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Trace Element Concentrations of the Rough Limpet, *Acmaea scabra*, in California

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ABSTRACT

The trace element (Ag, Cd, Cu, Fe, Mn, Ni, Zn) concentrations of the rough limpet, Acmaea scabra, were determined at twelve locations along the California coastline. The mean silver concentration of the organisms was highest at Pt. La Jolla, but no elemental concentration exhibited measurable geographic differences. Simple linear correlation coefficients and multiple analysis of variance statistics indicated a general independence of the elemental concentrations from each other and from other biological and geographic variables, in the total sample.

INTRODUCTION

Trace element (Ag, Cd, Cu, Fe, Mn, Ni, Zn) concentrations of the rough limpet, Acmaea scabra, were determined at several sites along the California coastline (Figure I). The species was selected for the survey because the elemental concentrations of other limpets have been reported to vary geographically (Butterworth et al., 1972; Peden et al., 1973) and it is common to the upper intertidal zones of the California coastline.

MATERIALS AND METHODS

To limit the physiological and environmental differences among the limpets, the samples were restricted to large (1.3-2.7 cm) individuals collected during a single week, June 13-19, 1973.

The limpets were placed in plastic bags, allowed to purge themselves overnight and then frozen. Later, residual sea salts were rinsed off with deionized-distilled water and sediments, vegetative material and commensal organisms were scraped off with a plastic blade. The animals were dried at 60°C for 72 hours, then extracted from their shells with plastic forceps. This material was redried at 60°C for 24 hours.

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The samples were dissolved in 5 ml of 70% redistilled nitric acid at 90°C, charred to 350°C, and redissolved in 5 ml of 70° redistilled nitric acid. The oxidation was completed with 30% hydrogen peroxide. Prior to the analysis, the samples were brought to a standard volume (10 ml) with deionized-distilled water and 1 ml concentrated hydrochloric acid.

The elemental analyses were made with a Perkin-Elmer 305B atomic absorption spectrophotometer, using standard flame techniques and the manufacturer's recommended operating conditions, wavelengths and fuel mixtures. Background interferences were corrected by subtracting the absorbance of nonabsorbing wavelengths. The maximum absorbance of three reagent blanks was also subtracted. National Bureau of Standards orchard leaves digested and analyzed concurrently were found to be within 10% of their certified values.

Following the elemental analyses, an inorganic residue, which was not dissolved by the digestion process, was weighed after decanting off the supernatant, rinsing the residue with 25 ml of deionized-distilled water three times, and drying it at 90°C. The relative contribution of this residue to the total sample dry weight was estimated by dividing the residue weight by the sample dry weight. (Since the digestion process will partially dissolve lithogenic material these estimates were conservative.) The source of the residue is believed to be ingested sediment since it appeared to increase the absorbance of elements (Fe and Mn) commonly associated with such material (Flegal and Martin, 1977).

RESULTS AND DISCUSSION

The elemental concentrations (mean and standard deviation) of A. scabra at each site are listed in Table 1. Other than the iron and manganese values, which are often positively correlated with the residue fraction indicating contamination (Flegal and Martin, 1977), there are no measurable differences in concentrations between locations. However, the highest mean silver concentration (3.9µg/g dry weight) is found in the limpets from Pt. La Jolla, where other similar surveys have also reported relatively high silver concentrations in abalone (Anderlini, 1974), mussels (Alexander and Young, 1976) and the turban snail (Flegal, 1977).

The product-moment correlation coefficients of the log transformed, standardized data for the entire sample set are listed in Table 2. The variable component

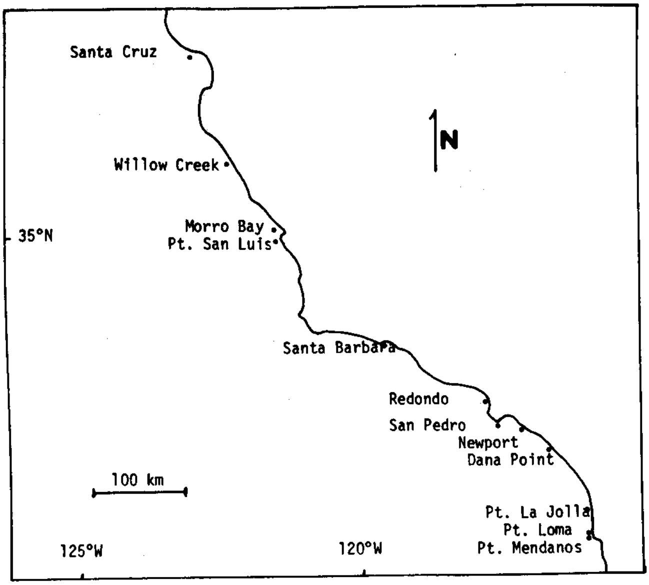

FIGURE I

Collection sites for trace element analyses of the rough limpet, *Acmaea scabra*.

TABLE 1

Elemental Concentrations (µg/g dry weight) of *Acmaea scabra* (mean ± standard deviation)

STATION	SAMPLE SIZE	SHELL LENGTH (cm)	Ag	Cd	Cu	Fe	Mn	Ni	Zn
Pt. Loma	11	1.8 ± 0.3	1.1 ± 1.5	9.6 ± 4.2	5.9 ± 2.3	3360 ± 970	71.0 ± 83.0	17.0 ± 10.0	56 ± 19
Pt. Mendanos	14	1.8 ± 0.3	.5 ± .6	6.4 ± 3.0	4.1 ± 3.0	620 ± 250	5.6 ± 4.4	15.0 ± 9.0	49 ± 12
Pt. La Jolla	14	1.7 ± 0.1	3.9 ± 7.7	6.2 ± 3.6	6.0 ± 3.3	1460 ± 720	32.0 ± 21.0	11.0 ± 14.0	57 ± 12
Dana Point	12	2.1 ± 0.6	0.4 ± 1.0	17.6 ± 6.5	4.5 ± 4.1	960 ± 390	11.2 ± 17.0	16.0 ± 9.0	62 ± 16
Newport	15	1.8 ± 0.2	0.4 ± 0.6	9.4 ± 4.0	4.2 ± 3.4	700 ± 260	4.5 ± 3.8	9.0 ± 7.2	56 ± 17
San Pedro	20	1.8 ± 0.2	0.2 ± 0.4	9.2 ± 5.4	7.0 ± 4.0	1280 ± 690	11.1 ± 7.2	8.6 ± 8.4	59 ± 29
Redondo	15	1.9 ± 0.2	N.D.*	8.3 ± 3.7	7.1 ± 7.2	970 ± 290	5.3 ± 3.0	13.1 ± 11.5	58 ± 26
Santa Barbara	15	1.6 ± 0.2	0.9 ± 1.0	18.7 ± 7.2	7.3 ± 5.1	660 ± 160	7.1 ± 4.1	7.0 ± 6.6	60 ± 38
Pt. San Luis	10	1.9 ± 0.3	N.D.	9.8 ± 4.7	8.1 ± 2.1	3000 ± 1390	38.2 ± 26.1	11.0 ± 12.0	57 ± 26
Morro Bay	14	1.8 ± 0.2	N.D.	14.9 ± 10.3	6.8 ± 1.6	1010 ± 480	13.8 ± 6.9	12.3 ± 12.1	33 ± 18
Willow Creek	15	1.8 ± 0.4	N.D.	21.9 ± 13.1	5.6 ± 3.2	880 ± 240	13.3 ± 7.4	13.3 ± 10.4	32 ± 10
Santa Cruz	15	2.1 ± 0.2	0.8 ± 0.9	11.9 ± 6.0	3.3 ± 3.5	1940 ± 480	7.4 ± 5.9	6.1 ± 5.6	54 ± 10

*N.D.=not detected

TABLE 2

Log Transformed-Standardized Product-Moment Correlations Coefficients (Total Sample)

	1	2	3	4	5	6	7	8	9	10	11	12
1) Station		.15	-.02	.04	-.34	-.22	.22	.14	-.25	-.30	-.23	-.02
2) Wt.			.22	.59	.34	-.14	-.00	.23	.01	.19	.01	-.31
3) length				.35	.11	-.15	.02	.03	-.10	-.03	.07	-.09
4) width					.10	-.17	.07	.13	.03	.18	.12	-.35
5) residue						-.05	-.06	.13	.29	.28	.01	.01
6) Ag							-.00	-.10	.14	.13	.05	.04
7) Cd								.03	-.10	.09	.13	-.13
8) Cu									.08	.24	.02	-.02
9) Fe										.54	.08	.10
10) Mn											.06	-.02
11) Ni												-.07
12) Zn												

n=121

TABLE 3

PRINCIPAL COMPONENT ANALYSIS

Correlations of Variables and Components (Total Sample)

	Component			
Variable	1	2	3	4
1) Station	-.21	.65	.42	.30
2) Wt.	.73	.36	.14	-.04
3) length	.37	.33	-.24	-.42
4) width	.71	.40	-.16	-.03
5) residue	.56	-.32	.12	-.25
6) Ag	-.13	-.45	-.31	.27
7) Cd	-.01	.32	-.26	.64
8) Cu	.37	.07	.49	.39
9) Fe	.38	-.64	.15	.20
10) Mn	.57	-.53	.16	.23
11) Ni	.19	-.10	-.64	.24
12) Zn	-.38	-.37	.34	-.15

TABLE 4

PRINCIPAL COMPONENT ANALYSIS

Variable Component Coefficients (Total Sample)

	Component			
Variable	1	2	3	4
1) Station	-.14	.45	.38	.28
2) wt.	.48	.25	.13	-.04
3) length	.24	.23	.21	-.40
4) width	.46	.28	-.14	-.03
5) residue	.37	-.22	-.10	-.23
6) Ag	.09	-.31	-.27	.25
7) Cd	-.01	.22	-.23	.60
8) Cu	.24	-.05	.43	.37
9) Fe	.25	-.45	.13	.18
10) Mn	.37	-.36	.14	.22
11) Ni	.13	-.07	-.57	.23
12) Zn	-.25	-.03	.30	-.14
variance	2.35	2.08	1.27	1.15
% of total variance	19.58	17.33	10.58	9.58
cumulative % of variance	19.58	36.91	47.49	57.07

coefficients and the correlations of the variables and the components of a principal component analysis are listed in Tables 3 and 4, respectively. These statistics indicate generally low correlations between the elemental concentrations with each other and with the other sample variables (location, sample weight, shell length, shell width, and the residue fraction). The first principal component, which is identified as the "size-residue" component, accounts for less than 20% of the total variance. The second principal component represents the "geographic effect", and the third and fourth components represent "interelemental effects". These first four principal components account for only 57% of the total variance. A canonical correlation analysis produced similar results.

The same statistical analyses were made for the data from each sample site, separately. The correlation coefficients were often significant ($p<.05$) and the first four principal components accounted for most (~80%) of the total variance. The relationships between the variables were, however, not consistent between locations, which accounts for the low statistical values in the total data set.

SUMMARY

The trace elemental concentrations (Ag, Cd, Cu, Fe, Mn, Ni, Zn) of the rough limpet, A. scabra, collected intertidally from the California coastline did not differ measurably between sites, except for elements associated with an inorganic residue. The mean silver concentration, however, was highest in the limpets from Pt. La Jolla, which is consistent with the relative distribution of silver concentrations in other organisms. Statistical analyses of the data indicated a lack of consistent covariance between an elemental concentration and other elemental concentrations, size, an indicator of comtamination or location for the total sample.

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