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Studies on the Depuration of Cadmium and Copper by the American Oyster *Crassostrea virginica*

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Few studies concerned with the accumulation of trace metals by the oyster have dealt with depuration (PRINGLE et al. 1968, CUNNINGHAM and TRIPP 1973, 1975, 1975a; MANDELLI 1975, GREIG and WENZLOFF 1978). Depuration, or a loss of metal, has been observed during gametogenesis (FRAZIER 1975). Spawning has also been implicated in metal loss from the oyster (CUNNINGHAM and TRIPP 1973, 1975). Some depuration studies have been performed under controlled conditions (PRINGLE et al. 1968, CUNNINGHAM and TRIPP 1975, 1975a) while others have been performed under natural conditions (IKUTA 1968, MANDELLI 1975, CUNNINGHAM and TRIPP 1973, 1975, 1975a). In most studies, some depuration of metals was observed.

The effect of seawater temperature on metal depuration from the oyster remains uncertain. SHUSTER and PRINGLE (1969) reported that metal depuration proceeded more slowly at seawater temperatures of 4-12° than at 20°. The study of CUNNINGHAM and TRIPP (1975) indicated that mercury clearance in oysters was greater when temperature was held constant at 25 $\pm$ 2°C than in a declining temperature regime (25 to 5°C). However, MANDELLI (1975) reported that winter conditions were more favorable for copper depletion in oysters.

This study was an attempt to establish under laboratory conditions whether treated oysters would depurate accumulated cadmium and copper when returned to cleaner waters containing natural concentrations of these metals. In addition, an attempt was made to determine if cadmium accumulation would promote copper loss in the oyster.

MATERIALS AND METHOD

Adult oysters, *Crassostrea virginica*, were obtained from Long Island Sound in October, 1973. After harvest, the oysters were acclimatized in fiberglass troughs for one month. With the exception of the 0.015 ppm cadmium added to the seawater, the system and procedure reported by ZAROOGIAN and CHEER (1976) were used in this study. Seawater concentrations of cadmium and copper

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in the troughs were analyzed weekly by atomic absorption spectroscopy using the method of DAVEY and SOPER (1975). The concentration of cadmium in the experimental troughs ranged from 0.0146 to 0.0154 ppm. The seawater in the control troughs contained 0.001-0.002 ppm copper.

The oysters were treated with cadmium for 40 weeks starting November, 1973, and terminating August, 1974. Depuration of cadmium proceeded for 16 weeks (September to January) following treatment.

Since the oysters contained high concentrations of copper at the time of collection, depuration of copper was studied for 56 weeks. Oysters were not fed supplements during the study since the flowing seawater contained sufficient food.

Five oysters were sampled weekly from the control and experimental groups during the depuration phase of the study. The tissue preparation and digestion were performed as described by ZAROOGIAN and CHEER (1976). Samples were analyzed by atomic absorption spectroscopy for cadmium and copper, and the results were expressed as ug Cd/g dry weight.

RESULTS AND DISCUSSION

Cadmium addition was terminated and depuration of cadmium started after the spawning period since spawning has been implicated in metal loss from oysters (GALTSOFF 1964, CUNNINGHAM and TRIPP 1973, 1975, FRAZIER 1975). During the spawning period (July 3 - Aug. 1) no apparent loss of copper was observed.

Data expressed in Table 1 indicated that cadmium was not depurated by _C. virginica_ under the conditions of this experiment, particularly a declining temperature regime (Figure 1).

No significant decrease in copper concentration occurred in either the control or cadmium treated oysters with increasing or decreasing temperature regimes. Although not significant, the slopes obtained with regression analyses for each treatment were positive. This indicated a general increasing trend rather than a decreased copper concentration with time.

IKUTA (1968) observed depuration of copper by _Ostrea gigas_ 14 or more days after transplantation from copper polluted waters to cleaner waters. He also reported that oysters with high copper concentrations reduced body burdens to normal values in 116 days. CUNNINGHAM and TRIPP (1973) observed depuration in _C. virginica_ only during the first 18 days after termination of mercury addition.

TABLE 1

Tissue residues of cadmium after 16 weeks and copper after 56 weeks in *Crassostrea virginica* held in flowing ambient seawater. Each figure represents the mean of 5 animals.

			CONTROL				TREATED				
Date	(weeks)	Dry Weight	ug Cadmium	ug Copper	ug/g dry weight Cd	Cu	Dry Weight	ug Cadmium	ug Copper	ug/g dry weight Cd	Cu
Nov 73	0	2.39		2006		837	2.39		1992		837
Dec	4	2.11		1844		873	2.53		2334		922
Jan 74	8	1.82		1779		1023	2.42		1876		755
Feb	12	1.42		1039		919	1.94		2089		1076
Mar	16	1.77		1489		854	2.04		1561		756
Apr	20	1.87		1854		1083	1.94		2650		1366
May	24	1.84		1085		587	1.74		1623		932
June	28	2.11		1508		767	2.50		1915		765
July	32	1.97		1168		574	2.46		2317		941
July	36	1.60		1546		1049	1.65		2519		1526
Aug	40	2.14	26.62	1853	12.45	782	2.29	608	2213	274	966
Sept	42	1.36	22.46	928	16.51	686	1.57	443	989	279	626
Oct	44	1.52	28.32	1490	19.78	983	1.42	390	1279	280	898
Oct	46	1.79	13.77	1743	7.79	971	1.18	379	1103	323	932
Nov	48	1.18	14.42	1124	12.06	948	1.36	378	1641	277	1204
Nov	50	1.52	23.91	1281	15.75	840	0.93	269	884	281	958
Dec	52	1.41	21.68	1332	14.36	948	1.08	363	1002	327	935
Dec	54	1.15	20.69	859	18.81	746	1.20	417	889	350	746
Jan 75	56	1.45	19.98	1345	13.83	926	1.07	270	1011	256	941

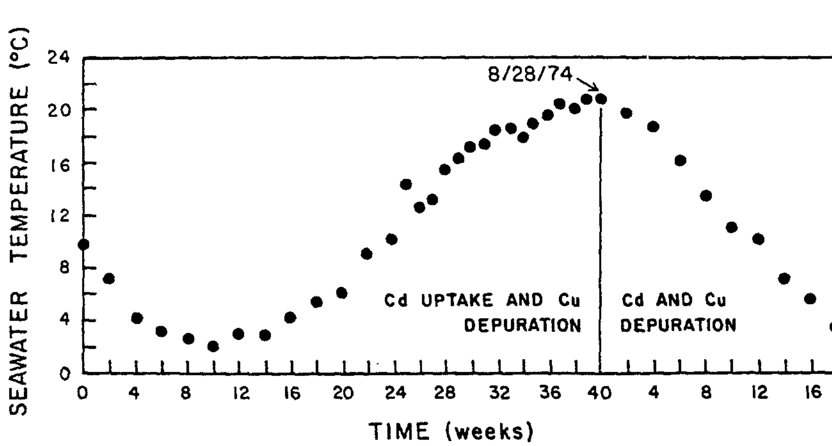

Figure 1. Mean seawater temperature for sampling periods starting November 11, 1973 and terminating January 2, 1975.

GREIG and WENZLOFF (1978) did not observe a decrease in cadmium concentration in C. virginica when transferred from metal impacted waters to cleaner waters. However, under these same conditions, they did observe a decrease in copper concentration. Their study suggested that C. virginica tissues retain cadmium and copper residues when transferred to cleaner waters.

Regression analyses suggested that during the period September to January, dry weight of both control and cadmium treated oysters decreased with time.

A significant relationship existed between copper concentration and dry weight in cadmium treated oysters. The negative slope suggested that loss of copper varied directly with size or that accumulation varied inversely with size. However, the R^2, a measure of the amount of variability which can be explained by the linear regression, was low (.10). There was no significant relationship between copper concentration and dry weight in control oysters. However, the negative slope indicated a trend of decreased copper concentration with increased weight in controls. No significant relationship existed between copper content and time.

SHUSTER and PRINGLE (1969) reported that metal depletion was governed by temperature, salinity dosage, duration of exposure to metals and the physiological condition and activity of the shellfish. They also indicated that loss of trace metals from the tissues proceeded more slowly at 4-12°C than at 20°C. MANDELLI (1975) reported that the winter season offered particularly favorable environmental conditions for copper depletion in *C. virginica*. His fall-winter copper depletion studies indicated that, after an initial period characterized by fairly constant rates, the process of depletion slowed down considerably. CUNNINGHAM and TRIPP (1975) reported that 79% of the residual mercury was lost after 80 days in a declining temperature regime (25 - 5°C).

In this study we observed no significant relationship between time and depuration of cadmium nor with time or seasonal effects and depuration of copper. The small, but non-significant losses of copper observed in our study were probably a reflection of decreasing copper concentrations with increasing oyster size rather than the result of depuration. The weight-copper concentration relationship we observed did not, however, explain why the copper concentration-dry weight relationship became significant in oysters exposed to .015 ppm cadmium.

It appeared that depuration of cadmium did not occur when metal concentration alone was studied; however, when the relationships of content and weight with time were included, a loss of cadmium was indicated since content decreased over time as did weight. During the depuration period, cadmium content significantly decreased from 608 to 270 ug (approximately 56%).

CASTERLINE and YIP (1975) suggested that metals such as Cd, Cu and Zn may exist unbound in oyster and CHOU et al. (1978) reported that approximately 50% of the total cadmium in oyster tissues was free or unbound. In view of the fact that we detected approximately 56% of the cadmium content was lost, it might very well be this unbound or free cadmium which is lost. If we assume that bound metal is not depurated and unbound metal is, we might explain the incomplete depuration of metal, where metal loss occurred rapidly initially then ceased (IKUTA 1968, CUNNINGHAM and TRIPP 1973, 1975; MANDELLI 1975).

Losses or gains of weight by experimental oysters during the study period could effect the interpretation of depuration data when body burdens of metal are examined only as concentration. An observed decrease in cadmium content with time and no significant change in cadmium concentration during the depuration period suggested a possible depuration of cadmium. Because concentration is weight dependent, a loss of cadmium or copper in the tissues could go undetected when accompanied by a decrease in soft tissue weight. Therefore, it is important to consider tissue weight, content and concentration with respect to time during a study of metal depuration in order to preclude any weight effects.

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