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# RADIO-NUCLIDES AND HEAVY METALS IN *NOTOTODARUS GOULDI*

By J. David Smith

School of Chemistry, University of Melbourne, Victoria, Australia

## Introduction

Cephalopods have been shown to accumulate heavy metals and some radio-nuclides to a remarkably high degree (Martin & Flegal, 1975; Heyraud & Cherry, 1979). The respiratory pigment in the blood of cephalopods is haemocyanin (Lontie & Witters, 1973) which in pure form has a copper content of 0.25% (2,500 ppm). The presence of high levels of copper is essential, but other heavy metals normally regarded as toxic are also present at high levels. The biological success of cephalopods indicates that they have an adequate mechanism for fixing the heavy metals in non-toxic form. Where dissections and analyses of different organs have been carried out, they show that the digestive gland contains the metals at much higher levels than those found in the white muscle (Martin & Flegal, 1975; Miramand & Guary, 1980). The radio-nuclide Po-210 follows the same pattern, with high concentrations in the digestive gland.

Po-210 is the major contributor to the natural radiation dose received by many marine organisms (Cherry & Shannon, 1974, Heyraud, 1982), and the squid digestive gland receives one of the highest recorded doses (Heyraud & Cherry, 1979). This makes Po-210 in squid of great potential value in food chain studies. Laboratory studies have shown that the cephalopod *Octopus vulgaris* can accumulate the transuranic elements Pu-237 and Am-241 preferentially in the branchial heart (Guary & Fowler, 1982).

Early knowledge of the levels and behaviour of potentially toxic elements is essential in the development of any fishery. This protects public health, and can prevent the problems that may be encountered with their later discovery.

## Research Objectives

This preliminary work, involves the study of the distribution of heavy metals and the radio-nuclide Po-210 in cephalopods from the waters off south-east Australia. The work is concentrated on *Nototodarus gouldi* which is the common commercial squid species in this area. We are investigating the relationships between the elements being studied, and the sex, size and age of the squid. The work is being further extended to other species, including those found in Antarctic waters.

The programme will be extended to a study of the heavy metals and Po-210 in the food chain, in one direction to the predatory fishes and birds, and in the other direction to the zooplankton and phytoplankton. The sources of the large amount of copper needed by the cephalopods, and the capacity of the cephalopods to detoxify some elements usually regarded as highly toxic, will also be studied.

The behaviour of Po-210 is not well known, and is being investigated and compared with the metals. The presence of Po-210 in excess of that supported by its precursor Pb-210 indicates that it is accumulated independently of the Pb-210.

## Methods

1. *Characterisation.* Squid were obtained in a trial fishery in Bass Strait and immediately snap frozen. The sex, weight and length of each animal was noted and the digestive gland removed. Tissues were freeze dried in preparation for analysis.

1. *Heavy metals.* A sample of the tissue (1 g) was digested under reflux in nitric-perchloric acid, and the trace metals determined by atomic absorption spectrometry or ICP atomic emission spectroscopy. An X-ray fluorescence analyser is being calibrated for the simultaneous determination of many elements in milligram samples of freeze dried tissue.

3. *Polonium-210.* A sample of the tissue digest was evaporated to near dryness and taken up in dilute hydrochloric acid. The Po-210 was plated out onto a silver disc, and

the alpha-activity counted (Flynn, 1968). Correction was made for radioactive decay since the time of sampling. The contribution of the Po-210 supported by Pb-210 was determined by re-plating and counting after a suitable delay (usually 3 months).

## Results

Values from the literature for heavy metals and for Po-210 in the digestive gland of various cephalopods are summarised in Table 1, with preliminary results for *Nototodarus gouldi* from waters off south-east Australia.

Supported and unsupported Po-210 have been measured and at the time of capture about 0.3% of the Po-210 was supported by Pb-210. The level of Po-210 in the digestive gland of *Nototodarus gouldi* is higher than the levels reported for *Loligo* spp. and sufficiently high to make it useful for food chain studies.

The weight of digestive gland plotted against weight of the whole animal for *Nototodarus gouldi* collected on one night in Bass Strait is shown in Figure 1. The results indicate that there is high variability in both males and females.

## Future Developments

The direction of future work depends on the results of experimental work in progress, and will include studies of the form of binding of the metals and radio-nuclides in the cephalopods, and the fate of these elements in the food chain. The main work will continue to concentrate on *Nototodarus gouldi*, but will be extended to other species, especially those of commercial importance in other parts of Australia.

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TABLE 1

Reported values for heavy metals and for Po-210 in the digestive gland of cephalopods. The concentration of Po-210 in seawater, given for comparison is 0.034 pCi/l. Results for *Nototodarus gouldi* are from the present work with the metals determined by L. Plues and the Po-210 by M. Heyraud. Other results are from Folsom & Beasley, 1973; Martin & Flegal, 1975; Heyraud & Cherry, 1979; and Miramand & Guary, 1980.

| SPECIES | Ag | Cd | Cu | Fe | Zn |
|---|---|---|---|---|---|
| | | | (Metal concentration ug/g dry) | | |
| Loligo opalescens | 9.8-83 | 22- 265 | 680-15160 | 19-338 | 113- 892 |
| Simplectoteuthis oualaniensis | 14.0-40 | 427-1106 | 1520- 1940 | 260-415 | 162- 838 |
| (Ommastrephes bartrami?) | 4.4-39.6 | 71- 694 | 17- 696 | 149-850 | 93- 258 |
| Octopus vulgaris | – | 50 ± 10 | 2500 ± 700 | 700 ± 130 | 1450 ± 400 |
| Nototodarus gouldi | 2- 5 | 30- 100 | 50- 1100 | 340-820 | 470-1500 |
| | | | Po-210 (pCi/g dry) | | |
| Loligo vulgaris | | | 46-164 | (Mediterranean) | |
| Loligo vulgaris | | | 49- 73 | (Atlantic) | |
| Loligo sp. | | | 0.75 | (N.E. Pacific) | |
| Octopus vulgaris | | | 23 | (small) | |
| Octopus vulgaris | | | 22 | (large) | |
| Sepia officinalis | | | 63 | (small) | |
| Sepia officinalis | | | 54 | (medium) | |
| Sepia officinalis | | | 44 | (large) | |
| Eledone aldrovandii | | | 13 | | |
| Nototodarus gouldi | | | 65-658 | (Bass Strait) | |

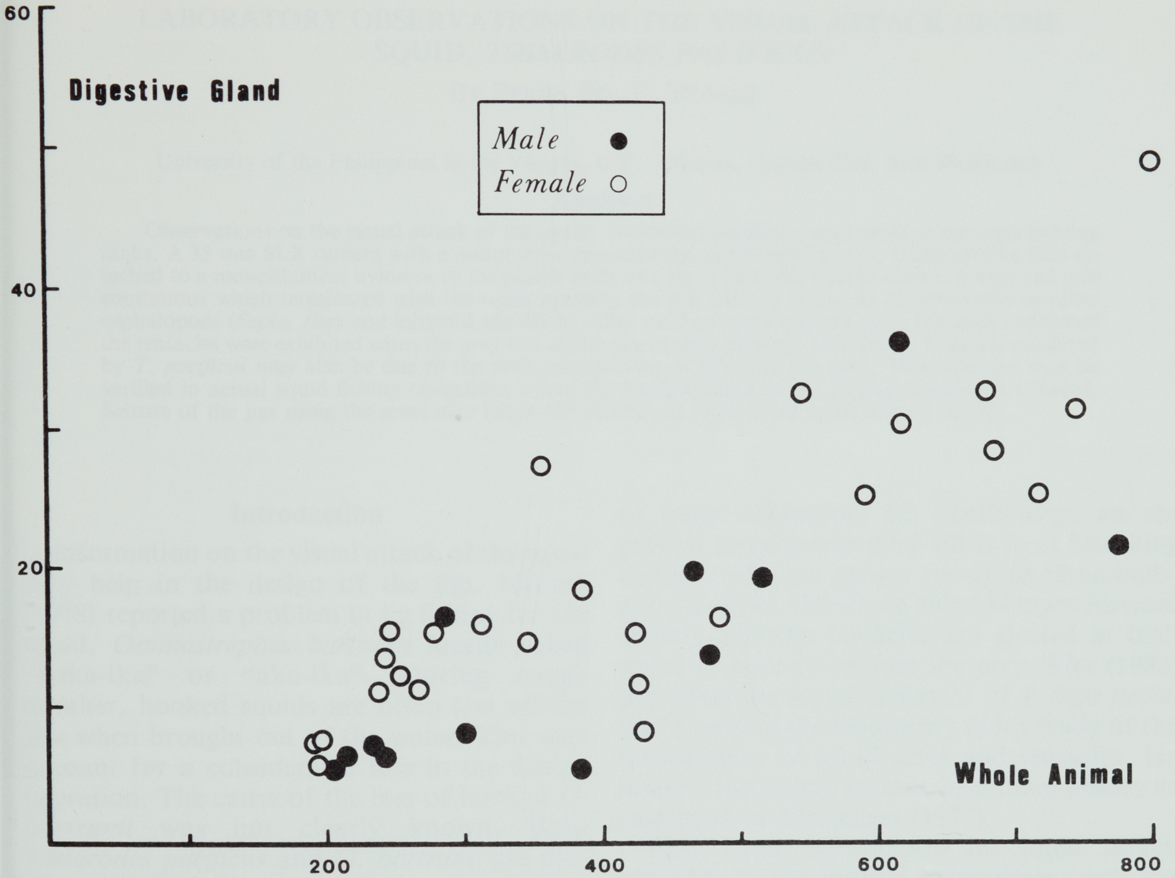


Figure 1. Weight of digestive gland *vs* weight of whole animal for *Nototodarus gouldi.* Figures are wet weight in grammes.

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