

Mercury in *Eledone cirrhosa* from the Northern Tyrrhenian Sea: contents and relations with life cycle

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The Hg concentration in horned octopus was studied in relation to its biological cycle. The metal was measured in the muscle tissue of specimens of different size, sex and maturity. This species proved to be a strong accumulator of mercury, whose concentration was found to be correlated with length independently of the sex. The relationship with size was found also for the organic form. Consideration was given to the danger of frequent consumption of this cephalopod and to its use as a biomonitor of environmental mercury impact.

It has long been known that the ecosystem of the Northern Tyrrhenian Sea is contaminated by Hg due to the cinnabar anomaly of Mt Amiata (Tuscany) and the related mercury extraction activities carried out there for many centuries.

High mercury concentrations have been reported in sediment (Baldi *et al.*, 1979; Barghigiani *et al.*, 1986) as well as in important edible fish, crustaceans and molluscs (Renzoni & Baldi, 1975; Barghigiani *et al.*, 1991; Barghigiani *et al.*, 1992). In all the organisms studied the mercury concentration in muscle tissue increased with the size, varied depending on the species, and in the same species showed variation with depth (Barghigiani *et al.*, 1986). It has also been reported that the different mercury concentrations of similar species of flatfish were probably due to the structure of the corresponding trophic chains (Pellegrini & Barghigiani, 1989). In fish of other geographic regions, differences of accumulation were found between the two sexes (Monteiro & Lopes, 1990; Monteiro *et al.*, 1991) and among the different organs (Hornung & Cohen, 1986), depending on the environment (Luten *et al.*, 1987).

From this evidence, it appears that information on Hg accumulation in marine organisms is wide but fragmentary and mainly addresses fish and crustaceans. Considerably less information exists on this topic for cephalopods, even though they play important roles

both in the marine ecosystem and in the human diet (Amaratunga, 1983).

The present investigation is directed at the study of mercury uptake and concentration in the muscle tissue of the horned octopus, *Eledone cirrhosa* (Lamarck 1798, Cephalopoda, Octopoda), in the Northern Tyrrhenian Sea. This species, occurring from the western basin of the Mediterranean to the North Sea, is truly benthic, living at a wide range of depths (Mangold & Boletzky, 1987). Mangold *et al.* (1971) refer to it as "probably the most abundant cephalopod of the north-western Mediterranean". Seasonal minimum stock biomass estimates for the whole Tyrrhenian Sea show that the highest production occurs in the study area (Würtz *et al.*, 1992), where *Eledone cirrhosa* represents the largest catch among cephalopods (Belcari *et al.*, 1986; Belcari & Sartor, in press).

Eledone cirrhosa stops growing with the attainment of sexual maturity and after spawning it disappears from the fishery area, probably dying (Mangold-Wirz, 1963; Boyle, 1983).

It is possible to suggest a complete life cycle for this species in the Northern Tyrrhenian Sea that never exceeds two years, with a maturation period in the second year of life in the months of June, July and August (Belcari *et al.*, 1990). In this area the species is found from 5 to 630 m depth and sizes range from 1.5 cm to 14.5 cm mantle length (Belcari & Sartor, in press), in agreement with data reported for the other areas of the Mediterranean Sea (Mangold & Boletzky, 1987).

Since this is one of the most widespread and most consumed molluscs of the Tyrrhenian Sea and its cycle is brief and known, it has been studied with the aim of giving an evaluation of its possible impact on human health and gaining information on its use for the biological monitoring of mercury contamination in the Mediterranean.

Materials and Methods

The specimens were collected during eighteen

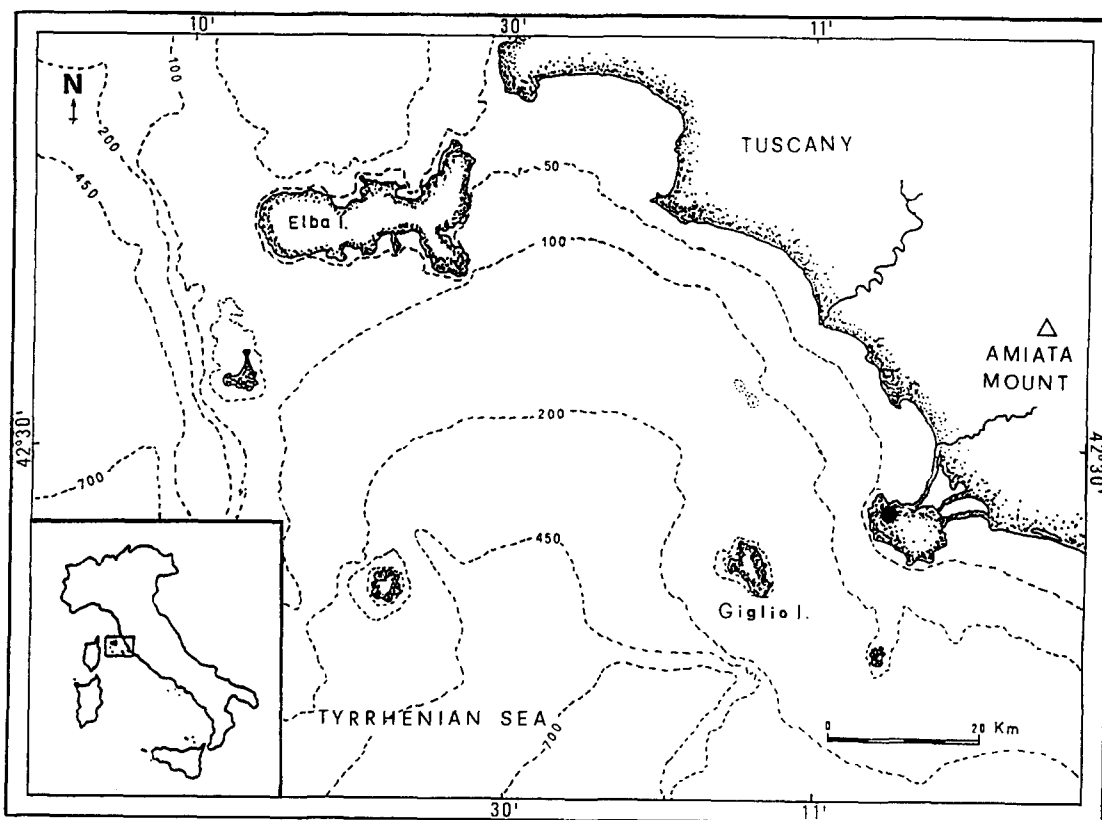


Fig. 1 Study area.

monthly samplings from March 1989 to August 1990 in the study area of the Northern Tyrrhenian Sea reported in Fig. 1, between 52 and 350 m depth, with the greatest abundance between 100 and 130 m.

Every specimen was weighed, measured as dorsal mantle length and sexed. The state of maturity of the gonads was assessed on the criteria of relative size, colour and appearance of the eggs and spermatophores, according to Mangold & Wirz (1963), Sanchez (1976) and Moriyasu (1981). The sizes ranged from 3.5 to 13.5 cm mantle length (ML).

From the analysis of size-frequency histograms of the field catch (Bhattacharia, 1967) and observation of the maturity stages (Fedi, 1988; Belcari *et al.*, 1990), it was possible to single out a cohort to be followed every month from the juvenile stages to the completely mature stages.

Total and methylmercury analyses were performed on mantle muscle tissue of 142 specimens. Total mercury was determined by cold vapour atomic absorption spectrometry (CVAAS) on samples digested with nitric acid in a closed system under pressure as reported elsewhere (Barghigiani *et al.*, 1986). Organic mercury was determined by CVAAS after extraction from samples according to Capelli *et al.* (1979) and mineralization in a closed system as performed for total mercury.

The analytical procedures were tested using Certified Reference Materials DORM-1 (dogfish muscle) of the National Research Council of Canada.

Results and Discussion

Despite its short life cycle, *Eledone cirrhosa* accumu-

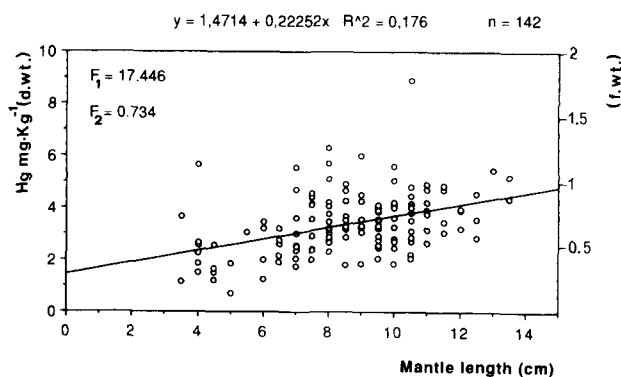


Fig. 2 Relationship between total mercury concentration (expressed as dry and fresh wt) and mantle length in all the specimens analysed.

lated high levels of mercury (Fig. 2) and from the size limit of 6 cm of mantle length upwards, 50% of specimens exceeded the maximum concentration of total Hg ($0.7 \mu\text{g/g}$ of fresh wt) set by Italian law for those species of edible marine organisms considered mercury concentrators, i.e. bivalve molluscs, sharks, smooth-hounds and dog-fish (FAO, 1983).

Mercury accumulation increased with size, as indicated by Fig. 2. This relationship was not observed earlier on a smaller sample of the same species collected without regard to its biological cycle (Barghigiani *et al.*, 1991). The relationship between Hg concentration and mantle length in females and males (Figs 3, 4) was significant. The linearity of the regression ($F_2=0.932$, $p>0.005$ for females; $F_2=0.526$, $p>0.005$ for males) and the significance of the regression ($F_1=9.175$, $p>0.005$ for females; $F_1=10.518$, $p>0.005$ for males) were tested. On the

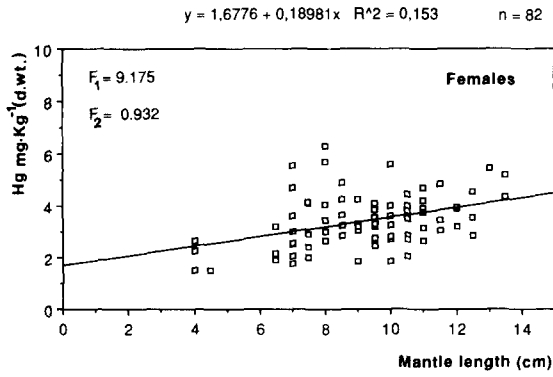


Fig. 3 Relationship between total mercury concentration (dry wt) and mantle length in females.

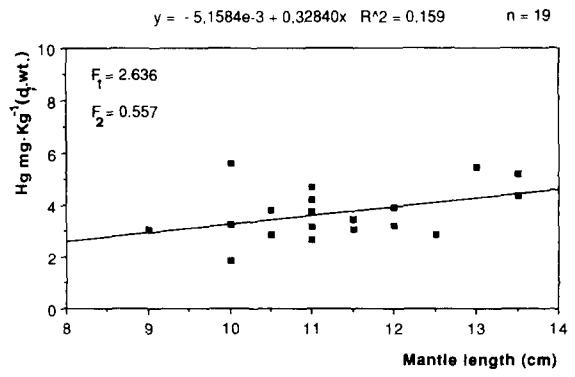


Fig. 6 Relationship between total mercury concentration (dry wt) and mantle length in mature females.

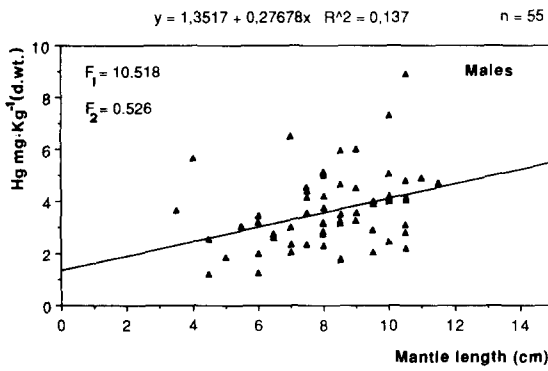


Fig. 4 Relationship between total mercury concentration (dry wt) and mantle length in males.

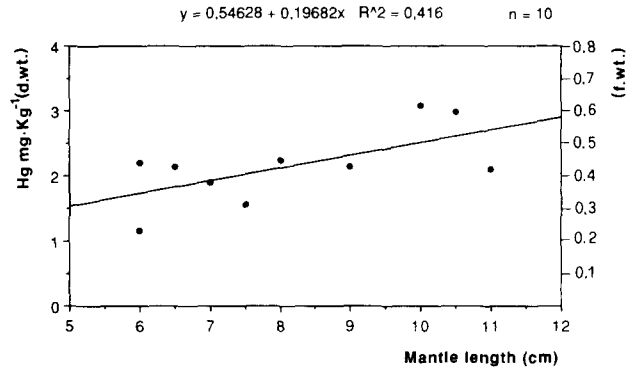


Fig. 7 Relationship between organic mercury content (expressed as dry and fresh wt) and mantle length.

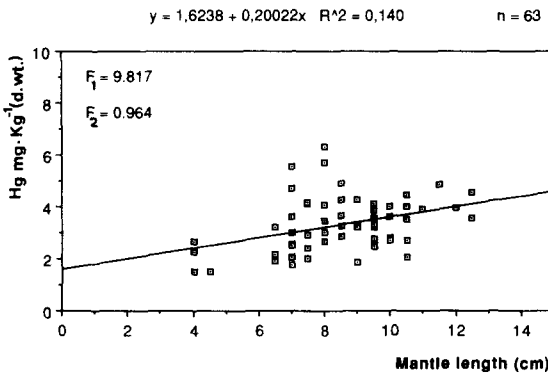


Fig. 5 Relationship between total mercury concentration (dry wt) and mantle length in immature females.

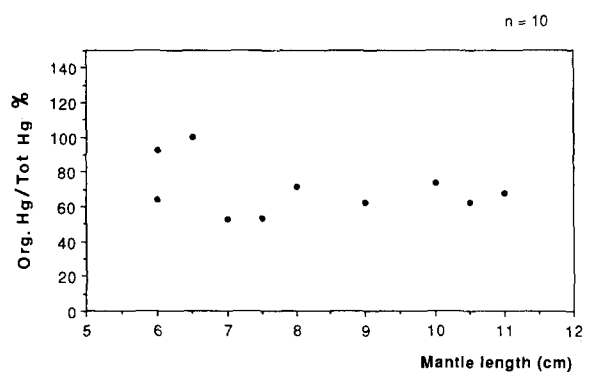


Fig. 8 Organic mercury as a percentage of total mercury vs. mantle length.

contrary, no significant difference was found between both the slopes ($t=0.500$, $p > 0.001$) and the intercepts ($t=1.980$, $p > 0.001$) of the two regression lines, indicating no difference in Hg accumulation between the two sexes. In other species (*Pontinus khulii*, *Galeorhinus australis*, *Mustelus antarcticus*, *Nephrops norvegicus*), however, different Hg contents have been observed between the two sexes (Monteiro *et al.*, 1991; Walker, 1976; Minganti *et al.*, 1980).

In immature females (Fig. 5) the relationship between Hg and size was significant ($F_2=0.964$, $p > 0.005$; $F_1=9.817$, $p > 0.005$); conversely, this was not observed in the few mature and maturing females ($F_2=0.557$, $p > 0.005$; $F_1=2.636$, $p > 0.005$) (Fig. 6). The analyses of the maturing and mature females suggest a reduction in the mercury uptake near spawning. This phenomenon could be due to a variation in the diet or a decrease in feeding; indeed, many octopodid females

near spawning are known to feed less or terminate ingestion altogether (Mangold, 1983). On the contrary, in female fish and crustacean species (Nicoletto & Hendricks, 1987; Minganti *et al.*, 1990), an increase in Hg concentration vs. size was observed with the acquisition of sexual maturity.

In the present study organic mercury increased with length (Fig. 7) and as a percentage of the total Hg it remained constant (Fig. 8). In other species from the nearby Ligurian Sea organic mercury increased with size more than did inorganic mercury (Capelli *et al.*, 1987; Minganti *et al.*, 1990), and a linear correlation with the total Hg existed for organic mercury only (Minganti *et al.*, 1990).

It is notable that the average organic mercury percentage with respect to the total (70 ± 15 S.D.) was found to be lower than that of some species of fish from the same area (84 ± 9 S.D.) (Barghigiani *et al.*, 1991).

Conclusions

Eledone cirrhosa proved to be a strong accumulator of mercury, and most of the specimens caught presented high mercury levels.

It is important to point out that no mercury concentration limits are provided by Italian law for *Eledone cirrhosa*. Thus, this organism, which frequently enters into the diet of people living along the Northern Tyrrhenian Sea, is not controlled and could be detrimental to their health. Indeed, from our data, a weekly consumption of 500 g of muscle tissue of this cephalopod would result in the average intake of 200 µg of methylmercury, which is the maximum limit per week indicated by FAO/WHO (1980) for a person weighing 60 kg.

From the environmental point of view, since this species is characterized by fast growth and a short life cycle which does not exceed two years, it could be usefully employed as a biomonitor of environmental mercury for comparing both the levels of the metal in different areas and especially the variations in the same area between different periods. It is important to note that due to the high variability of Hg concentration in specimens of the same size, effective biological monitoring of the mercury requires the analysis of a large number of specimens collected over the entire life cycle.

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