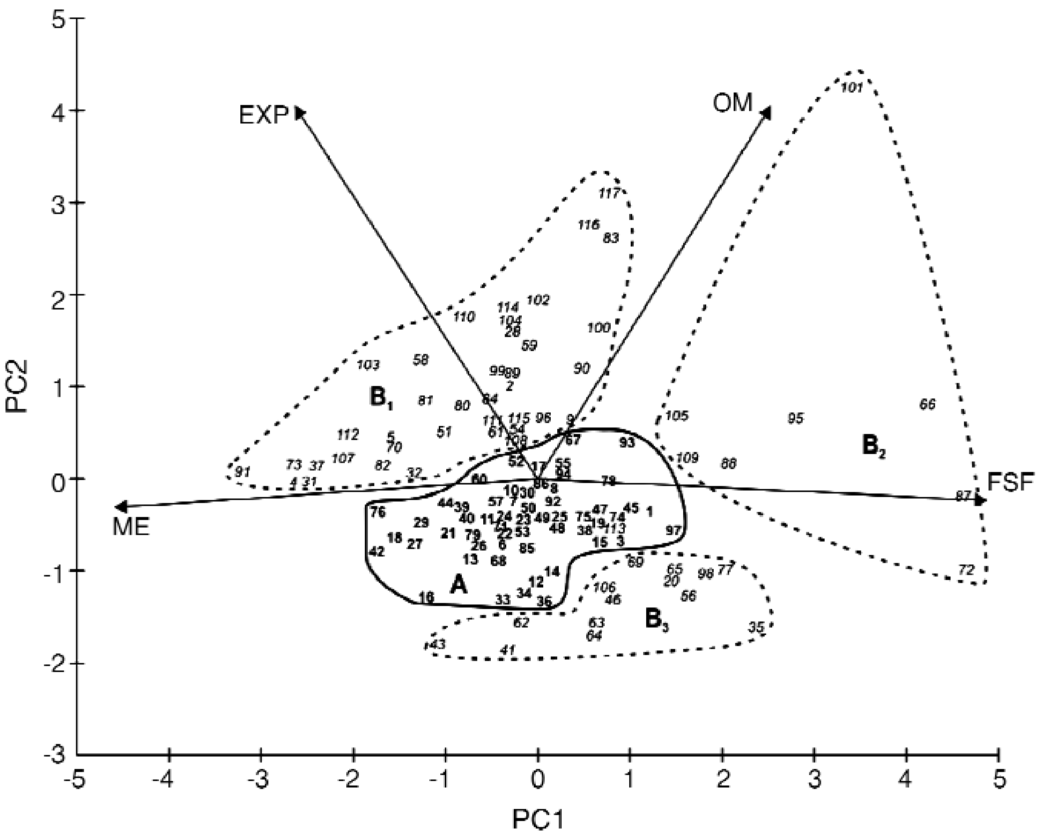

FIG. 2. PCA ordination bi-plot of the sampling stations based on exposure scale (EXP), mean particle size (ME), fine sand fraction (FSF) and organic mater (OM). Stations where *Donacilla cornea* was present are given in bold.

TABLE 2. Comparison of the values of the first two principal components derived form the PCA in each pair of station groups using the Mann-Whitney test

	PC1	PC2
B_1-B_2	741*	146
B_1-B_3	798*	105*
B_1-A	1401*	1696*
B_2-B_3	114*	107*
B_2-A	1653*	1721*
B_3-A	1809*	142*

* $p < 0.01$

for the second component (PC2) were organic matter content and exposure to wave action (Table 1). Spearman's correlation coefficient revealed a high correlation of PC1 with fine sand fraction and mean particle diameter and a high correlation of PC2 with exposure to wave action (Table 1).

From the ordination plot of Fig. 2, four station groups can be distinguished according to their placing in the plot; one where *D. cornea* is present (A), with the exception of station 113, and three where it is absent (B_1, B_2, B_3). Levene's test revealed that the variance among the groups for the values of PC1 and PC2 were not equal ($p = 0.021$ for PC1 and $p < 0.001$ for PC2). For this reason, non-parametric tests were used to compare the four groups. The Kruskal-Wallis test for PC1 (44.087, $p < 0.001$) and PC2 (84.363, $p < 10^{-4}$) showed that there are statistically significant differences among the medians of the four groups. The Mann-Whitney test (Table 2) indicated significant differences among the medians of all groups for the values of PC1, while for the values of PC2 significant differences were not observed only between the medians of groups B_1 and B_2.

The value ranges of sediment properties as well as the values of exposure scale are given separately for each station group in Table 3. *Donacilla cornea* was found only in stations of group A. This group does not include Levantine stations, so *D. cornea* was found only in the Aegean and the Ionian Seas. The sediment in the stations of group A was moderate to very coarse sand and very well to poorly sorted. The percentage of OM ranged between 0.19 and 2.01% and the percentage of $CaCO_3$ varied from 0.08 to 42.18%. In these stations, the fraction of medium sand - pebbles (> 250 μm) exceeded 50% of the sediment, the fraction of fine sand was less than 43% and the fraction of very fine sand - clay (< 125 μm) was less than 10% (Fig. 3).

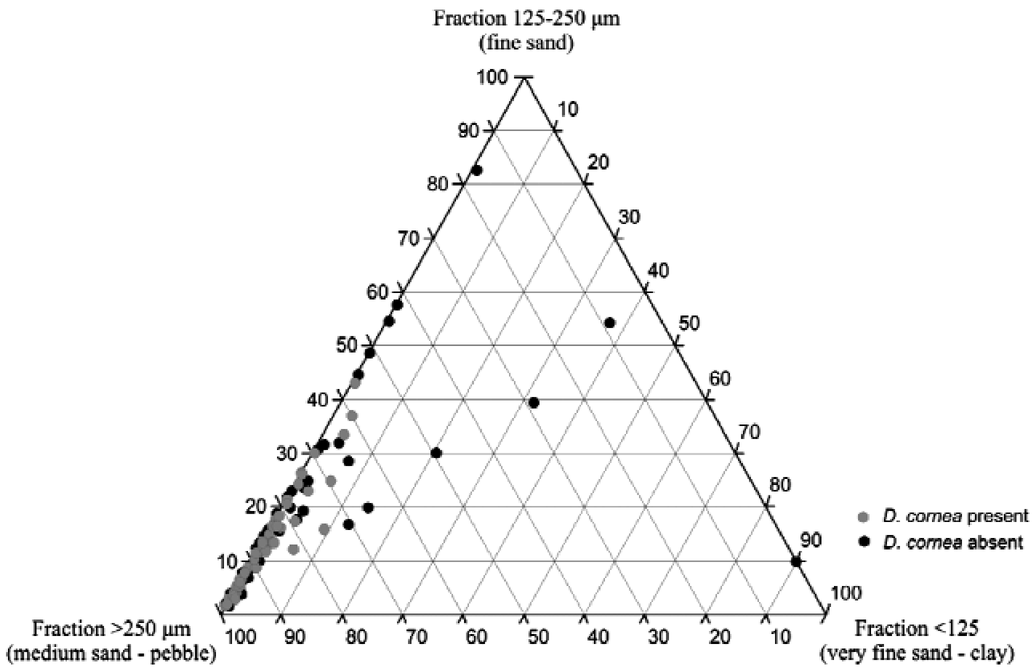

FIG. 3. Distribution of the sampling stations in relation to the percentages of very fine sand - clay, fine sand and medium sand - pebble fractions in the sediment.

TABLE 3. Value ranges of the studied parameters in the station groups derived from PCA [ME = mean particle size, GSD = sorting index, OM = organic mater in the sediment, FSF = fine sand (particles < 250 μm) fraction, EXP = exposure scale]

	A		B_1		B_2		B_3	
	min	max	min	max	min	max	min	max
ME	325	1866	361	2857	77	509	286	1822
GSD	0.23	2.01	0.37	2.05	0.35	1.84	0.45	2.11
OM	0.19	3.48	0.42	5.59	0.75	7.60	0.52	2.18
$CaCO_3$	0.87	96.53	1.83	95.40	11	95	1.56	67.44
FSF	0.08	42.18	0.08	33.95	32.75	98.68	0.09	49.01
EXP	3-6, 1*		7-8		1-2, 7		1-2	

* the exposure value of 1 corresponds only to the abnormal station 113 (see discussion)

In the stations of group A, the mean abundance of *D. cornea* varied from 1 to 230 individuals per 400 cm^2. The abundance values of *D. cornea* were moderately correlated with PC1 values for these stations (Spearman's $\varrho = 0.512$, $p < 0.01$) while they were not significantly correlated with PC2 values (Spearman's $\varrho = -0.066$, $p = 0.620$).

The backward stepwise regression analysis revealed a statistically significant relationship of *D. cornea* abundance with exposure to wave action, mean diameter and sorting index of the sediment. The equation of the fitted model is ln (*D. cornea* abundance) = 18.215 – 2.664 ln(EXP) – 1.836 ln(ME) + 0.869 ln(GSD) ($p < 0.01$, $R^2 = 0.356$, df = 3, F = 9.58). No co-linearity effects were observed amongst the predictor variables (correlation coefficient values < 0.3).

The effect of exposure to wave action on the abundance of *D. cornea* is presented in the scatter plot of Fig. 4, which clearly shows a Gaussian correlation between the two variables. The abundance of *D. cornea* populations increases from sheltered to moderately exposed stations and decreases towards very exposed stations.

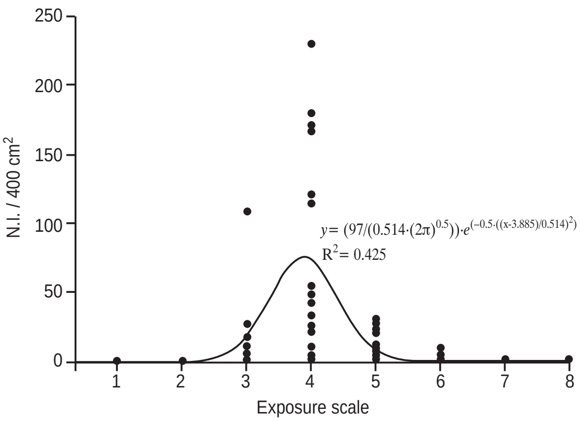

FIG. 4. Distribution of *Donacilla cornea* abundance in the sampling stations where it was found in relation to exposure to wave action (N.I. = number of individuals).

DISCUSSION

During the present study, the entire range of sandy sediments was studied. *Donacilla cornea* was found in sediments with a mean grain diameter of 325 to 1866 μm, i.e. from medium to very coarse sand. Similarly, Koukouras (1979) found *D. cornea* in sediments with a median grain diameter of 312 to 2143 μm in coasts of the northern Aegean Sea, while Gomoiu (1971) found it in sands with an average grain diameter of 759 to 1001 μm, along the Romanian coast of the Black Sea. Generally, deposit feeding bivalves are prevalent in fine sediments, and filter feeding bivalves such as *D. cornea*, are common in coarser sediments (Rhoads & Young, 1970).

The Gaussian distribution pattern of *D. cornea* abundance in relation to exposure agrees with McLachlan (1983) who suggested that bivalves reach maximum abundances in intermediate situations between exposed and sheltered beaches. *Donacilla cornea* was not found in sheltered or very exposed beaches, or in sediments with high percentage of fine sand. Reduced wave action and high percentage of fine particles in the sediment may be both responsible for the absence of *D. cornea* in very sheltered beaches. This is because reduced wave action minimizes the input of detritus in the system (Bustamante & Branch, 1996) limiting the main food source for midlittoral suspension feeders (Langdon & Newell, 1990). Suspended fine sediment particles may reduce the growth rate of the bivalve, as the latter has to spend more energy for the production of pseudofeces (Newell & Hidu, 1986; Dame, 1996), or even clog the filtering device, thus causing smothering of the bivalve (Rhoads & Young, 1970). On the other hand, in very exposed beaches, high energy waves may destabilize the sediment and wash away *D. cornea* before it can be settled in the sediment.

All the Levantine stations (Rhodes and Cyprus islands) were extremely exposed to wave action with the exception of station 113 which is very sheltered. In the Levantine stations, the absence of *D. cornea* should be attributed to exposure, as discussed above. *Donacilla cornea* has not been reported from the south Turkish coast (Demir, 2003), the coast of Israel (Dexter, 1986/87) or the coast of Egypt (Dexter, 1989), a fact possibly due to the high exposure of these coasts. According to Koukouras & Russo (1991), the absence of *D. cornea* from the sea of Levant possibly reflects the generally accepted qualitative impoverishment of the Levantine basin fauna (Por & Dimentman, 1989). The orientation of station 113 in the PCA plot with the stations where *D. cornea* was present (group A), should be attributed to the recorded sediment properties of this station. Station 113 is a very touristic beach and during summer local authorities transfer sand from other areas to improve the sediment quality. Thus, the sediment properties of station 113 do not correspond to the real profile of this beach. Under natural conditions, this station would probably belong to station group B_3.

In our samples, *D. cornea* was found both in quartz and calcareous sands. Furthermore, the multiple regression analysis did not correlate the abundance of *D. cornea* with the percentage of $CaCO_3$ in the sediment. Thus, it can be concluded that $CaCO_3$ content in the sediment is not a factor controlling the presence or the abundance of *D. cornea* in sandy beaches. Probably, the calcium carbonate saturation state at the sediment-water interface and not the $CaCO_3$ content in the sediment is a regulating factor for abundance, since in conditions of undersaturation, recently settled bivalves may suffer high mortality due to shell dissolution (Green *et al*., 2004).

Our results agree with those of Koukouras & Russo (1991) that the percentage of organic matter (OM) in the sediment is not related with the abundance of *D. cornea*. The organic matter content in the sediment is a rough estimator of food availability and is seldom correlated with faunal distributions (Little, 2000), while proteins and total lipids in the sediment are considered better descriptors of food quality (Grémare *et al*., 1997). Furthermore, dissolved organic matter (DOM) may also play an important role in bivalve nutrition (Dame, 1996).

The multiple regression analysis model as fitted explained only 35.6% of *D. cornea* abundance variability. This is because other physical and biological factors, not studied here, may also affect the presence or the abundance of *D. cornea* in a beach. Such factors are the morphodynamic state of the beach (Defeo & McLachlan, 2005), the quality of organic matter available as food (Dame, 1996), the preference of larvae to settle in sediments with specific conditions (Harris, 1991; Crimaldi *et al*., 2002; Schoeman & Richardson, 2002), the predation pressure on the population (Mackinnon, 1997; Beal *et al*., 2001; Seitz *et al*., 2001), the competition with closely related organisms (Defeo *et al*., 1997), mass mortality events (Fiori & Cazzaniga, 1999; Cremonte & Figueras, 2004) or human activities (Defeo & Alava, 1995; Gomoiu & Petran, 1998; Marcomini *et al*., 2002).

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APPENDIX

Exposure values, sediment properties and abundance of *Donacilla cornea* in the studied stations (EXP = exposure scale, ME = mean particle size, GSD = sorting index, OM = organic mater in the sediment, FSF = fine sand fraction, N.I. = mean number of individuals/400 cm^2)

Station	Area	Date	EXP	ME (μm)	GSD (phi)	OM (%)	$CaCO_3$ (%)	FSF (%)	N.I.
1	Apalos, Evros	27-10-01	4	571	1.63	1.42	4.05	35.43	54
2	Alexandroupoli, Evros	6-10-02	7	1191	1.99	2.11	36.19	19.70	0
3	N. Chili, Evros	6-10-02	4	468	1.05	0.87	21.29	25.09	33
4	N. Makri, Evros	6-10-02	7	2324	0.90	0.44	17.55	1.24	0
5	Platanitis, Komotini	7-10-02	7	1550	1.39	1.10	15.24	1.83	0
6	Imeros, Rodopi	7-10-02	4	1222	2.01	0.91	2.98	13.96	120
7	Molyvoti, Rodopi	28-10-01	5	560	0.48	0.93	3.46	1.02	28
8	Glyfada, Rodopi	7-10-02	6	514	1.09	0.56	14.46	19.64	5
9	Mandra, Xanthi	8-10-02	7	413	0.75	1.35	11.43	19.84	0
10	Avdira, Xanthi	8-10-02	5	699	1.16	1.00	10.89	5.03	1
11	West of Nestos R. Estuary	6-11-01	5	636	0.46	0.47	1.26	1.24	4
12	Keramoti, Kavala	29-9-02	3	511	0.40	0.47	1.19	1.41	5
13	Agiasma, Kavala	29-9-02	4	998	0.60	0.49	0.87	0.15	22
14	Xifias Aquaculture, Kavala	29-9-02	4	559	0.97	0.23	1.06	13.75	11
15	N. Karvali, Kavala	8-11-01	4	415	0.98	0.79	7.71	20.15	230
16	Kavala, Kavala	30-9-02	3	1633	1.17	0.45	3.09	2.25	2
17	N. Hrakleitsa, Kavala	30-9-02	4	857	0.53	2.08	1.35	3.69	2
18	N. Peramos, Kavala	6-11-01	5	1587	0.23	0.42	8.44	0.40	1
19	Brasidas cape, Kavala	1-10-02	5	401	0.90	0.59	12.09	24.84	20
20	Brasidas cape port, Kavala	1-10-02	2	475	1.40	1.22	11.32	31.15	0
21	Ofrinio, Serres	8-11-01	5	1191	1.14	0.46	4.48	4.49	1
22	East of Strymonas R. Estuary	13-4-02	5	812	1.39	0.47	11.01	9.08	1
23	West of Strymonas R. Estuary	20-10-01	5	915	1.81	0.60	3.87	17.33	31
24	Panagia, Strymonikos G.	20-10-01	5	934	1.80	0.66	5.31	12.14	5
25	Stavros, Thessaloniki	20-10-01	5	479	0.75	0.59	1.66	15.21	24
26	Olympiada, Chalkidiki	9-3-02	5	818	0.89	0.30	2.12	3.05	1
27	SE of Olympiada, Chalkidiki	9-3-02	5	1337	0.55	0.27	1.93	0.08	2
28	Stratoni, Chalkidiki	9-3-02	7	788	0.93	2.99	20.07	0.86	0
29	SE of Stratoni, Chalkidiki	9-3-02	5	1373	0.33	0.67	1.47	0.09	1
30	Ierisos, Chalkidiki	9-3-02	3	1434	1.89	2.41	17.05	12.06	1
31	N. Roda, Chalkidiki	9-3-02	7	2128	0.86	0.42	10.91	0.26	0
32	Ouranoupoli, Chalkidiki	9-3-02	7	1283	1.25	0.47	1.83	5.68	0
33	Ormos Panagias, Chalkidiki	21-4-02	3	978	0.84	0.32	1.64	6.38	6
34	Vourvourou, Chalkidiki	16-9-01	3	865	1.11	0.43	2.00	10.35	27
35	Porto Koufo lagoon, Chalkidiki	17-2-02	1	286	1.23	0.97	1.56	49.01	0
36	Porto Koufo, Chalkidiki	17-2-02	3	983	1.85	0.25	3.74	19.40	5
37	Toroni, Chalkidiki	17-2-02	7	2127	0.72	0.72	4.07	0.20	0
38	Nikiti, Chalkidiki	16-9-01	5	467	1.08	0.53	3.08	23.24	1
39	Mikiverna, Chalkidiki	16-9-01	5	1420	1.66	1.00	4.70	11.65	1
40	Agios Mamas, Chalkidiki	16-9-01	5	1312	1.61	0.81	3.48	11.68	2
41	N. Fokies, Chalkidiki	18-10-01	1	1140	0.45	0.52	8.58	2.07	0
42	Chanioti, Chalkidiki	18-10-01	5	1716	1.47	0.19	1.80	0.88	1
43	Glarokavos, Chalkidiki	18-10-01	1	1822	0.97	0.73	6.43	0.09	0
44	Paliouri, Chalkidiki	18-10-01	5	1133	0.45	0.94	8.16	0.21	3
45	N. Moudania, Chalkidiki	11-3-02	6	401	1.08	0.33	3.12	42.18	10
46	Axios R. Estuary, Thessaloniki	17-10-01	2	763	1.94	0.94	24.57	23.96	0

APPENDIX continued

Station	Area	Date	EXP	ME (μm)	GSD (phi)	OM (%)	$CaCO_3$ (%)	FSF (%)	N.I.
47	Kitros, Pieria	19-10-01	4	709	1.60	1.42	29.24	24.34	167
48	Korinos, Pieria	18-5-02	4	629	0.99	1.21	9.51	10.25	171
49	Bariko, Pieria	5-11-01	5	610	1.11	0.68	4.75	15.06	13
50	Stomio, Larisa	5-11-01	5	590	0.91	0.84	4.81	7.21	10
51	Apothika, Lesvos	5-11-02	7	1183	1.10	1.21	8.42	6.25	0
52	Skala Kallonis, Lesvos	1-10-02	5	864	1.48	1.79	4.71	8.28	4
53	Nimfida, Lesvos	30-9-02	5	987	1.55	0.51	7.98	19.62	8
54	N. Kidonia, Lesvos	29-9-02	7	739	1.69	1.21	13.41	15.65	0
55	Skala Sikountas, Lesvos	30-9-02	4	1050	1.70	2.34	11.09	16.28	48
56	Glufa, Fthiotida	19-9-01	1	615	1.72	1.55	11.38	33.69	0
57	Orei, Evoia	8-5-02	4	1253	1.37	1.63	19.30	8.47	4
58	Kria Vrisi, Evoia	9-5-02	7	1759	1.64	2.63	45.27	5.87	0
59	Pili, Evoia	9-5-02	7	915	1.58	2.79	4.09	11.80	0
60	Agioi Apostoloi, Evoia	10-5-02	6	742	0.87	0.82	32.94	1.67	1
61	Liani Ammos, Evoia	10-5-02	8	619	1.52	0.69	27.99	14.19	0
62	N. Stira, Leuka, Evoia	10-5-02	1	1349	1.86	1.26	7.13	8.90	0
63	Almiropotamos, Panagia, Evoia	9-5-02	1	1121	2.11	1.02	10.18	25.22	0
64	Leukanti, Evoia	10-5-02	1	981	1.91	0.97	4.97	21.66	0
65	Bourtzi, Evoia	10-5-02	1	690	2.04	2.04	11.99	27.93	0
66	Liani ammouda, Chalkida, Evoia	9-5-02	1	296	1.84	5.17	36.40	69.88	0
67	Vrysakia, Evoia	8-5-02	3	1442	1.83	3.48	52.08	14.03	2
68	Gialtra, Evoia	8-5-02	3	1137	0.92	1.05	4.28	4.35	2
69	Valopoula, Evoia	9-5-02	1	916	1.86	2.18	67.44	21.76	0
70	Diakofto, Achaia	15-7-02	7	1552	1.28	0.98	39.81	3.96	0
71	Chiliadou, Etoloakarnania	10-7-02	4	898	0.89	1.00	23.28	2.23	3
72	Tourlida, Etoloakarnania	4-5-02	1	77	0.46	2.16	11.00	98.68	0
73	North of Astakos, Etoloakarnania	4-5-02	7	2371	1.04	0.78	13.45	0.19	0
74	Bonitsa, Etoloakarnania	4-5-02	4	601	1.79	1.15	52.82	29.06	179
75	Koronisia, Arta	6-5-02	3	743	1.57	1.80	84.13	16.57	108
76	Nikopoli, Preveza	6-5-02	5	1866	0.50	0.94	5.26	0.08	2
77	Ammoudia, Thesprotia	7-10-01	2	391	1.33	1.46	32.27	43.48	0
78	Plataria, Thesprotia	7-10-01	4	732	1.71	1.97	17.21	23.39	26
79	Sagiada, Thesprotia	7-10-01	4	1190	1.50	0.98	60.51	3.26	114
80	Roda, Corfu	5-9-02	7	1449	2.05	1.77	33.87	15.79	0
81	Ag. Ioannis, Sidari, Corfu	5-9-02	7	1767	1.97	1.91	33.11	13.42	0
82	Ag. Georgios Pagon, Corfu	5-9-02	7	1584	1.08	0.65	46.88	3.99	0
83	Palaiokastritsa, Corfu	5-9-02	7	590	1.33	4.73	74.16	11.71	0
84	Issos, Kefallonia	4-9-02	7	668	0.37	1.72	45.31	0.08	0
85	Perama, Corfu	6-9-02	3	1297	1.88	1.36	38.45	15.92	12
86	Assos, Kefallonia	2-5-02	3	1032	1.01	2.65	96.53	1.77	18
87	Elos Livadiou, Kefallonia	2-5-02	1	144	0.62	3.46	95.00	89.74	0
88	Ag. Dimitrios, Kefallonia	2-5-02	2	509	1.71	3.43	73.08	32.75	0
89	Platis Gialos, Kefallonia	2-5-02	7	658	0.75	2.20	95.40	2.15	0
90	Lourdata, Kefallonia	2-5-02	7	1011	1.91	2.45	79.81	33.95	0
91	Sami, Kefallonia	4-5-002	7	2857	0.54	0.73	74.05	0.12	0
92	Agia Ephymia, Kefallonia	3-5-02	4	845	1.43	1.58	72.48	12.62	22
93	Varda, Ileia	22-9-01	6	325	0.62	1.52	30.29	29.14	5
94	Areti, Ileia	22-9-01	6	395	0.64	0.90	33.21	16.35	1
95	Kiani akti, Ileia	24-9-01	7	197	0.54	1.55	32.96	82.00	0
96	Spianza, Ileia	24-9-01	7	390	0.51	1.36	27.13	10.71	0

APPENDIX continued

Station	**Area**	**Date**	**EXP**	**ME (μm)**	**GSD (phi)**	**OM (%)**	**$CaCO_3$ (%)**	**FSF (%)**	**N.I.**
97	Ormos Navarinou, Messinia	25-9-01	4	338	0.93	1.04	13.51	38.44	42
98	Kompi, Messinia	26-9-01	1	409	1.06	1.91	46.89	29.75	0
99	Marmari, Lakonia	27-9-01	8	514	0.50	1.66	34.67	2.64	0
100	Karavostasi, Lakonia	28-9-01	7	463	1.17	3.07	58.81	16.77	0
101	Elafonisi, Crete	1-10-02	7	242	0.35	7.60	90.71	53.34	0
102	Falaserna, Crete	11-9-04	8	515	0.71	2.98	82.84	4.86	0
103	Kissamos, Crete	1-10-02	7	2105	1.34	2.58	35.37	0.68	0
104	Lazareta Is., Chania, Crete	9-9-04	7	871	0.56	3.16	95.14	1.36	0
105	Chania, Crete	9-9-04	7	266	0.53	1.49	36.81	47.34	0
106	Souda, Crete	9-9-04	1	542	0.80	1.56	52.93	4.95	0
107	Kavros, Crete	10-10-02	7	1914	1.06	0.83	17.89	0.61	0
108	Tobrouk, Iraklion, Crete	8-10-02	7	440	0.49	1.13	59.54	5.92	0
109	Karteros R. Estuary, Crete	8-10-02	7	265	0.68	0.75	49.37	56.51	0
110	Elounta, Crete	9-10-02	7	1407	1.12	3.37	89.24	2.23	0
111	Sitia, Crete	9-10-02	7	775	0.96	1.29	18.71	7.50	0
112	Kouremenos, Crete	9-10-02	7	1965	1.14	1.27	18.27	0.20	0
113	Ag. Paulos, Lindos, Rhodes	26-12-01	1	735	1.09	2.72	84.81	3.92	0
114	Lindos, Rhodes	26-12-01	7	970	1.07	3.47	74.62	1.27	0
115	Tsampika, Rhodes	26-12-01	7	427	0.54	1.24	69.61	5.36	0
116	Lara, Akamas, Cyprus	2-1-03	8	361	0.37	4.36	63.90	4.76	0
117	Lanta, Ag. Napa, Cyprus	2-1-03	7	762	1.27	5.59	94.88	9.73	0