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Accumulation and Elimination of Radioactivity in the Norway Lobster (*Nephrops norvegicus*) Following Intragastric Administration of [9-^{14}C]Phenanthrene

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Only a few reports are available involving the accumulation and elimination of aromatic hydrocarbons given in the diet or intragastrically to benthic crustaceans (e.g. LEE et al. 1976). In this study the Norway lobster (Nephrops norvegicus) was used as a representative mud-dwelling crustacean of commercial importance in the North-East Atlantic ocean including Norwegian coastal waters. PALMORK (1974) detected high concentrations of polycyclic aromatic hydrocarbons (PAH) in sediments of Norwegian fiords having industries like aluminium smelters and ferrosilicon-, iron- and coke-works, and it is therefore expected that benthic organisms in such areas might accumulate these compounds. Exploitation of oil from offshore installations, increasing industrialization based on oil and gas, and transport of oil leads to increasing oil pollution of the sea, including the benthic communities. Experiments performed by BAKKE & JOHNSEN (1979) showed that phenanthrene accumulates to a greater extent than other PAH-components in sediments exposed to a stock water extract of Ekofisk crude oil in seawater.

This study is part of a series conducted under the same experimental conditions using intragastric administration of ^{14}C-labeled phenanthrene in marine organisms (SOLBAKKEN et al. 1979, 1980; SOLBAKKEN & PALMORK 1980).

EXPERIMENTAL

Organisms. Norway lobsters (N. norvegicus) were obtained from a coastal area south of Bergen. Crustaceans of both sexes (mean weight $\pm$S.D. was 141$\pm$64 g) were acclimatized seven days prior to dosing and regularly fed thawed frozen krill (Meganyctiphanes norvegica) during the entire experimental period.

Treatment. The same amount (7.9 µg containing 0.5 µCi) of [9-^{14}C]phenanthrene (Radiochemical Centre, Amersham, England) was given to all organisms. The specific activity of the material was 11.3 mCi/mmol and the purity was 99%. The material was dissolved in dimethyl

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sulfoxide (DMSO) and stored and dosed at room temperature (above 18.5 ^{o}C) to prevent solidification of the DMSO. The low temperatures in marine poikilothermic organisms will not solidify DMSO, since it is freely soluble in the water always present in the alimental channel of marine organisms. The radioactivity dissolved in DMSO (200 µL) was introduced orally to the crustaceans using a modified one-mL syringe affixed to a teflon tube (ID. 1.25, OD. 1.8 mm).

Maintenance. Crustaceans were kept in a 1250-L container (flow rate 30 L/min, 8 ^{o}C and salinity 34 ^{o}/oo) in total darkness.

Sample preparation. At the appropriate times the organisms were frozen and maintained at -20 ^{o}C until required. Samples were taken from hepatopancreas, green gland, gonads, heart, muscle from the tail, intestine and stomach. Duplicate samples of approx. 100 mg were taken from the tissues except for the heart, intestine and the stomach. The entire heart and intestine was used to determine the radioactivity. Standard methods, using Soluene-350 and Dimilume-30 (Packard Instrument Co.) and an internal standard ([^{14}C]toluene), were employed in the scintillation counting. The stomach, however, was extracted with 15 mL of toluene and one mL of this extract was analysed for radioactivity.

RESULTS AND DISCUSSION

The distribution and amounts (as % of dose) of radioactivity in the tissues analysed are shown in table 1. The highest amounts of radioactivity were recovered from hepatopancreas and muscle. In all tissues, except for the intestine, the highest levels of radioactivity were measured one day after dosing and after 28 days only minute amounts of the radioactivity remained in the tissues. The distribution pattern of radioactivity in the Norway lobster corresponds well with that of bony fishes dosed with [^{14}C]phenanthrene (SOLBAKKEN et al. 1979, SOLBAKKEN & PALMORK 1980).

LEE et al. (1976) fed blue crabs (*Callinectes sapidus*) with shrimps containing radiolabeled hydrocarbons (benzopyrene, fluorene, naphthalene, methylnaphthalene, methylcholanthrene, hexadecane, heptadecane and dotriacontane) dissolved in ethanol. They found that the fecal material excreted during the first two days was high in hydrocarbon (20-50% of the total ingested) and they concluded that a great deal was passed directly

TABLE 1. Distribution of radioactivity in some tissues of Norway lobster at various times following intragastric administration of [9-^{14}C]phenanthrene (7.9 µg/animal).

	1 day	4 days	7 days	28 days
Heart	0.2* (4, 0.2)**	0.1 (3, 0.02)	0.07 (3, 0.02)	0.01 (4, 0.01)
Green gland	0.9 (4, 0.6)	0.2 (3, 0.04)	0.2 (3, 0.1)	0.01 (4, 0.002)
Hepato-pancreas	44.3 (4, 24.0)	29.8 (4, 7.2)	19.2 (3, 3.5)	0.8 (4, 0.4)
Gonads	7.5 (4, 4.8)	0.4 (4, 0.2)	0.2 (3, 0.1)	0.2 (4, 0.2)
Muscle	16.6 (4, 9.0)	6.2 (4, 1.9)	4.3 (3, 1.3)	0.4 (4, 0.2)
Stomach	2.7 (4, 2.5)	1.4 (4, 1.7)	0.8 (4, 0.3)	0.04 (4, 0.05)
Intestine	0.6 (4, 0.4)	1.3 (4, 0.4)	1.1 (3, 0.6)	0.04 (4, 0.02)

* mean value, % of administered dose found in organ

** number of animals, standard deviation of mean

through the intestinal tract. Our experiments with the Norway lobster, however, show a low content of radioactivity in stomach (2.7%) and intestine (0.6%) 1 day after administration. The tissues analysed at that time contained about 70% of the total given dose. This indicates that most of the [^{14}C]phenanthrene was absorbed from the intestine. It is possible that PAHs dissolved in DMSO will be absorbed at a higher rate than PAHs given in food (e.g. shrimps). LEE et al. (1976) found small amounts of radioactivity in the green gland and heart of blue crabs. They believed that the specific activity of some of these tissues was high because of their low weight. This agrees with the present results if the values in table 1 are calculated as dpm per unit of weight. The concentration of radioactivity in heart and green gland are as much as 10 and 39% respectively, of the concentration found in hepatopancreas. However, the radioactivity in percentages of the total dose in these tissues were very small (table 1). The muscle contained 3% of the concentration found in hepatopancreas but 17% of the given dose, as the weight of the muscle is about 40% of the total weight. The values for muscle radioactivity are much greater than those found in bony fish dosed with [^{14}C]phenanthrene (4 and 6% of the dose in saithe and rainbow trout, respectively, SOLBAKKEN et al. 1979 and SOLBAKKEN & PALMORK 1980).

This study shows that the Norway lobster, an organism living in sediments, accumulates [^{14}C]phenanthrene at a high rate, and is able to eliminate most of the radioactivity within a few weeks after a single dose. Whether the prosess of elimination depends on enzymatic activities or other factors will be discussed in a subsequent publication.

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