The role of euphausiid molts in the transport of radionuclides in the sea

by

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The relatively large biomass of euphausiids in the world ocean and their ability to molt continually throughout their lifespan suggest that this planktonic crustacean is a prime contributor to the rain of organic detritus in the sea. These vertical migrators are also able to concentrate radionuclides to relatively high levels and thus frequent molting might be a major route in the vertical transport of radionuclides throughout the water column. Therefore, experiments were designed to test the importance of molting under different environmental conditions utilizing ^{57}Co, ^{54}Mn, ^{65}Zn, and ^{59}Fe, radio-isotopes of four biological important trace metals.

Observations were made at several temperatures on the molting rate of different species of euphausiids as well as different size groups within the same species. In all the groups tested the length of the intermolt period was extremely regular and inversely related to temperature over the experimental temperature range. For large adult *Meganyctiphanes norvegica* from the Mediterranean the molting frequency was 12 days at 10° C and decreased to 7 days at 15° C. On the other hand, *Euphausia pacifica*, a much smaller species from the colder waters of the North Pacific, molted every 12 days at 5° C, 8 days at 10° C, and every 4 days at 15° C. The temperature effects on euphausiids migrating vertically through a thermocline were assessed by cycling *Meganyctiphanes* on a night-day basis between two temperatures which simulate the extremes of the temperature range that the animals experience daily. The euphausiids were found to molt regularly at a rate expected at the mean of the two temperatures. Size of the individual within a species also influenced the molting frequency. Small-sized *Meganyctiphanes* molted anywhere from 1 to 2 days sooner than the larger, full-grown individuals, depending on the temperature. Size dependent molting rates were also shown by an actively growing *Nyctiphanes couchii*, which was molting every 5 days when first brought into the laboratory and nine months later had increased its intermolt period to every 9 days at the same temperature. In addition, monthly collections indicated that the time of year the animals were caught did not affect the molting frequency of a given size group or species at similar temperatures. Starved individuals molted at the same frequencies as feeding animals although the former died relatively soon after commencement of starvation. Most deaths occurred at molt in all species.

Eighty to 90 % of all molts took place during the nighttime hours in all species and size groups despite the fact that the animals were maintained in the laboratory for several months without any obvious environmental clues. Nighttime molting was somewhat depressed by colder temperatures as evidenced by the significantly lower percentages (66-70 %) in species held at constant temperature toward the low end or out of the range of temperatures normally encountered by the species.

Meganyctiphanes was allowed to accumulate radionuclides from a mixed-isotope seawater medium for 5 days. Molts retrieved during this time averaged 53, 38.8, 59.3, and 71.6 % of ^{57}Co, ^{54}Mn, ^{65}Zn, and ^{59}Fe, respectively, in the animals. These percentages were drastically reduced to 3.5, 2.4, 3.3, and 10.6 % of the same isotopes when they were accumulated through the food chain by grazing on radioactive *Artemia*. Despite the mode of isotope accumulation, the percentages of radioisotopes held in the molts were greatly reduced in the second and succeeding molts of the animals.

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Molts of euphausiids were found to desintegrate from 48 to 96 hrs after being shed, the time depending on the species, size of molt, and water temperature. Freshly shed exuvia of *Meganyctiphanes* were periodically measured before disintegration and found to lose the incorporated isotope at an exponential rate dependent upon the isotope. Loss rates from molts were fastest for ^{54}Mn and decreased for ^{65}Zn, ^{57}Co, and ^{59}Fe, in that order. In addition euphausiid molts were found to sink at continuous rates anywhere from 14 to 33 m/hr. These sinking rates were dependent upon a number of variables such as species, size of organisms, and water temperature and salinity.

In view of the above information euphausiid molts can be considered important in the transfer of radioisotopes throughout the marine ecosystem. Contaminated exuviae would constitute a source of radionuclides to benthic organisms only within the sinking range of the molts. Nevertheless, sinking molts that eventually disintegrate would be an important means for the redistribution of radio-isotopes to the water column both above and below the thermocline.