METABOLISM OF RADIONUCLIDES IN FISH—IV. STRONTIUM-CALCIUM DISCRIMINATION IN THE RENAL EXCRETION OF FISH*

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The discrimination against strontium in favour of calcium was demonstrated in the uptake and accumulation of these radionuclides in fish body through diet or environmental water¹⁾. Various parts of fish body, such as gill, fin, kidney or digestive tract, play an important role in the absorption and excretion of radionuclides²⁾. In the previous paper³⁾⁻⁵⁾, the authors reported on the behaviour of strontium and calcium in the branchial absorption and excretion of fish, and pointed out that calcium was absorbed and excreted by the gill more easily than strontium.

On the other hand, it has been demonstrated in mammals that strontium is excreted by the kidney more rapidly than calcium⁶⁾. However, so far as the authors are aware, no studies are reported on the behaviour of these two minerals in the renal excretion of fish. The present paper deals with this subject.

Material and Methods

Twenty-two snake-head fish (*Channa argus*) of 160–450 g in body weight were used in this experiment. Among these fish, 12 fish received intraperitoneally 1–1.5 μ c of calcium-45 and strontium-89 dissolved in 0.2 ml of distilled water, after closing urogenital pore by the method reported in the previous paper⁷⁾. Another 10 fish were injected at first with 10 mg of Diamox (acetazolamide). The administration of calcium-45 and strontium-89, and the closing of urogenital pore were conducted, at about thirty minutes after Diamox-injection.

After about 24 hours, the urine stored in the urinary bladder was collected by the method described in the previous paper⁷⁾. The activity of calcium-45 and strontium-89 in the collected urine was measured separately using aluminium absorber. The ratios of strontium-89 to calcium-45 in the urine were compared with those in the injected solution. Thus, the strontium-calcium discrimination rate at the renal excretion (DR_{renal}) defined as Sr/Ca in the urine: Sr/Ca in the injected solution was calculated.

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Results and Discussion

Table 1 shows the experimental results on the strontium-calcium discrimination rate in the renal excretion of 12 fish used. The discrimination rate was 1.9 ± 0.2 on an average. Accordingly, strontium is excreted more abundantly than calcium in the renal excretion of fish, as demonstrated in that excretion of mammals⁶⁾.

Table 1. Strontium-calcium discrimination rate in the renal excretion of the snake-head fish, *Channa argus*.

Fish No.	Sex.	Body weight (g)	Sr-89 : Ca-45 in solution injected (A)	Sr-89 : Ca-45 in urine (B)	DR _{renal} (B/A)
1	F	190	1.92	2.64	1.4
2	"	225	0.51	1.12	2.2
3	"	250	"	0.98	1.9
4	"	350	0.65	0.90	1.4
5	"	300	"	1.16	1.8
6	"	"	"	1.92	3.0
7	"	240	0.51	1.45	2.8
8	"	375	0.63	1.06	1.7
9	"	385	"	0.92	1.5
10	"	415	0.84	1.79	2.1
11	"	330	"	1.68	2.0
12	"	360	"	1.25	1.5

Mean $1.9 \pm 0.2^*$

* Mean $\pm$ S.E.

The discrimination against strontium in favour of calcium was ascertained by one of the authors in the uptake and accumulation of these minerals in fish body through diet or environmental water¹⁾. The "Observed ratio" (OR freshwater-fish body) defined as Sr/Ca in fish body: Sr/Ca in the environmental water was 0.4 in case of rainbow trout, *Salmo gairdnerii irideus*. As for the discrimination in each excreting or absorbing process contributing to the overall discrimination ("Observed ratio"), the authors^{3), 5)} reported that the discrimination factor at gill absorption, was 0.7 in case of fresh-water fish, *Anguilla japonica*. Furthermore, it was reported by the authors⁴⁾ that calcium was excreted a little more easily than strontium in piscine gill.

In fish, the bivalent minerals such as calcium and magnesium are excreted mainly via kidney, whereas the monovalent minerals such as sodium and potassium are excreted mainly through gill⁸⁾. As mentioned above, it was demonstrated that strontium is excreted more abundantly than calcium in the renal excretion of fish. Accordingly, it is concluded that strontium-calcium discrimination in the renal excretion is important in the contribution to the overall discrimination in fish body.

In mammals, it has been ascertained that carbonic anhydrase is abundant in the

kidney and plays an important role in the urinary acidification and sodium reabsorption⁹⁾. In the previous paper⁷⁾, the authors reported that carbonic anhydrase was involved in the acidification of the snake-head fish, and Diamox inhibited the activity of carbonic anhydrase in the fish kidney as known in mammals. Table 2

Table 2. Strontium-calcium discrimination rate in the renal excretion of the snake-head fish, *Channa argus*, injected with Diamox (10 mg).

Fish No.	Sex.	Body weight (g)	Sr-89 : Ca-45 in solution injected (A)	Sr-89 : Ca-45 in urine (B)	DR _{renal} (B/A)
1	F	210	0.65	0.97	1.5
2	"	190	"	0.78	1.2
3	M	170	0.62	1.03	1.7
4	F	230	"	1.07	1.7
5	"	180	"	0.61	1.0
6	"	175	0.58	1.16	2.0
7	"	160	"	0.81	1.4
8	"	300	"	0.83	1.4
9	"	190	"	1.00	1.7
10	M	450	"	1.23	2.1
				Mean	1.6±0.1*

* Mean±S.E.

shows the strontium-calcium discrimination rate in renal excretion of fish injected with 10 mg of Diamox. The discrimination rate was 1.6 ± 0.1 on an average. Compared with strontium-calcium discrimination rate in the Diamox-uninjected fish (Table 1), difference is not significant statistically. ICHIKAWA et al¹⁰⁾ reported that Diamox depressed the calcium reabsorption in the renal tubules of newt, *Triturus pyrrhogaster*, but reabsorption rate of strontium was not altered. However, it was obtained from the present experiment that Diamox have no effect on the strontium-calcium discrimination in the urinary excretion of fish.

Summary

The behaviour of strontium and calcium is the renal excretion of fish was investigated, using the snake-head fish, *Channa argus*.

1. The strontium-calcium discrimination was demonstrated in the renal excretion of fish. Strontium was excreted by the kidney more abundantly than calcium.
2. The intraperitoneal injection of Diamox to fish gave no effect to the strontium-calcium discrimination in renal excretion.

References

- 1) ICHIKAWA, R.: *Rec. Oceanogr. Works in Japan*, **5**, 120-131 (1960)
- 2) MASHIKO, K. and K. JOZUKA: *Annot. Zool. Japon.*, **37**, 41-50 (1964)
- 3) ICHIKAWA, R. and M. OGURI: *This Bull.*, **27**, 351-356 (1961)

- 4) ICHIKAWA, R., M. OGURI, and N. FUKUDA: *This Bull.*, **27**, 990-995 (1961)
- 5) ICHIKAWA, R., M. OGURI, and N. TAKADA: *This Bull.*, **28**, 1160-1163 (1962)
- 6) WALSER, M. and B.H.B. ROBINSON: "*Renal Excretion and Tubular Reabsorption of Calcium and Strontium.*" In "*Transfer of Calcium and Strontium Across Biological Membrane.*" Edited by WASSERMAN, R. H., Academic Press, New York (1963)
- 7) OGURI, M. and N. TAKADA: *This Bull.*, **31**, 293-296 (1963)
- 8) PPOSSER, C. L. and F. A. BROWN, Jr.: "*Comparative Animal Physiology.*" W. B. Saunders Co., Philadelphia, P. 27-31 (1961)
- 9) TOIDA, N. and K. UTIZONO: "*Textbook of Modern Physiology.*" (In Japanese) Vol. II, Igakushoin, Tokyo, P. 404-405 (1961)
- 10) ICHIKAWA, R., Y. ENOMOTO and F. SAKAI: *Science*, **144**, 53-54 (1964)