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THE BEACH SHELL ASSEMBLAGE OF PONTEDORO: A PRELIMINARY LIST OF MOLLUSC SPECIES WITH SOME NOTES ON PREDATION PHENOMENA

Riassunto — *Le conchiglie spiaggiate a Pontedoro: breve nota sui molluschi rinvenuti con alcune osservazioni sui fenomeni di predazione.* Vengono riportati i risultati di un'indagine su gusci di molluschi rinvenuti spiaggiati a Pontedoro (Piombino, Livorno). È riportata la lista sistematica delle specie raccolte. Nel campione sono presenti tracce di un'intensa predazione, soprattutto su bivalvi, ad opera di gasteropodi perforatori, in special modo naticidi. Una gran parte della mortalità dei molluschi delle biocenosi antistanti il punto di raccolta sembra essere dovuta all'azione di questi predatori.

Abstract — Results are here presented for a preliminary characterization of a shell assemblage on the beach of Pontedoro (Piombino, Leghorn). The sistematic list of species is reported. In the sample numerous traces of drilling activity were found, especially on bivalves, and are mostly due to naticid and muricid snails. A great deal of the total mortality on molluscs of the corresponding biocoenoses seems to be caused by these drills.

Key words — Beach shell assemblage / Mollusc / Predation.

INTRODUCTION

The beach of Pontedoro, near Piombino (Leghorn), is characterized by a great abundance of mollusc shells which are gathered here by sea waves. This peculiar feature provides an easy opportunity for a preliminary analysis of the malacofauna of the nearby sea bottom communities, through the examination of these beach shell assemblages. The study of beached shells can also give some infor-

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mations on the ecological relationships existing in the benthic biocoenoses.

The area of interest is typically soft bottomed and previous reports record it as characterized by fine and rather uniform sands (LARDICCI, 1981; ZUNARELLI VANDINI and COGNETTI VARRIALE, 1981). The communities of this area have been studied in relation to their possible alteration by the coastal power station of Torre del Sale (CREMA and BONVICINI PAGLIAI, 1981; LARDICCI, 1981; ZUNARELLI VANDINI and COGNETTI VARRIALE, 1981); special attention was here given to polychete species. Another previous report (BIAGI and POLI, 1981) concerned the malacofauna of a rather isolated and peculiar area, the so called «Chiusa di Pontedoro».

Data are here presented concerning the molluscan species recovered in just one sampling operation; special attention was paid to the phenomena of predation by both muricid and naticid gastropods on bivalves. The traces of the predatory activity of these prosobranchs can be easily detected as typical holes on preyed shells. The morphology of these holes reveals whether they were the product of either muricid or naticid snails; muricid holes are in fact cylindrical while naticid ones are clearly conical (CARRIKER and YOCHELSON, 1968). The mechanisms by which these holes are actively drilled through the prey shells have been studied by several Authors (TURNER, 1953; ZIEGELMEIER, 1954; CARRIKER *et al.*, 1967; WEBB and SALEUDDIN, 1977; CARRIKER, 1978).

MATERIALS AND METHODS

The sampling site is located about 400 m on the right from the estuary of the River Cornia. The sample was collected on a surface area of about 100 m^2 by sieving the superficial layer of sand with a 2 mm mesh. The organogenic remains were thus separated from sand, and mollusc shells, which constituted almost all the sample, were classified according to BRUSCHI *et al.* (1985).

For each species the number of collected individuals was recorded as follows:

— as for gastropods, any fraction of shell larger than half a shell was recorded as an individual; other minor parts were recorded as fragments;

— as for bivalves, each disarticulated valve and each entire specimen were considered representative of single individuals; care

was taken to be sure that each disarticulated valve did not match with any other in the lot (otherwise two matching valves would have been recorded as a single individual). Thus we have that the number of individuals, n, is given by:

$$n = C.I.S. + C.D.S. + I.V. + D.V.$$

where C.I.S. = complete intact specimens; C.D.S. = complete drilled specimens; I.V. = intact valves; D.V. = drilled valves

For those bivalve species represented at least by 30 individuals, also the predation mortality (p.m.) was calculated. The p.m. is defined as

$$p.m. = \frac{C.D.S. + 2\ D.V.}{n}$$

where doubling of D.V. at the numerator is necessary because only one of the two valves of the prey is usually bored by drills. It should be noted that only entire valves were considered in evaluating both n and p.m. for each bivalve species. Since broken valves were not recorded for the quantitation of n, and since may of these fractured shells may have been the product of crustacean activity, then it descends that our p.m. is an overestimate of the real mortality caused by piercing gastropods on the prey population. We can assume p.m. as the maximum fraction of the total mortality which can be attributed to gastropod predation solely (see also CADÉE, 1968).

RESULTS

The following list reports the mollusc species found in the shell assemblage. The species showing traces of predation by either naticid or muricid gastropods are marked respectively by (*) or (**); n is the number of individuals, D.V. the number of drilled valves, D.S. the number of drilled specimens, and p.m. the predation mortality. When fragments were recovered for a species, they are reported as fr. (single fragment) or as frs. (fragments).

GASTROPODA

Diodora graeca (L., 1758) - n = 2

Fissurella nubecula (L., 1758) - n = 3
Patella caerulea L., 1758 - n = 4
Patella rustica L., 1758 - n = 1
* *Jujubinus exasperatus* (PENNANT, 1777) - n = 21; D.S. = 1
Monodonta mutabilis (PHILIPPI, 1846) - n = 1
Gibbula adansoni (PAYRAUDEAU, 1826) - n = 3
Gibbula ardens (VON SALIS, 1739) - n = 5
Gibbula philberti (RECLUZ, 1843) - n = 5
* *Gibbula varia* (L., 1758) - n = 27; D.S. = 2
* *Calliostoma laugieri* (PAYRAUDEAU, 1826) - n = 4; D.S. = 1
Calliostoma zizyphinum (L., 1758) - n = 1
Astraea rugosa (L., 1767) - n = 1
** *Homalopoma sanguineum* (L., 1758) - n = 2; D.S. = 1
** *Tricolia pullus* (L., 1758) - n = 7; D.S. = 1
Tricolia tenuis (MICHAUD, 1829) - n = 13
Smaragdia viridis (L., 1758) - n = 7
Hydrobia stagnalis (BASTER, 1765) - n = 3
Peringia ulvae (PENNANT, 1777) - n = 11
Truncatella subcylindrica (L., 1767) - n = 13
Apicularia lia (BENOIT in MONTEROSATO, 1884) - n = 1
Rissoa hyalina FREMINVILLE, 1814 - n = 120
Rissoa ventricosa DESMAREST, 1814 - n = 157
Rissoa labiosa (MONTAGU, 1803) - n = 1
Turboella lineolata (MICHAUD, 1832) - n = 1
Turboella radiata (PHILIPPI, 1836) - n = 1
Alvania discors (ALLAN, 1818) - n = 25
Alvania lineata RISSO, 1826 - n = 5
Turbona cimex (L., 1758) - n = 46
Turbona geryonia (CHIEREGHIN in NARDO, 1847) - n = 1
Rissoina bruguièrei (PAYRAUDEAU, 1826) - n = 9
Turritella communis RISSO, 1826 - n = 1
* *Philippia mediterranea* (MONTEROSATO, 1872) - n = 6; D.S. = 1
Bittium reticulatum reticulatum (DA COSTA, 1778) - n = 1238
Cerithium rupestre RISSO, 1826 - n = 3
* *Cerithium vulgatum* (BRUGUIERE, 1792) - n = 55
Epitonium commune (LAMARCK, 1822) - n = 3
Epitonium turtoni (TURTON, 1819) - n = 7
* *Strombiformis glaber* (DA COSTA, 1778) - n = 11; D.S. = 2
Calyptraea chinensis (L., 1758) - n = 3
Lunatia macilenta (PHILIPPI, 1844) - n = 12

Neverita josephinia Risso, 1826 - n = 7
Naticarius hebraeus (Martyn, 1784) - n = 1
Cymatium cutaceum (L., 1767) - fr.
Bolinus brandaris (L., 1758) - fr.
Phyllonotus trunculus (L., 1758) - n = 2
Ocenebra erinaceus (L., 1758) - fr.
Ocinebrina edwardsi (Payraudeau, 1826) - n = 1
Cantharus dorbignyi (Payraudeau, 1826) - fr.
Columbella rustica (L., 1758) - fr.
Cyclope donovani Risso, 1826 - n = 11
Cyclope neritea (L., 1758) - n = 3
Hinia incrassata (Strom, 1768) - n = 3
Hinia reticulata (L., 1758) - n = 1
Nassarius mutabilis (L., 1758) - frs.
Nassarius cuvierii (Payraudeau, 1826) - n = 1
Fusinus pulchellus (Philippi, 1844) - n = 1
Vexillum tricolor (Gmelin in L., 1791) - n = 1
Conus ventricosus (Gmelin in L., 1791) - n = 9
Bellaspira septangularis (Montagu, 1803) - n = 1
Bela laevigata (Philippi, 1836) - n = 51
Bela nebula (Montagu, 1803) - n = 3
Mangelia attenuata (Montagu, 1803) - n = 3
Mangelia rugulosa (Philippi, 1844) - n = 1
Mangelia vauquelini (Payraudeau, 1826) - n = 3
Mangiliella multilineolata (Deshayes, 1833) - n = 1
Raphitoma echinata (Brocchi, 1814) - fr.
Gibberula miliaria (L., 1758) - n = 23
* *Acteon tornatilis* (L., 1758) - n = 1 + frs.; D.S. = 1
Ringicula auriculata (Menard de la Groye, 1811) - n = 2
Bulla striata Bruguiere, 1789 - n = 2
Turbonilla rufa (Philippi, 1836) - n = 9
Ovatella myosotis (Draparnaud, 1801) - n = 3

Scaphopoda

Dentalium dentalis L., 1758 - n = 4
Dentalium inaequicostatum Dautzenberg, 1891 - n = 6
Dentalium vulgare Da Costa, 1778 - n = 17
Fustiaria rubescens (Deshayes, 1825) - n = 10

BIVALVIA

Nucula nucleus (L., 1758) - n = 9
* *Nuculana pella* (L., 1767) - n = 8; D.V. = 1
** *Arca noae* L., 1758 - n = 26; D.V. = 1
Barbatia barbata (L., 1758) - n = 11
** *Striarca lactea* (L., 1758) - n = 66; D.V. = 8; p.m. = 0.242
* *Glycymeris insubrica* (BROCCHI, 1814) - n = 1401; D.V. = 369; p.m. = 0.526
Mytilaster minimus (POLI, 1795) - n = 2
** *Mytilus galloprovincialis* LAMARCK, 1819 - n = 192; D.V. = 19; p.m. = 0.197
Modiolus barbatus (L., 1758) - n = 3
Chlamys multistriata (POLI, 1795) - n = 3
Chlamys varia (L., 1758) - n = 15
Spondylus gaederopus L., 1758 - n = 2
Anomia ephippium L., 1758 - n = 96 + frs.
Lima inflata (LINK, 1807) - n = 3
** *Ostrea spp.* - n = 94; D.V. = 15; p.m. = 0.319
* *Ctena decussata* (O.G. COSTA, 1829) - n = 1; D.V. = 1
* *Loripes lacteus* (L., 1758) - n = 1414; D.V. = 138; p.m. = 0.195
* *Divaricella divaricata* (L., 1758) - n = 72; D.V. = 15; p.m. = 0.416
Anodonta fragilis (PHILIPPI, 1836) - n = 2
Myrtea spinifera (MONTAGU, 1803) - n = 1
** *Chama gryphoides* L., 1758 - n = 14; D.V. = 3
Pseudochama gryphina (LAMARCK, 1819) - n = 7
Scacchia ovata PHILIPPI, 1844 - n = 2
Bornia sebetia (O.G. COSTA, 1829) - n = 1
Tellimya ferruginosa (MONTAGU, 1808) - n = 1
Glans trapezia (L., 1767) - n = 5
Acanthocardia paucicostata (G.B. SOWERBY II, 1841) - n = 2
* *Acanthocardia tuberculata* (L., 1758) - n = 210; D.V. = 20; p.m. = 0.190
Parvicardium exiguum (GMELIN in L., 1791) - n = 27
Plagiocardium papillosum (POLI, 1791) - n = 8
Cerastoderma glaucum (POIRET, 1789) - n = 368
Cerastoderma edule (L., 1758) - n = 779
* *Mactra stultorum* (L., 1758) - n = 33; D.V. = 14; p.m. = 0.848
* *Spisula subtruncata* (DA COSTA, 1778) - n = 294; D.V. = 17; p.m. = 0.115

Solen marginatus PENNANT, 1777 - frs.
Ensis siliqua minor (CHENU, 1843) - n = 1 + frs.
Tellina tenuis DA COSTA, 1778 - n = 2
Tellina fabula GRONOVIUS, 1781 - n = 4
Tellina incarnata L., 1758 - n = 1
* *Tellina donacina* L., 1758 - n = 5; D.V. = 1
Tellina nitida POLI, 1791 - n = 5
Tellina planata L., 1758 - n = 7
* *Tellina pulchella* LAMARCK, 1818 - n = 43; D.V. = 2; p.m. = 0.093
Gastrana fragilis (L., 1758) - n = 1
* *Donax semistriatus* POLI, 1795 - n = 209; D.V. = 5; p.m. = 0.0478
* *Donax trunculus* L., 1758 - n = 131; D.V. = 23; p.m. = 0.351
Psammobia fervensis (GMELIN in L., 1791) - n = 1
Scrobicularia plana (DA COSTA, 1778) - n = 11
Abra ovata (PHILIPPI, 1836) - n = 18
Abra alba (W. WOOD, 1802) - n = 2
* *Venus verrucosa* L., 1758 - n = 8; D.V. = 2
* *Chamelea gallina gallina* (L., 1758) - n = 611; D.V. = 168; p.m. = 0.550
* *Gouldia minima* (MONTAGU, 1803) - n = 1; D.V. = 1
* *Dosinia lupinus* (L., 1758) - n = 47; D.V. = 11; p.m. = 0.468
Irus irus (L., 1758) - n = 2
Tapes decussatus (L., 1758) - n = 4
* *Venerupis aurea* (GMELIN in L., 1791) - n = 4; D.V. = 1
* *Venerupis senegalensis* (GMELIN in L., 1791) - n = 23; D.V. = 1
Petricola lajonkairii (PAYRAUDEAU, 1826) - n = 2
Petricola lithophaga (RETZIUS, 1786) - n = 1
* *Corbula gibba* (OLIVI, 1792) - n = 17; D.V. = 1
Lentidium mediterraneum (O.G. COSTA, 1829) - n = 1
Barnea candida (L., 1758) - n = 19
Pholas dactylus L., 1758 - n = 7
Pandora inaequivalvis (L., 1758) - n = 1

DISCUSSION

The analysis of beached thanatocoenoses has been frequently used as an approach for the study of marine mollusc communities (see CADÉE, 1968; LUQUE and TEMPLADO, 1981), and has provided some observations on the incidence and modalities of gastropod preda-

tion upon bivalve molluscs (PIERON, 1933; ANSELL, 1960; GEORGE, 1965; NEGUS, 1975; VIGNALI and GALLENI, 1986). The stringency of this kind of studies, as well as of this brief report, is however limited by an imperfect correspondence between the real community and the relative beach shell assemblage (for a full discussion see CADÉE, 1968).

In the sample 73 gastropod species, 4 scaphopod species and 65 bivalve species were found (see Results). As expected, the great majority of them are typical of soft bottom substrata; the occurrence of rocky bottom species is explained by the existence of artificial rocks not far from the sampling site and/or by the contribution made to the shell assemblage by remains coming from off-coast.

Gastropod shells from the sample show sometimes traces of predation by muricid or naticid snails, but a much more extensive predation exists on bivalves. The distribution of naticid and muricid holes fits very well with the ecological distribution of the preys, especially in the case of bivalve prey species; thus muricid holes are found on rocky bottom species, such as *Arca noae, Striarca lactea, Mytilus galloprovincialis*, while naticid holes are found on sandy bottom species such as *Glycymeris insubrica, Donax trunculus, Chamelea gallina.*

Muricid holes were present in fewer species than naticid ones, but this may reflect the relative proportion of rocky bottom to soft bottom species. Muricid can account for a substantial part of the mortality found in *Mytilus galloprovincialis, Striarca lactea* and *Ostrea* spp. (see p.m. values in Results). Frequently two or sometimes even three holes were observed on the shells of *Mytilus galloprovincialis*, as if more than one predator fed on the same mussel. *Ocinebrina edwardsi*, which is present in the thanatocoenosis, seems to be most probably responsible for these attacks; its predatory behavior is well documented by both field and laboratory studies (CURINI GALLETTI and GALLENI, 1981; TONGIORGI *et al.*, 1981; CURINI GALLETTI and GALLENI, 1984).

Soft bottom bivalves suffer an intense predation by naticid snails (see Results). If we sum up all the valves recovered for preyed species that have at least 30 individuals in the sample and then we consider the p.m. for this heterogeneous population, we obtain an overall value for it of about 0.35; this means that up to 35% of the total mortality within this group of species could be the result of naticid predation events. It should be noted, however, that this high overall p.m. is the result of a heterogeneous situation; in fact, we can observe that

some species are very intensely predated while others show low values of p.m.; thus the p.m. from such a fractionated population is to be considered as a very indicative parameter. More definite data on naticid impact on bivalve populations can be obtained when studying homogeneous populations; however even within a single species there are different predation pressures according to the size of individuals (see VIGNALI and GALLENI, 1986).

Three naticid species are present in the sample that can account for predation on soft bottom bivalves; these are *Naticarius hebraeus, Lunatia macilenta* and *Neverita josephinia*; they may each be co-responsible for predation on all the drilled species, but it is impossible, from the present data, to tell their respective incidence on the prey populations.

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