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Alterations in Calcium Accumulation Behavior in Response to Calcium Availabilty and Polychlorinated Biphenyl Administration

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The presence of polychlorinated biphenyls (PCBs) as contaminants of many ecosystems has been increasingly appreciated in the years following JENSEN'S (1966) report of these compounds in the Baltic Sea. Levels of PCBs in the environment have been enhanced by their resistance to metabolism, their bioaccumulation through successive trophic levels and their lypophilic characteristics.

Although the Yusho incident has resulted in a dramatic reduction in the rate of new PCB contamination, their persistence and the presence of numerous "hot spots" (Hudson River, New Bedford Harbor, Duwamish River) underline the importance of their continued study.

The effects of other chlorinated hydrocarbons upon calcium metabolism and biological mineralization processes (GRESS et al. 1973, BITMAN et al. 1970, HAEGEL and TUCKER 1974) and an observation by CLENCH (1930) in particular, suggested to us that conspecific shell cannibalization by the pulmonate gastropod Cepeae (=Helix) nemoralis (L.) might provide a novel and informative model system by which to examine the effects of PCBs upon calcium accumulation as a reflection of alterations in calcium appetitive behavior by the snails.

CLENCH (1930) reported that C. nemoralis frequently were observed rasping at the shells of conspecifics in areas of their distribution which were low in lime. This rasping behavior is easily observed and is characterized by rhythmic movement of the radula accompanied by synchronous contraction and relaxation of the odontophore which may be seen through the translucent tissues of the head. It results in mechanical abrasion of areas of the shell under attack and was presumed by Clench to represent an attempt on the part of the snails to obtain calcium rather than to cannibalize the soft parts of their prey.

MATERIALS AND METHODS

In order to verify and possibly extend these observations, 650 healthy snails were collected on Matinicus Island, Maine and maintained in the laboratory on diets either replete in calcium provided as calcium carbonate (the calcium-abundant diet; 20.00 mg/g; 250 animals) or on a diet delivering low calcium levels

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(the calcium-deficient diet; 0.53 mg/g; 150 snails). A third group of snails was fed the calcium-abundant diet to which was then added the commercially utilized polychlorinated biphenyl mixture of Aroclors MS1016 and MS1254 resulting in final concentrations in the diet of 0.5 ppm (50 snails), 1.0 ppm (100 snails) and 5.0 ppm (100 snails). Animals were maintained upon these regimens for 30 days in large (120 x 60 x 10 cm) plastic cages at 17^{o} and received 15 hours of light per 24 hours.

RESULTS

Snails were examined daily during the course of the experiment. Rasping behavior was observed in all experimental groups over the 30-day interval. Its effects were divided into two distinct categories: 1) those which produced abrasive damage to the shells of the conspecific victims without resulting in shell penetration and 2) those in which penetration occurred. Among snails receiving the calcium-abundant diet, damage was produced in 3% of the study population and penetration did not occur. In the calcium deficient group, however, damage was produced by 97% of the snails with 9% resulting in penetration.

Administration of PCBs in food resulted in increased shell abrasion at all doses tested. Relationships between dosage and rasping effects are presented in Table 1.

TABLE 1

Effect of PCB ingestion on conspecific rasping activity in *C. nemoralis*

Dosage (ppm)	Penetration (%)	Damage (%)
0.5	2	16
1.0	5	21
5.0	7	20

In response to increasing amounts of the PCB mixture, penetration also increased, though not in a linear fashion. Abrasion damage not resulting in shell penetration increased with dosage up to the 1.0 ppm level. When this dose was increased fivefold, however, no significant increase in shell damage frequency was observed.

DISCUSSION

Because nonpenetrant damage was observed in snails provided with calcium-abundant diets, whereas penetration was not, we adhere to the view that penetration data form the more reliable index of dietary and PCB effects. In those instances where penetration has occurred we speculate that rasping has been sufficiently protracted and aggressive to support the contention that the demineralization of conspecifics was related to altered calcium demand. This is reinforced by the observation that the snails ingested chips of the abraded shell surface and that portions of these chips were visible in their feces.

While we are presently unable to identify the step(s) in calcium metabolism interfered with by ingestion of PCBs, the data and observations presented above suggest that shell rasping behavior is related to calcium deficiency and that PCB administration evokes the behavior characteristic of inadequate supply of this element even though it is present in abundance in the diet.

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