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POTASSIUM AND CESIUM-137 IN BIRGUS LATRO (COCONUT CRAB)  
MUSCLE COLLECTED AT RONGELAP ATOLL

by

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## ABSTRACT

Radiocesium and stable potassium levels were determined in samples of muscle tissue of Gerygus latre, the coconut crab, collected at Rongelap Atoll, Marshall Islands, during March and August, 1958, and March 1959, and at Utrik Atoll in March 1959. Levels of cesium-137 ranged between 731 d/m/g dry weight at Kabelle Island, Rongelap Atoll, and 28 d/m/g dry weight at Utrik Island, Utrik Atoll. The average potassium value for all samples was 13.95 mg/g dry weight with a standard deviation of 3.56. No significant correlation between cesium-137 and potassium levels was found. There was no significant difference in the average levels of cesium-137 in crabs collected at different times at the same island.

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INTRODUCTION

Rongelap Atoll was contaminated with radioactive fallout resulting from the Bravo test on March 1, 1954, to the extent that it was necessary to evacuate the population of 82 Rongelapese. Some 200 Marshallese returned to Rongelap in June 1957, after the area had been declared safe for human habitation. Since 1954, there have been several surveys to determine the level of radioactive contamination of the biota at Rongelap Atoll (Dunning, 1957). In March 1958, a long-term study of the ecology of the atoll, relative to radioactive contamination, was initiated at the request of the U. S. Atomic Energy Commission, Division of Biology and Medicine.

The objective of this investigation was to determine the radiocesium and stable potassium content in the muscle of Birgus latro (coconut crab) and to evaluate the relationship between the two, if any, under the existing conditions at Rongelap Atoll.

Birgus latro, the coconut crab, is of particular interest because it is edible and is a land crab known to contain cesium-137 in its muscle tissue. Cesium-137 is also the principal long-lived (27 years half life) fission product found in plants on contaminated islands in the Marshall

Islands. There have been conflicting reports in the literature concerning the relationship of potassium to cesium-137 uptake in plants (Auerbach and Crivello, 1958; Nichols, et al., 1958; Uhler, 1959, Nichols et al., 1959). Apparently the uptake of cesium-137 by plants is directly associated with potassium uptake in some cases and not in others.

It was suggested from the results of studies of Crematogaster at Bikini Atoll that seasonal differences in precipitation might influence cesium-137 levels in muscle tissue (Hild, 1959); the data presented here do not support this suggestion.

#### MATERIALS AND METHODS

Samples of Birgus muscle were collected from Kabelle, Rongelap, and Eniwetok Islands at Rongelap Atoll during March 1958, August 1958 and March 1959. Two samples were also collected at Utrik Island, Utrik Atoll (Fig. 1) in March 1959. The Birgus were oven-dried at 98°C and the wet weight to dry weight ratios were determined. For potassium analysis, the samples were wet ashed with concentrated  $HNO_3$  and  $H_2O_2$ . The ash was dissolved in a known volume of 1N  $HNO_3$  and the potassium content determined by flame photometry. Details of the method used have been reported by Chakravarti and Jeyar (1959).

The levels of cesium-137 were determined by gamma spectroscopy. Five to ten-gram samples of dried muscle were counted. The counting

equipment consisted of a three-inch thallium-activated sodium iodide crystal used in conjunction with a 386-channel analyzer with digital print out. The total counts per minute under the photopeak were calculated by summing counts per minute of all channels included in the peak and subtracting the background counts. The counting efficiency for the gamma energy measured was determined by calibrating the instrument with a cesium-137 standard with an error of  $\pm 10$  per cent. The factor used for converting counts per minute to disintegrations per minute was derived from the counting efficiency and from the fraction of the disintegrations giving rise to the gamma radiation being counted. The factor used for cesium-137 - barium-137 was 18.6. Detailed descriptions of the counting equipment and standardization procedures used have been given by Lowman et al. (1964).

### RESULTS AND DISCUSSION

The individual values for potassium and cesium-137 in Burgeo muscle collected at Rongelap Atoll and Utrik Island are presented in Table 1. Average values and their standard deviations for each collection also are given.

The levels of cesium-137 found in individual samples ranged between 731 d/m/g dry weight at Kabelle Island, Rongelap Atoll, and 28 d/m/g dry weight at Utrik Island, Utrik Atoll. The individual

variation at any one island was large. Range in values in  $\mu\text{Ci/g}$  dry weight of three islands of Rongelap Atoll was as follows: Kabolle 104-731, Eniwetok 104-498, and Rongelap 183-922. However, the average cesium-137 levels were highest at Kabolle Island, which lies in the northern part of the atoll, and lowest at Rongelap Island, in the southern part. Analysis of variance gave an F value of 28.96 (significant at 1 per cent level), indicating that the difference in cesium-137 values between these two islands is statistically significant. At Eniwetok Island, which lies about half way between Rongelap Island and Kabolle Island, only three samples were obtained, two in March 1956, and one in August 1956. In the former collection the levels were higher than at Kabolle while in the latter collection the level was lower than at Kabolle for the corresponding dates. This apparent inconsistency is probably a result of individual variation. At Utrik Atoll, which lies some 200 miles to the east (Fig. 1), the levels were about one-tenth of the lowest levels at Rongelap.

The gamma dose rates give an indication of the relative levels of radioactive contamination of the different islands. The average gamma dose rates measured three feet above ground in March 1956 at these islands were, Rongelap 881, Eniwetok 661, Kabolle 668 and Utrik 268, expressed in milliroentgens per hour.

Determinations of other radionuclides in Mytilus muscle indicate that over 80 per cent of the radioactivity is from cesium-137.

For comparison with cesium-137 levels, the average potassium value for each collection is given in Table . The average potassium value for all samples was 13.65 mg/g with a standard deviation of 1.08. The range in values was 2.06 to 21.2 mg K/g dry weight, but 83 per cent of the 30 samples analyzed fell in the range of 10 to 15 mg K/g dry weight. The two lowest values of 2.06 and 3.45 mg K/g dry weight appear to be completely out of line. Repetition of the analysis of these samples gave essentially the same results and no explanation for the disparity is offered.

A significant difference in potassium levels associated either with island or season of collection is not apparent (March falls in the dry season and August in the wet season). Nor is there any correlation between potassium and cesium-137 levels at any one island. In this regard the data should not be pooled since it has been established that there are differences in cesium-137 levels from island to island. The regression of cesium-137 on potassium in the muscle as determined in the largest sample from Kabella Island, indicated no relation between these elements.

Cesium-137 levels have been reported as cesium units, micro microcuries of cesium-137 per gram of potassium (U. S. AEC reports on fallout). This unit is based on metabolic similarity of cesium and potassium and is used to facilitate comparison of different types of materials in a manner similar to the use of the strontium unit adopted by Libby (1964). Anderson, Schach, Fisher and Langham (1957) have used

the gross ratio of cesium-137 to potassium-40 in place of the cesium unit. Cesium units for Birgus muscle are given in Table I for comparison with other published data on fallout given in the same units. However, since the potassium and cesium levels are both highly variable in Birgus muscle, there is some doubt as to the usefulness of the unit in this case. For example, the comparatively high value for cesium units of samples from Rongelap Island is due to the exceptionally low potassium content of one of the samples. On the other hand, the high value for the March 1950 collection at Kabone Island is due to high levels of cesium-137, while the potassium levels are about average.

These differences are not surprising when the following facts are considered. Gross (1950) has reported that Coccyzus, which has habits similar to those of Birgus, obtains blood salts from its food. From work in progress at this Laboratory it is known that Pandanus fruits, which form a part of the diet of Birgus, vary by as much as a factor of five in cesium-137 content and a factor of four in potassium content and that the range in potassium levels is such on which Pandanus grows at Rongelap is 0.1 to 1.5 milliequivalents per 100 grams. Also, the extremes in the range of gross beta activity in the top inch of soil at a single island can differ by more than a factor of ten. On a basis of the variability in cesium-137 and potassium levels found in the environment alone, one might expect the high degree of variability found in Birgus.

An additional factor which may accentuate the condition found in Birgus is currently under study at this Laboratory in cooperation with the Department of Botany, University of Washington. The low potassium levels in the soils at Rongelap represent a potassium deficiency for at least some of the plants. Greenhouse experiments in which Rongelap soil was used as well as field trials at Rongelap have demonstrated that potassium fertilization decreases cesium-137 uptake by plants (Walker and Held, 1950). This observation is in agreement with the reported increase in cesium-137 uptake by plants in other soils as the potassium concentration in the soil is reduced by prolonged cropping (Nishita et al., 1953 and 1954). It appears possible that if a surplus of potassium were present in the soils at Rongelap, potassium levels in Birgus muscle would be more uniform and cesium-137 levels lower.

The simplest system studied at Rongelap with respect to cesium-137 and potassium was the soil. Cesium-137 and potassium in rain water which had percolated through undisturbed areas were found to be present in approximately proportional amounts under changing conditions of precipitation and fertilization (Cole et al., 1950). However, at the second or higher trophic level, represented by Birgus, if any such relationship exists between the uptake of cesium and potassium, it is masked by several unknown variables in the ecosystem.

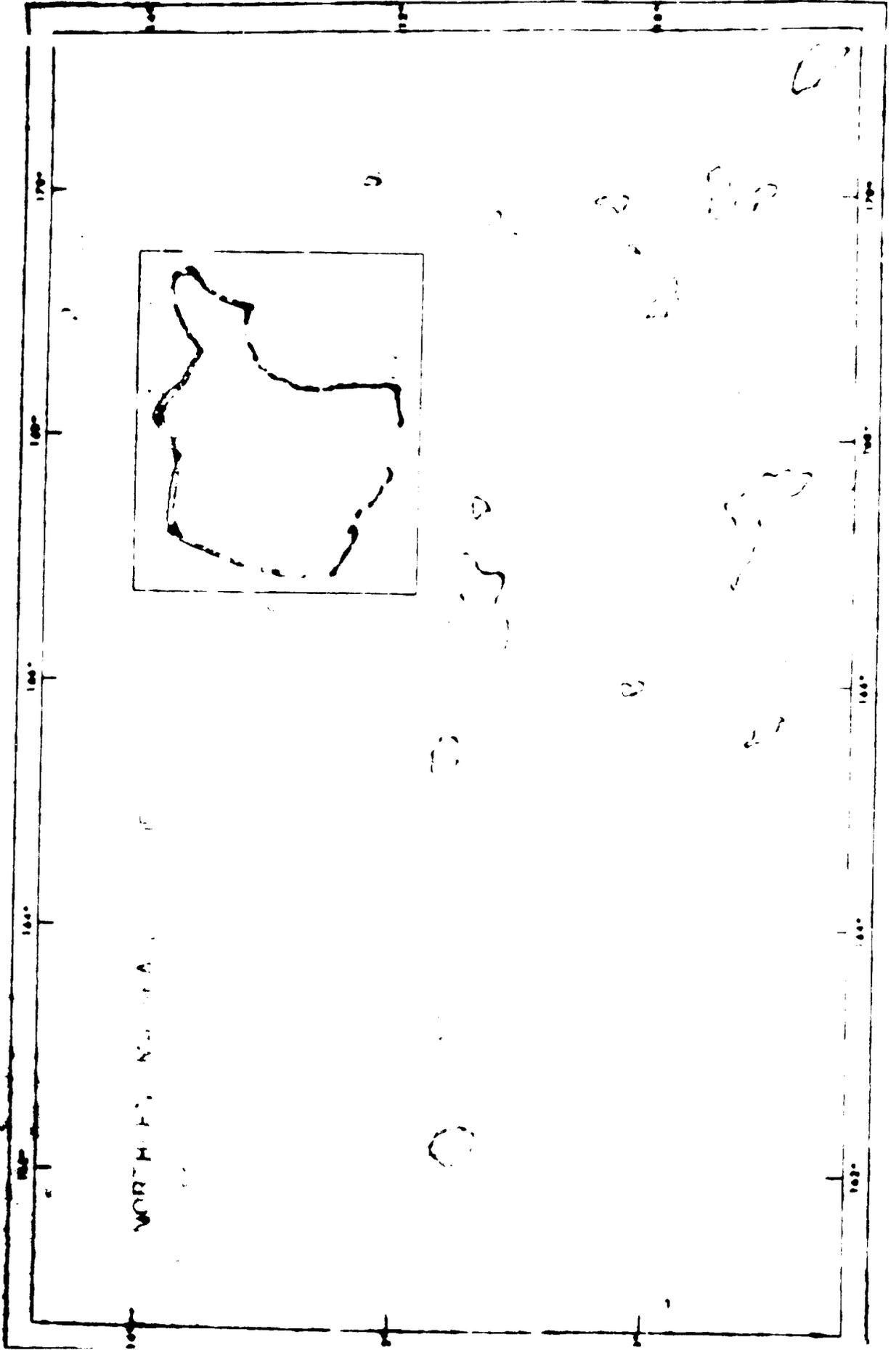


Figure 1. Map of the Marshall Islands with Inset of Rongelap Atoll

Table 1 Potassium and cesium-137 in Birgus latro (coconut crab) muscle collected at Rongelap Atoll and Utrik Island, Utrik Atoll

Kabells Island

Sample no	Cesium-137		Potassium	Cesium Unit	Wet dry ratio
	dm/g dry weight	mg/g dry weight	mg/g	µmc Cs <sup>137</sup> / µg K	
34	604	13.28		20489	4.2.2
35	426	10.32		18504	3.794
March 1958 (dry season)	36	349	11.40	13789	3.59.
37	410	17.68		10447	4.062
38	437	13.04		15092	3.743
	Av = 445	Av = 13.14		Av = 15622	Av = 3.884
	S D = .95	S D = 2.6.		S D = 3966	S D = 0.252

7	661	17.25		17258	4.930
8	438	14.68		13440	3.490
August 1958 (wet season)	9	454	11.99	17056	3.807
10	325	15.03		9741	4.306
11	660	11.92		24564	3.946
12	324	13.87		10519	3.660
	Av = 475	Av = 14.12		Av = 15430	Av = 4.022
	S D = 150	S D = 2.02		S D = 5474	S D = 0.424

1	524	11.2		18546	4.470
2	619	12.64		23065	4.330
March 1958 (dry season)	3	731	11.76	27993	4.840
5	645	12.00		24217	5.149
	Av = 630	Av = 12.28		Av = 23205	Av = 4.625
	S D = .85	S D = 0.47		S D = 3986	S D = 0.366

Rongelap Island

84	190	12.18		7356	3.895
85	219	15.40		6403	4.247
March 1958 (dry season)	86	276	19.20	6474	4.419
87	202	2.96		30743	3.693
88	261	14.72		7989	5.130
	Av = 231	Av = 12.89		Av = 11793	Av = 4.276
	S D = .35	S D = 6.08		S D = 10614	S D = 0.556

Table 1. - (continued)

Rongelap Island

Sample no	Cesium-137	Potassium	Cesium Unit	Wet dry ratio
	d/m/g dry weight	mg/g dry weight	μmc Cs <sup>137</sup> /g K	
2	228	12 71	8080	5 354
3	206	11 77	7884	3 794
4	334	9 86	14648	4 258
5	330	15 35	9661	4 373
6	254	13 44	8512	4 154
Av	• 268	Av • 12 65	Av • 2761	Av • 4 330
S D	• 56	S D • 2 00	S D • 2819	S D • 0 543

Eniwetok Island

March 1958 (dry season)	61	498	14 90	15030	5 000
	62	496	21 18	10590	6 314
Av	• 498	Av • 17 83	Av • 3261	Av • 4 574	
S D	• 00	S D • 5 02	S D • 3776	S D • 1 655	

August 1958  
(wet)

1	380	14 01	11563	4 114
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Ujae Island

March 1958 (dry season)	4	31	3 48	6020	4 121
	5	28	5 54	1105	4 238
Av	• 29 5	Av • 7 58	Av • 3542	Av • 4 280	
S D	• 4 8	S D • 5 77	S D • 2051	S D • 0 051	

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