# *Temporal trends in heavy metal concentrations in the clam* Egeria radiata *(Bivalvia : Tellinacea : Donacidae) from the Cross River, Nigeria*

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ABSTRACT

*Temporal variations in the concentrations of lead, cadmium, nickel, and zinc were observed in the dried tissue of* Egeria radiata *(Lam) (Bivalvia : Tellinacea : Donacidae) which were collected at monthly intervals from the Cross River, Nigeria. The sampling covered the period from November 1987 to September 1989. Every metal displayed a peculiar temporal fluctuational pattern. Concentrations of zinc were lower than the maximum permissible levels set by the World Health Organization (WHO) and were more or less presumed to be close to background values. Low concentrations were also obtained for nickel. Concentrations of lead and cadmium were higher and in some months even exceeded the maximum permissible levels. The variation in the concentration of lead appeared to be strongly related to the tissue weight of the clam. There was no significant linear average relationship between any two of the metals studied. A significant negative correlation was observed between cadmium and dry tissue weight of the clam.*

KEY WORDS : Heavy metals — Molluscs — *Egeria radiata* — Nigeria — West Africa.

RÉSUMÉ

VARIATIONS SAISONNIÈRES DE LA CONCENTRATION EN MÉTAUX LOURDS DU BIVALVE *EGERIA RADIATA* (BIVALVIA : TELLINACEA : DONACIDAE) DE LA CROSS RIVER, NIGERIA

*Les concentrations en plomb, cadmium, nickel et zinc contenues dans la chair des mollusques de taille comprise entre 7,0 et 7,3 cm ont été suivies par des prélèvements mensuels de novembre 1987 à septembre 1989. Chaque métal a évolué de façon indépendante. Les concentrations en zinc et en nickel sont restées faibles, et inférieures aux seuils définis par l'Organisation Mondiale de la Santé (OMS). Les concentrations en plomb et en cadmium ont parfois dépassé ces seuils. La concentration en plomb est apparue liée au poids de la chair. Une corrélation négative entre la concentration en cadmium et le poids de chair a été trouvée.*

MOTS CLÉS : Métaux lourds — Mollusques — *Egeria radiata* — Afrique de l'Ouest — Nigeria — Cross River.

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## INTRODUCTION

Heavy metals in aquatic environment can be studied by any or a combination of the following methods :

— analysing the sediment (CLIFTON and HAMILTON 1979; NTEKIM, 1987);
— analysing the water (BRULAND, 1980);
— analysing the biota such as :
  - the seaweed *Fucus vesiculosus* (BRYAN and GIBBS, 1983);
  - polychaete worms *Neris diversicolor* (HOWARD and BROWN, 1983);
  - bivalve molluscs like *Scrobicularia plana* (LUOMA and BRYAN, 1978);
  - crustaceans like *Cancer panqurus* (DAVIES *et al.*, 1981);
  - fish like *Platichthys flesus* (PENTREATH, 1976).

The analysis of water or sediment samples are subject to a variety of shortcomings, the most salient of which is that the methods do not allow for the estimation of the quantity of the metal which is biologically available. The obvious way of overcoming this problem is to use a living organism for the analysis. The contamination problems associated with sampling and analysis are overcome as a result of the high enrichment of pollutants in organisms (BUTTLER *et al.*, 1971). An additional advantage with living organisms is that the extent of bioaccumulation of these metals along the food chain could be revealed.

In Nigeria, some studies on heavy metal concentrations in the aquatic environment and its living organisms have been carried out. Such works include those of KAKULU *et al.* (1987, 1987 a), NTEKIM (1987), IBOK *et al.* (1989).

Studies of heavy metal levels in aquatic organisms have been carried out for a number of reasons :

— to assess or monitor the degree of environmental pollution (BRYAN *et al.*, 1985, AMIARD *et al.*, 1986);

— to assess the suitability of the seafood for human consumption (MACKAY *et al.*, 1975; KAKULU *et al.*, 1987 a);

— to assess the medicinal or pharmacological properties of the organism. WESTON and PATTERSON (1983) determined 13 different trace metals in a health food extract "Seatone" prepared from the mussel *Perna canaliculus* in order to determine the component responsible for its activity against osteo and rheumatoid arthritis.

The principal aim of the present work is to elucidate the temporal changes in the levels of heavy metals in the tissues of the bivalve *E. radiata* from the Cross River in Nigeria. Such information is necessary in order to assess the wholesomeness of the clam with reference to the permissible levels of heavy metals in seafood and to provide baseline data for future studies.

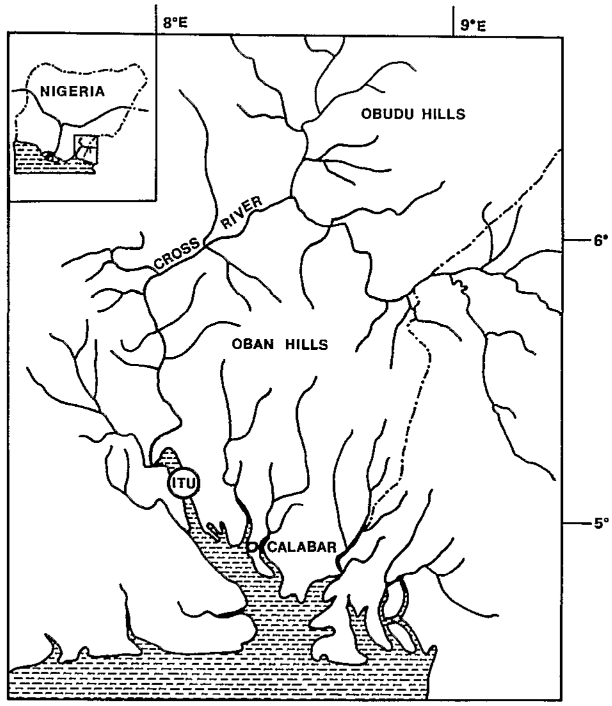


FIG. 1. — Map of the Cross River showing the sampling station at Itu, Nigeria.
*Carte de la Cross River et localisation de la station de prélèvement à Itu, Nigeria.*

## MATERIALS AND METHODS

Monthly samples of *E. radiata* were collected from the Cross River at Itu, Nigeria (fig. 1). The bivalves were maintained in filtered river water in aquaria in the laboratory for 3 days for defecation. The aquaria water was changed daily. The soft tissues of the bivalves were collected and dried in the laboratory oven at 60 °C for 72 hours to a constant weight. Only bivalve samples with lengths ranging between 7.0 and 7.3 cm were selected for the work. This was to minimize the variations in metal concentrations in relation to body size. According to LOBEL and WRIGHT (1982), the concentrations of metals in bivalve molluscs could vary with body size. Each monthly sample consisted of 10 clams which were ground together in a porcelain mortar before mineralization.

The samples were mineralized under pressure as described by KOTZ *et al.* (1972). This involved taking 300 to 500 mg of homogenized sample in a pre-cleaned Teflon vessel to which purified concentrated nitric acid (70 %) is added (about 1 ml $HNO_3$ to 100 mg sample). The mineralization is performed in steel bombs at 180 °C for 5 hours. A detailed description of the equipment is given in KOTZ *et al.* (1972). After cooling, the vessels are cautiously opened and the mineralized samples are taken up in pre-cleaned plastic vessels, diluted to 1 : 10 with double distilled water and analysed by AAS. All determinations were carried out in triplicate.

TABL. I

Mean dry tissue weight (DTW, g) and metal concentrations (mg/kg DTW) in the tissue of *Egeria radiata* from the Cross River for the period November 1987 - September 1989

*Poids moyen de la chair (DTW, poids sec en g) et concentrations en métaux (mg/kg DTW) de la chair de* Egeria radiata *de la Cross River pendant la période novembre 1987 à septembre 1989*

| | DTW | Pb | Cd | Ni | Zn |
|---|---|---|---|---|---|
| Mean | 4,11 | 0,96 | 0,32 | 1,39 | 117 |
| S.D. | 1,23 | 0,94 | 0,13 | 0,85 | 22 |
| Min. | 1,63 | 0,3 | 0,11 | 0,61 | 96 |
| Max. | 5,64 | 3,6 | 0,6 | 4,5 | 172 |

S.D. = Standard Deviation, n = 18 samples.
DTW = Dry Tissue Weight.
Min. & Max. = Minimum and maximum concentration
n = 18 samples

## RESULTS

The variations in the mean concentrations of lead, cadmium, nickel and zinc and the mean dry tissue weight of *E. radiata* during the period of study are presented in fig. 2. The mean dry tissue weight of the clams show a gradual increase from the beginning of the sampling in November 1987 and reaches a peak value of 5.64 g in June 1988, after which it dropped to a minimum of 1.63 g in November 1988. A similar peak (5.67 g) was obtained again in June 1987. These peaks coincided with the onset of spawning season.

From fig. 2, it was observed that high lead concentrations coincided with low dry tissue weight and vice versa. In the case of cadmium, a major peak occurred in November 1988, coinciding with the minimum of the mean dry tissue weight of the clam. In contrast to lead and cadmium, peak concentrations of zinc occurred in July 1988 and April 1989. Table I shows the mean concentration of the metals in relation to the mean dry tissue weight of the clams for the whole sampling period. For a mean dry tissue weight of 4.11 g, the metal varied as follows : Zn > Ni > Pb > Cd.

— Lead : The concentration of lead varied throughout the period of study with a total mean content of 0.96 mg/kg dry weight. The peak values of 3.6 and 3.1 mg/kg which were obtained in January and December 1988 respectively, are well above the World Health Organization maximum permissible level of 2.0 mg/kg for seafoods.

— Cadmium : The concentration of cadmium throughout the study period remained below the WHO permissible limit of 2.0 mg/kg. The lowest concentration of 0.11 mg/kg was obtained in August 1988 while the maximum concentration of 0.6 mg/kg occurred in November of the same year.

— Zinc : zinc concentrations ranged between a maximum of 172 mg/kg in July and a minimum of 96 mg/kg dry weight in August 1988 respectively. The total mean content of 117 mg/kg is well below the maximum permissible limit of 1000 mg/kg for zinc.

— Nickel : nickel concentration ranged between 0.61 mg/kg in June 1989 and 4.5 mg/kg in August 1988 with a mean concentrations of 1.4 mg/kg dry weight.

Pair-wise regression analysis was carried out and significant correlations were obtained only between cadmium concentration and dry tissue weight. The regression equations were :

$$Cd = 0.664 - 0.083\ DTW, \quad r = -0.823$$
$$\log Cd = -0.009 - 0.916 \log DTW, \quad r = -0.785$$
$$(DTW = \text{dry tissue weight},\ n = 18,\ P = 0.05)$$

## DISCUSSION

The pattern of variation in mean dry tissue weight of clam during the period of study have been shown to coincide with the reproductive cycle of the organism (ETIM, 1990; ETIM and ENYENIHI, *in press*). The spawning which starts in June (when mean dry tissue weight maximum occurs), is completed between the end of October and the beginning of November (when mean dry tissue weight minimum occurs). This shows that the spawning starts in the early period of the rainy season and is completed by the beginning of the dry season. The fluctuation in

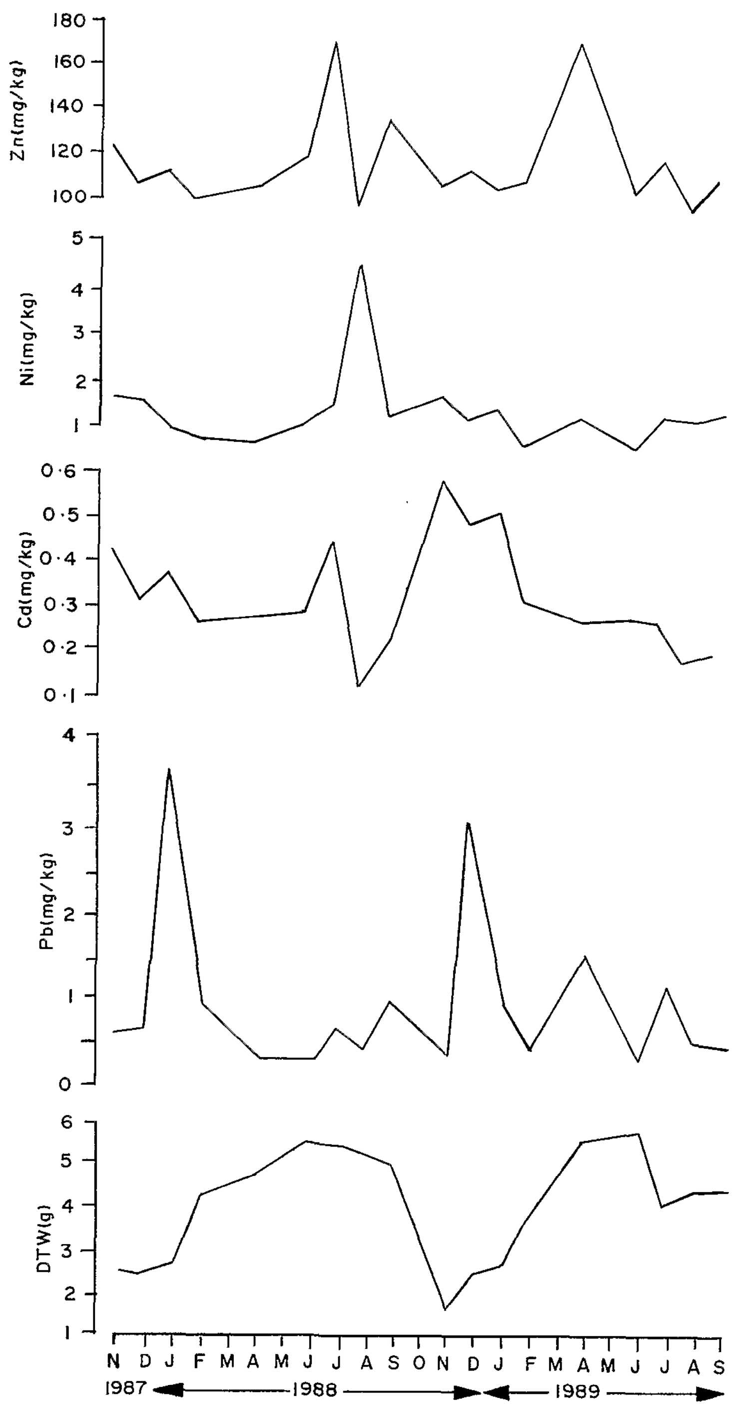


FIG. 2. — Temporal changes in dry tissue weight (DTW) and metal concentrations in *E. radiata* from the Cross River, Nigeria.
*Variations au cours du temps du poids sec de la chair et des concentrations en métaux de* E. radiata *de la Cross River, Nigeria.*

the dry tissue weight exerts an influence on the temporal variations of the metal (fig. 2) : while the peak concentration of zinc coincides with the peak of the mean dry tissue weight, the reverse is true in the case of lead and cadmium. BRYAN (1976) observed that cadmium concentrations in the bivalve *Scrobicularia plana* from the East Looe estuary remained constant with increasing body weight while those from the highly polluted Gannel and Plym estuaries increased with increasing body weight. Most authors, however, report a reciprocal relationship between metal concentrations and body weight of mussels (PHILLIPS, 1976). BOYDEN (1974) reported that concentration of lead, copper, zinc and iron in *Mytilus edulis* decreased with increasing body weight whereas nickel and cadmium remained constant. It is possible that gonadal development in the species leads to dilution of some of the body metal concentrations. A similar conclusion was drawn by BRYAN *et al.* (1980) for the species *Scrobicularia plana* and by AMIARD *et al.* (1986) for *Mytilus edulis.* GALTSOFF (1964) observed that the ripe oyster gonad may comprise 31 to 41 % of the total body weight. On the basis of this, CUNNINGHAM and TRIPP (1975) argued that if metals were accumulated in the gonad tissues, an appreciable loss might occur during spawning.

The importance of finfishes and shellfishes as a protein source for Nigerians have been pointed out (EKPO and ETIM, 1989; ETIM, 1990, ETIM and ENYENIHI, *in press*). However, there have never been any reported cases of metal toxicity in humans from the consumption of fish and shellfish in Nigeria.

It is necessary to note that neither the mechanism nor the rate of accumulation of metals by *Egeria radiata* has been studied. But it has been known for a long time that bivalves are able to accumulate metals in excess of what occurs in the aquatic environment (BROOKS and RUMSBY, 1965).

In the Cross River, the provenance of metal in the aquatic milieu is both natural and anthropogenic. Such sources include :

— erosional input from metalliferous rocks;
— industrial effluents and waste discharges at Itu;
— domestic wastes, wastes from automobile workshops, exhaust fumes from vehicles and outboard motors;
— drainage from agricultural fields.

As industrialization and urbanization increase in the country, the levels of pollutants in the environment are bound to increase. From their studies on fishes of the Niger delta area of Nigeria, including the Cross River, KAKULU *et al.* (1987), found very low levels of cadmium, lead and zinc and concluded that these represented background values. In a recent study, IBOK *et al.* (1989), reported high levels of lead in some finfish species which hitherto were regarded as uncontaminated. Within this context, the present work may be useful :

— to monitor a possible pollution link with increasing population and/or industrialization of the area;
— to indicate some existing pollution by lead and to serve as a springboard for future research in this area.

The history of pollution studies in Nigeria is a short one. And, as reported by IBOK *et al.* (1989), the Nigerian government is concerned more with oil pollution in coastal waters while the rather "insidious" effect of heavy metal pollution is completely overlooked.

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