INDUCTION OF NOVEL RE-SEGREGATION AND SELECTION PROCESSES BY ANTHROPOGENIC FACTORS ON LITTORAL MARINE MOLLUSCS

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Abstract

Various in vivo and in vitro methods, contact microscopy and fluorescent markers, were used by us to compare several populations of molluscs from polluted and reference sites along the Israeli littoral in the Mediterranean Sea and the Gulf of Aqaba (Red Sea). The parameters compared included multixenobiotic and antianionic defense systems, micronucleation, membrane permeability and cholinesterase activity. In all species studied the samples from the polluted sites differed markedly from these of the reference sites in all the investigated parameters. Based on the data we hypothesize the occurrence of a special type of stress-induced selection in which specific genotypes proved more fit under stress.

Key words: Anthropogenic stressors, marine molluscs, selection

Already in 1913, an environmental publication of the Smithsonian Institution noted that "life is the reaction of the living substance to the ceaseless play of the environment". Man-made environmental factors are especially prominent in the near-shore habitats of enclosed seas, exemplified by the Mediterranean Sea, the Gulf of Aqaba and similar basins. These negative influences have become especially disturbing during the last 50 years, as thousands of biologically active substances find their way into the littoral, causing a decline in species richness and inducing pathological alterations in the surviving taxa (1,2). Consequently, assemblages of genotypes were confronted with new selection regimes. As a result, new fitting mechanisms have become activated, showing features of successive selection, especially changes in polymorphism (3). Today this constitutes the very essence of response to environmental stress, in which genotypes of specific phenotypic qualities either vanish or must recombine their biological qualities to form novel genotypes suited to the demands of the habitat. One of the first such described adaptive forms was the "industrial race" of butterflies, whose melanistic pattern blended into the darkened tree-trunks. Nevo and Laevi (3, 4) described such developments in some Mediterranean molluscs. During the last five years we have studied a group of littoral molluscs from both clean and polluted sites, recognized by us as good indicators of environmental health (5, 6). These included two species of patellid gastropods, *Patella caerulea* (Mediterranean Sea) and *Cellana rota* (Red Sea), and three species of bivalves, *Pteria aegyptia* (Red Sea), *Brachidontes pharaonis* and *Donax trunculus* (Mediterranean Sea). Using in vitro and in vivo fluorescent and fluorimetric methods as described by Bresler *et al.* (5), we compared in these taxa the state of defense systems, such as multixenobiotic resistance transporters (MXRtr) and the system of active transport of organic anions (SATOA), the permeability (PERM) of the external epithelia, the levels of micronucleation (MNT), and other parameters. The results showed that the populations from polluted sites differed significantly ($p<0.05$, t-test for comparisons of means) from those from the clean sites (Table 1); correlation procedures also corroborated these results. Figure 1 compares samples of *Donax trunculus* from sandy shores of the Israeli Mediterranean. A convergent picture is shown by the Red Sea patellid *Cellana rota* and the Mediterranean *Patella caerulea* (Fig. 2). In both basins, the populations of the two taxa from polluted and clean sites are definitely separated. Moreover, in each site samples of the two taxa are closer to each other than to their con-specifics in other sites. It would be safe to assume that the examined features are, at least partly, genetically controlled, reflecting changes in genotype frequencies, probably due to action of limited, local selection. The results of such selective processes will depend primarily on three major factors: the strength and duration of the stressors, and the ability of the populations to adapt. An additional and important factor for stabilization of the novel phenotypes depends on the transport of their propagules. The shorter living these stages will be, the more rapidly the locally produced genotypes become fixed.

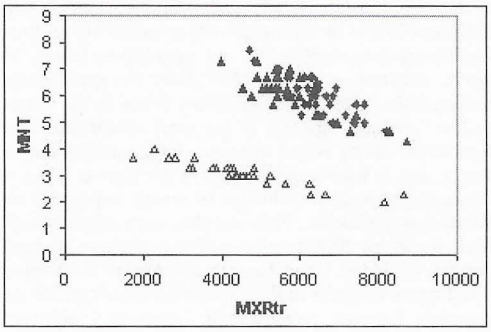

Figure 1. MNT and MXRtr values (in arbitrary units) of ninety specimens of *D. trunculus* from three sites in the Mediterranean (black marks = polluted).

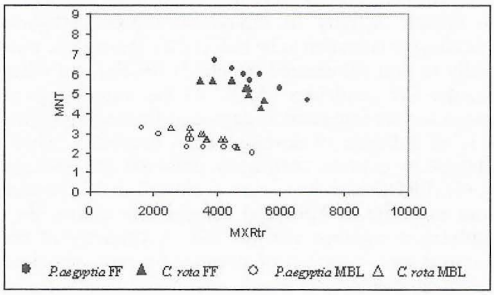

Figure 2. MNT and MXRtr values (in arbitrary units) of *P. aegyptia* and of *C. rota* from the Red-Sea (black marks = polluted). MBL = Marine Biological Laboratory (reference site); FF= fish farming cages (polluted site).

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Table 1. Average ± standard deviation values of defense systems activity in some of the studied molluscs sampled from polluted and reference sites (arbitrary units).

Species	SITE	MXRtr	MNT	SATOA	PERM
Brachidontes pharaoni	Reference	4112.20 ± 988.13	2.43 ± 0.33	265.20 ± 34.11	4.34 ± 0.28
	Polluted	7433.40 ± 790.75	5.50 ± 0.60	379.20 ± 42.15	7.96 ± 0.56
Donax trunculus	Reference	4398.70 ± 659.22	3.12 ± 0.43	303.15 ± 47.58	3.55 ± 0.25
	Polluted	6328.45 ± 1735.17	6.32 ± 0.76	344.00 ± 36.09	6.00 ± 0.21
Patella caerulea	Reference	5046.90 ± 995.45	2.66 ± 0.31	294.00 ± 57.45	4.05 ± 0.21
	Polluted	7631.00 ± 522.99	5.81 ± 0.66	397.80 ± 17.92	7.40 ± 0.75