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Accumulation and Elimination of [9-^{14}C]Phenanthrene in the Calico Clam (*Macrocallista maculata*)*

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This study shows the accumulation and elimination of radioactivity after exposure of [9-^{14}C] phenanthrene in various tissues in the calico clam (Macrocallista maculata). The calico clam is a sand-dwelling bivalve well represented in parts of the Western North Atlantic and the Caribbean, and in Bermuda is the only bivalve used as a food source. This experiment belongs to a series of experiments in which the disposition of [9-^{14}C]-phenanthrene has been studied in various marine animals from different environments (KNAP et al. 1982; PALMORK & SOLBAKKEN 1980, 1981; SOLBAKKEN & PALMORK 1980, 1982; SOLBAKKEN et al. 1979, 1982).

KNAP et al. (1982) have shown that the brain coral (Diploria strigosa) accumulate [9-^{14}C]phenanthrene from the seawater, and that the elimination of the radioactivity from the coral colony is slow compared to a species of coral reef fish (SOLBAKKEN et al. 1982). The bluestriped grunt (Haemulon sciurus), from the subtropical island of Bermuda exhibits a different disposition of phenanthrene/radioactivity compared to fish from temperate environments (SOLBAKKEN & PALMORK 1980, 1982; SOLBAKKEN et al. 1979). It was therefore of interest to study benthic filter feeders to investigate the relationship between habitat and temperature and the disposition of phenanthrene.

EXPERIMENTAL

Organisms. Calico clams (Macrocallista maculata) were collected at 15 m depths in Harrington Sound, Bermuda. Clams of both sexes were used and the mean weight (mean± SD) of the meat was 12±3 g. They were not fed during the experiment.

Treatment and maintenance. [9-^{14}C]Phenanthrene (600 µg containing 60 µCi, sp.act. 19.3 mCi/mmol) was dissolved in 150 µL ethanol and mixed in a small volume of seawater which subsequently was mixed with 12 L of seawater. Thirty clams were placed in a tank (50 L)

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containing the labelled seawater (25°C). The seawater was aerated using small air pumps. Samples of seawater were analyzed for radioactivity at the beginning of the experiment. After 48 h of exposure the clams were transferred to a tank containing running clean seawater (70 L, 35.5 °/oo S, 24°C, flowrate 8 L/min). At the end of the experiment 3 clams were dead and only 2 clams were analysed at day 28.

Sample preparation. At appropriate time periods, 5 clams were frozen and maintained at -20°C until required. After thawing, the clams were analyzed for radioactivity. The hepatopancreas, gills, mantle and muscle (foot) were carefully removed. The clams were washed with methanol to remove the radioactivity from the total surface. Two samples (approx. 100 mg) of each tissue were analyzed for radioactivity using standard methods (Soluene-350 and Dimilume-30, Packard Instrument Co.) and [^{14}C]toluene as internal standard.

RESULTS AND DISCUSSION

The analyzes of the seawater samples indicate that 48% of the radioactivity was found in the water immediately after clams were transferred to the exposure tank. This corresponds to a concentration of 22 g/L (ppb).

The concentrations of radioactivity present in the foot (muscle), mantle, gills and hepatopancreas are given in Figure 1. The highest concentration was found in hepatopancreas; about 3 to 5 times the concentration found in gills, foot and mantle. There is a decline of radioactivity from the tissues during the elimination study, but high concentrations (>3000 dpm/g tissue) remain 28 d after transferring to clean seawater. PALMORK & SOLBAKKEN (1981) reported the distribution and elimination of [9-^{14}C]phenanthrene in the horse mussel (Modiola modioulus), a study performed under the same laboratory conditions as the present study, except the temperature was 9°C. They also found the highest concentrations immediately after transferring to clean seawater. The hepatopancreas was the site of the highest concentration compared to gills and mantle in both experiments.

In the study using the horse mussel (PALMORK & SOLBAKKEN 1981) the concentration of [9-^{14}C]phenanthrene in the seawater was 20 ppb which is nearly the same as in the present study (22 ppb). The concentration of radioactivity is, however, much higher in the tissues of the calico clams than the horse mussel. There is also a large difference in the rate of elimination. The concentration of radioactivity in the horse mussel is approximately 45 to 60% of the maximum value 1 d after

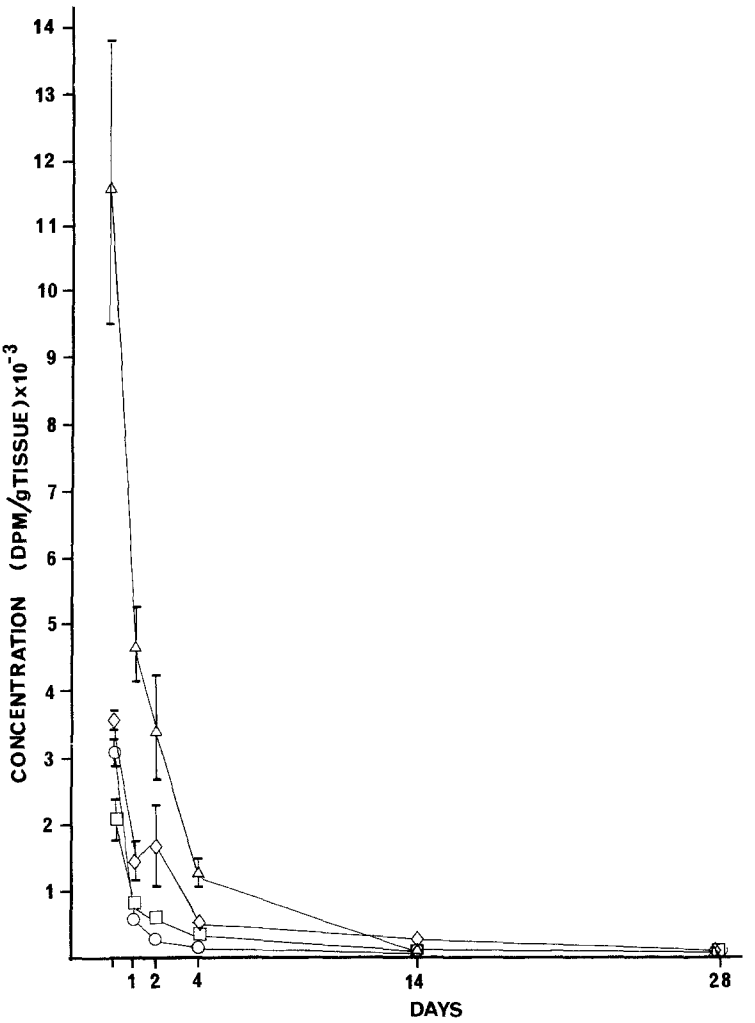

Fig. 1. Concentrations of radioactivity (dpm/g tissue ± SE) found in hepatopancreas (△), gills (◇), foot (○), and mantle (□) at various times after transferring to clean seawater.

exposure. The corresponding values in the calico clams are 35 to 40%. One month (28 d) after exposure high concentrations of radioactivity (14-24% of maximum value) were left in the tissues of the horse mussel (PALMORK & SOLBAKKEN 1981). In the calico clam, less than 2% of the maximum values were left in the tissues. The concentration of radioactivity in the hepatopancreas 28 d after the exposure was six times less the concentration found in the horse mussel, but the concentration found in the mantle and the gills are nearly the same. These concentrations are fairly high

compared to the levels found in bony fish given [9-^{14}C] phenanthrene (SOLBAKKEN & PALMORK 1980, 1982; SOLBAKKEN et al. 1979). A slow elimination of hydrocarbons from bivalve tissues has also been reported elsewhere (e.g. BLUMER et al. 1970; LEE et al. 1972; STEGEMAN & TEAL 1973; DUNN & STICH 1976). However, NEFF & ANDERSON (1975) found a small amount of radioactivity in the tissues of the clam Rangia cuneata, 30 days after exposure to 30.5 ppb of [^{14}C] benzo(a)pyrene.

The very efficient elimination in the calico clams was unexpected, and this study does not elucidate the reason. It is possible that the higher temperature (24°C) results in a faster elimination. PALMORK & SOLBAKKEN (1981) did not detect metabolites of phenanthrene in the horse mussels, and concluded that the absence of metabolits may be the reason for the high content of radioactivity one month after exposure. Benzo(a)pyrene hydroxylase has been found in bivalves (ANDERSON 1977; STEGEMAN 1980). The levels of enzymic activity for components of the detoxification system in bivalves may not play an important part in the excretion of organic xenobiotics from the tissues of bivalve molluscs (MOORE et al. 1980).

The present study shows that the calico clam, a subtropical species, accumulates [9-^{14}C] phenanthrene to a greater extent than the temperate horse mussel (PALMORK & SOLBAKKEN 1981). The accumulation is highest in the lipid-rich hepatopancreas, and the elimination is very efficient compared to the horse mussel. The calico clam, which is a sand-dwelling organism, can easily come in contact with hydrocarbon contaminated sediments and might accumulate the hydrocarbons at different extents in various tissues. The efficient elimination, however, will prevent a lasting accumulation.

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