Effects of pollution on the physiology of *Acartia clausi* and total zooplankton from Saronikos Gulf

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A study of the influence of pollution on the physiology of the crustacean copepod *Acartia clausi* and total zooplankton was carried out in coastal polluted and non polluted areas of the Saronikos Gulf (Gulf of Athens). The physiological situation of the organisms was examined by means of a dual approach : metabolic (respiration rate) and enzymatic in order to obtain a pluridimensional view of the effects of pollution on coastal zooplankton at the physiological level. The copepod species, *Acartia clausi*, was chosen as one of the basic elements of the zooplanktonic community of the Saronikos Gulf (MORAITOU-APOSTOLOPOULOU, 1974).

Two sampling areas were chosen : Elefsis bay (eutrophic, one of the most polluted areas in the eastern Mediterranean) and Vouliagmeni bay and Fleves islands (oligotrophic, non polluted area). Several samples were collected in both areas during spring and summer 1991. After transport to the laboratory, one zooplankton sample was used to select two or more sets of mature specimens of alive *Acartia clausi* (100 ind., 200 ind. when possible). The other total zooplankton samples and the sets of selected *A. clausi* were divided into two groups. The first one was preserved in a freezer (- 25°C) and transported by air to Marseille (France) in a dry ice container for electrophoresis and enzymatic tests. Oxygen consumption and dry weight were measured from the second group.

Electrophoresis were carried out on 7,5% polyacrylamide gel using a Tris-Glycine buffer pH 8,5. Several enzymatic activities were revealed. The API-ZYM system (Bio-Mérieux, France) was used as a semiquantitative micromethod to test enzymatic activity of 19 hydrolases. Oxygen consumption measurements were carried out using an oxymeter (YSI model 51 B) according to OMORI and IKEDA (1984). The statistical analysis of the results were based mainly on a multifactor analysis of variance, taking into account the respiration rate and the presence or absence of food during the experiment, the season and the locality.

Figures 1 and 2 show the differences observed in *A. clausi* and total zooplankton zymograms of esterases and amylase between the two sampling areas. Figure 3 gives the comparative activities of 19 hydrolases tested by the API-ZYM technique in the total zooplankton from the two areas.

Mean oxygen consumption rate for *A. clausi* was 5.9 ± 0.7 µl O_2. mg $DW^{-1}.hr^{-1}$ in spring and 3.1 ± 0.9 µl O_2. mg DW^{-1}. hr^{-1} in summer. This seasonal variation was statistically significant (P= 0.02). A geographical variation was also observed : the copepods of the non polluted area (Vouliagmeni-Fleves) had a higher respiration rate (5.6 ± 1.0 µl O_2. mg DW^{-1} hr^{-1} than those of the polluted eutrophic area of Elefsis bay (3.5 ± 0.7 µl O_2. mg DW^{-1} hr^{-1}). But the difference was only significant at the probability level P = 0.06.

No statistically significant variation was observed in the respiration rate of starved and fed *Acartia* collected at different seasons and in the two areas. Nevertheless, the variability induced by the absence of food was greater in *Acartia* from Vouliagmeni-Fleves than in those from Elefsis bay. The seasonal variation was also greater in *Acartia* from Vouliagmeni-Fleves.

The results, either concerning respiration metabolism or enzymatic activities, show that physiological differences exist either in *A. clausi* or total zooplankton according to the area concerned, the very polluted, eutrophic Elefsis bay, and the non polluted oligotrophic area of Vouliagmeni-Fleves.

Enzymes tested are essentially hydrolases acting on substrates provided by the environment. The differences in the activity observed for most of them according to the origin of the organisms, thus may be attributed to the trophic conditions of the sampling areas. Therefore, they appear to be an ecophysiological response to environmental conditions (RIVIERE et KERAMBRUN, 1983). The major tendency is a generally higher enzymatic activity in the zooplankton from Elefsis bay. In *A. clausi*, among the few enzymes whose activity appears to be greater at Fleves, we can only take into consideration alkaline phosphatase and amylase. In the case of *A. clausi*, the pollution of Elefsis bay seems to have an "activatory" effect on most of the enzymatic systems tested.

The respiration rate of *A. clausi* showed a clear geographical and seasonal variation in the metabolism. Copepods from the polluted, eutrophic area (Elefsis bay) have a lower respiration rate than those of the non polluted, oligotrophic area (Vouliagmeni-Fleves). Respiration rate also decreases by about 50% from spring to summer in *Acartia* from Vouliagmeni whereas this decrease is lower in polluted waters.

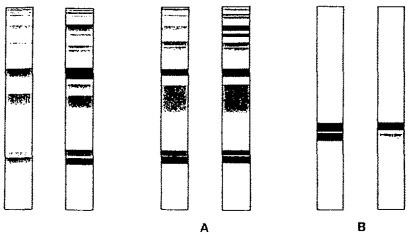

Fig. 1. Acartia clausi. Zymograms of esterases. Sample from Fleves on the left, from Elefsis on the right.

Fig. 2. Total zooplankton. A, zymograms of esterases; B, zymograms of amylase. In both cases, sample from Fleves on the left, from Elefsis on the right.

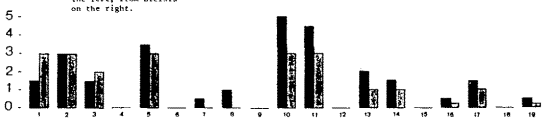

Figure 3. *Acartia clausi*. Comparative enzymatic activities mean obtained from API- ZYM (arbitrary units from 0 to 5). Dark: Elefsis bay samples; Light: Fleves islands samples.
1, acid phosphatase; 2, esterase (C4); 3, esterase lipase (C8); 4, lipase (C14); 5, leucine arylamidase; 6, valine arylamidase; 7, cystine arylamidase; 8, trypsine; 9, α-chymotrypsine; 10, acid phosphatase; 11, phosphoamidase; 12, α-galactosidase; 13,β-galactosidase; 14,β-glucuronidase; 15, α–glucosidase; 16,β–glucosidase; 17, N-acetyl-β-glucosaminidase; 18, α-mannosidase; 19, α-fucosidase

Literature data indicate that the population of *A. clausi* of Elefsis bay is adapted to pollution (MORAITOU-APOSTOLOPOULOU et VERRIOPOULOS, 1979, 1981 a, b). Our results, both concerning enzyme activity and respiration rate, show that the differences observed between sampling areas seems to be directly linked to the degree of water pollution, which influences ecophysiological relationships, thus affecting general metabolism.

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REFERENCES

MORAITOU-APOSTOLOPOULOU M., 1974. - *Boll. Pesca, Piscic. Idrobiol.*, 29 (1): 29-47.
MORAITOU-APOSTOLOPOULOU M. et VERRIOPOULOS, G., 1979. - *Rev. int. Océanogr. méd.*, LIII-LIV: 77-86.
MORAITOU-APOSTOLOPOULOU M. et VERRIOPOULOS G., 1981. - a. *Hydrobiologia*, 77: 3-6.
MORAITOU-APOSTOLOPOULOU M. et VERRIOPOULOS G., 1981. - b. *Hydrobiologia*, 77: 7-15.
RIVIERE D. et KERAMBRUN P., 1983. - *Mar. Biol.*, 75: 25-35.