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Comparison of Zinc Absorption between Common Carp and Other Fresh Water Fishes

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Sen-Shyong Jeng and Juanq-Lin Lian (1994) Comparison of zinc absorption between common carp and other fresh water fishes. *Zoological Studies* **33**(1): 78-85. In order to survey absorption rate differences between common carp and other fresh water fishes, ^{65}Zn was added to diet or water and zinc absorption studied. Results indicate that common carp absorb 3 times more zinc from their diet than tilapia, 3.4 times more than grass carp, and 6.8 times more than silver carp. The relative absorption rates of ^{65}Zn from water among common carp and other fishes were found to be insignificant. Obviously the reason why common carp have a higher zinc concentration in its tissue than other fishes is due to that it has several times higher absorption rate of zinc from diet than other fishes. Under experimental conditions, common carp absorbed 95% of its zinc from diet; whereas, tilapia, grass carp and silver carp absorbed 85%, 78%, and 78% of their zinc from diet, respectively. Diet was the predominate source for zinc absorption in all fishes studied. The absorption channel of zinc from water in common carp was investigated. It was found that gill was the major channel.

Key words: Zinc, Carp, Zinc absorption.

Zinc concentrations in most tissues of animals and fishes were around 10-50 ppm (Underwood 1977); however, those in the viscera of common carp, *Cyprinus carpio*, were found to be extraordinarily high, i.e., 174-585 ppm (Jeng et al. 1973). It was also found that the digestive tract and kidney of common carp were the major tissues responsible for these high concentrations of zinc (Jeng et al. 1974). Usually, the digestive tract and kidney of common carp had a 3-8 times higher concentration of zinc than other tissues. Jeng et al. (1981) reported that the fact that common carp had higher zinc concentration than other fishes was not caused by the feeding habits or the diet. It is more probably the case that the absorption rate of zinc in common carp was higher than that in other fishes. Fish can obtain zinc from diet or/and by direct absorption from the water (Hardy et al. 1987, Spry et al. 1988). Spry et al. (1988) concluded that dietary zinc is normally the primary source for zinc absorption in fish. It is very interesting to know which is the major route to make common carp having higher zinc concentration than other fishes, the route from diet, or the route from water, or both? In this report, the absorption rate zinc from diet only, or from water only in common carp was studied further by using ^{65}Zn, and compared to the rates of tilapia, grass carp and silver carp.

MATERIALS AND METHODS

Fish and basal diet

The fry of common carp, *C. carpio*, grass carp, *Ctenopharyngodon idellus*, and silver carp, *Hypophthalmichthys molitrix*, were obtained from the Wushanto Hatchery Station, Taiwan Fishery Bureau. The fry of tilapia, *Oreochromis niloticus* x *O. aureus*, were obtained from the Fareast Hatchery, Chia-I, Taiwan. The 1 g fry were taken to the laboratory, and reared in several 75 x 50 x 52 cm glass aquaria with a continuous flow of dechlorinated tap water, and the water in the aquaria was well aerated. The tap water was stored in 2 1,000-l tanks and exposed to sunlight for 2 days before use. During the experiment, water temperature was 26-30°C. The fry were fed basal diet 3 times a day, 6 days a week during growth. After reaching a 5 g body weight the fry were fed twice daily until they had grown to 50-70 g at which point the experiment was commenced. The basal diet was prepared according to Ogino's formula (Ogino et al. 1978) with the exception of replacing egg albumin with casein (Table 1). Feed provided was 3% of total fish weight. The zinc concentration in the basal diet was 28.3 ppm.

$^{65}ZnCl_2$

The $^{65}ZnCl_2$ was purchased from the Radiochemical centre (Amersham, UK). It was diluted to 360,000 a cpm/ml with redistillated water. The ^{65}Zn supplementing diet was prepared by adding the diluted $^{65}ZnCl_2$ solution to the basal diet.

Absorption of ^{65}Zn by fish from diet or/and water

Eighteen common carp were acclimated in three acrylic aquaria (45 x 35 x 45 cm) for one week. Each aquarium contained 6 fish and had a continuous flow of rearing water at a rate of about 50 ml/min. The aquaria were aerated. The fish were fed basal diet once a day. Feed provided was maintained at about 2% of the total fish weight. After acclimation, fish were not fed for 48 h. Thereafter, the fish in the first aquarium were fed 5 g of ^{65}Zn supplemented diet; on average, each fish consumed 0.83 g of diet with ^{65}Zn 101,915 cpm/g. The fish were then kept for 24 h with the continuous flow of rearing water. The fish in the second aqurium were fed 5 g of basal diet without adding ^{65}Zn. After the diet had been ingested, the diluted $^{65}ZnCl_2$ solution was added to the rearing water to make a final radioactivity of 260 cpm/ml. ^{65}Zn supplemented water (260 cpm/ml) stored in an acrylic reservoir was continuously flowed into the rearing tank at a rate of 50 ml/min for 24 h. The fish in the third aquarium were both fed 5 g of ^{65}Zn supplemented diet (specific radioactivity, 103,558 cpm/g), and kept in ^{65}Zn supplementing water (260 cpm/ml) for 24 h. After 24 h all fish were taken out and anaesthetized with 0.01% MS-222. A blood sample was obtained from the caudal vessels; the fish were then dissected to obtain tissues for ^{65}Zn radioactivity counts. The digestive tract and its contents were collectively counted. After bleeding and dissection, the carcass was ashed at 550°C, and the ash was collected for ^{65}Zn count. Tilapia treatment was identical to that of the common carp. However, only the first and second treatments for common carp were carried out on grass carp and silver carp; ^{65}Zn was supplied either by diet or water only, but not supplied by both diet and water. For tilapia, the first aquarium ^{65}Zn specific radioactivity in the diet was 105,992 cpm/g; the second aquarum ^{65}Zn in the water was 260 cpm/ml; the third aquarium ^{65}Zn in the diet was 106,771 cpm/g, and ^{65}Zn in the water was 260 cpm/ml. For grass carp, ^{65}Zn in the diet was 100,017 cpm/g, ^{65}Zn in the water was 260 cpm/ml. For silver carp, ^{65}Zn in the diet was 63,687 cpm/g, ^{65}Zn in the water was 260 cpm/ml.

Table 1. Composition of the basal diet

Ingredient	%
Casein	40
α-Starch	20
Dextrin	25
Soybean oil[1]	3
Cod liver oil	2
Cellulose	4
Vitamin mixture[2]	1
Mineral mixture[3]	4
Sodium alginate	1

[1]DL-α tocopheryl acetate was dissolved in soybean oil at a 2.5% level.

[2]Contained the following vitamin mixture per 100 g diet: thiamin HCl, 6 mg; vitamin B-12, 0.01 mg; riboflavin, 20 mg; pyridoxine HCl, 4 mg; nicotinic acid, 80 mg; menadione, 4 mg; myo-inositol, 400 mg; folic acid, 1.5 mg; choline chloride, 800 mg; calcium pantothenate, 28 mg; biotin, 0.6 mg; *p*-aminobenzoic acid, 40 mg; ascorbic acid, 200 mg.

[3]These individual salts were added per 100 g of U. S. P. XII. Salt mixture No.2: $AlCl_3 \cdot 6H_2O$, 15 mg; KI, 15 mg; CuCl, 10 mg; $MnSO_4 \cdot H_2O$, 80 mg; $CoCl_2 \cdot 6H_2O$, 100 mg; $ZnSO_4 \cdot 7H_2O$, 300 mg.

Pathway for absorption of ^{65}Zn from water in common carp

In order to know whether ^{65}Zn dissolved in water was absorbed from the gills or the surface of the fish, Kobayashi's apparatus was used (Kobayashi et al. 1979). The apparatus is separated into two compartments by a silicon rubber sponge sheet with a hole in the middle to hold the fish behind the pectoral fin. It suspended the fish in 2 compartments, the head and gills in one and the remaining body in the other. Common carp were not fed for 48 h, after which it was anaesthetized with 0.01% MS-222 and quickly transferred into the apparatus. Both compartments were filled with rearing water; the head compartment aerated. When the fish recovered from anaesthesia, the diluted ^{65}Zn solution was either introduced only into the head with gill compartment to produce a 500 cpm/ml final specific radioactivity, or to the body compartment to produce a 600 cpm/ml final specific radioactivity. During exposure, apparatus water was not changed and its temperature was maintained at 25°C. After 24 h exposure, the radioactive water in the compartment was first drained. Then the fish was taken out, and let it swim in an acrylic aquarium with rearing water for 10 min to remove any adhering ^{65}Zn on its surface. Thereafter, the fish was anaesthetized with 0.01% MS-222, a blood sample obtained, and the fish dissected to obtain tissues for ^{65}Zn radioactivity counts. The carcass was ashed at 550°C, and the ash was collected for a ^{65}Zn count. Two duplicates were performed in each compartment.

Counting of ^{65}Zn radioactivity

Samples weighing less than 1 g were put directly into a 5 ml counting vial, samples heavier than 1 g were evenly minced or mixed, and about 1 g of the sample was taken for the radioactivity count. The radioactivity was counted on a gamma counter (Parkard Model 5000); data is expressed as specific radioactivity (cpm/g wet tissue).

RESULTS

Absorption of ^{65}Zn from diet or/and water

Table 2 indicates that regardless of the ^{65}Zn supply by diet or water, the digestive tract and kidney of common carp had the highest specific radioactivies; moreover, the values were quite similar. The common carp gill had a high specific radioactivity when ^{65}Zn was supplied by water. Tilapia, grass carp and silver carp (Tables 3, 4, and 5), all had the highest specific radioactivities in their digestive tracts. But neither kidney nor gill had high specific radioactivity as digestive tract, whether ^{65}Zn was supplied by diet or water. When ^{65}Zn was supplied by diet, the diet might remain in the digestive tract 24 h after ingestion; additionally, when ^{65}Zn was supplied in water, ^{65}Zn absorbed by the fish might be excreted into the digestive tract. Therefore, the digestive tract and its contents were eliminated when calculating whole fish ^{65}Zn absorption.

Relative absorption rate of ^{65}Zn from diet

In order to calculate the relative absorption rate of ^{65}Zn from diet, the specific radioactivity of ^{65}Zn ingested by fish was calculated first, it is: ^{65}Zn ingested cpm/g fish = amount of diet consumed per fish x specific radioactivity of ^{65}Zn in diet ÷ fish weight. The values were: common carp, 1,596 cpm/g; tilapia, 1,472 cpm/g; grass carp, 1,483 cpm/g; and silver carp, 1,168 cpm/g.

Table 6 shows the percentage of absorption

Table 2. Absorption of ^{65}Zn by common carp *Cyprinus carpio* from diet or/and water 24 h after treatment[1]

Tissue	^{65}Zn supplied by diet only		^{65}Zn supplied by water only		^{65}Zn supplied by diet and water	
	Sample weight (g)	Specific radioactivity of tissue (cpm/g)	Sample weight (g)	Specific radioactivity of tissue (cpm/g)	Sample weight (g)	Specific radioactivity of tissue (cpm/g)
Digestive tract	1.31 ± 0.29	8,688 ± 2,754	1.17 ± 0.14	14,806 ± 4,394	1.24 ± 0.23	16,955 ± 5,186
Blood	0.82 ± 0.28	1,401 ± 494	0.84 ± 0.15	2,692 ± 429	0.72 ± 0.19	3,210 ± 830
Kidney	0.26 ± 0.06	9,196 ± 4,614	0.29 ± 0.03	10,006 ± 2,224	0.29 ± 0.04	17,154 ± 4,197
Other viscera	3.45 ± 2.34	1,967 ± 1,354	4.31 ± 1.95	1,939 ± 540	4.39 ± 3.04	4,050 ± 2,517
Gill	1.21 ± 0.35	2,607 ± 1,244	1.07 ± 0.24	8,002 ± 2,066	1.17 ± 0.25	11,146 ± 2,641
Muscle + skin + scale	1.04 ± 0.14	394 ± 198	1.09 ± 0.31	714 ± 53	0.98 ± 0.11	1,043 ± 320
Remaining carcass	44.90 ± 2.10	803 ± 305	45.90 ± 4.83	1,412 ± 199	44.95 ± 4.89	2,195 ± 516
Whole fish	52.99 ± 3.42	1,107 ± 448	54.72 ± 4.09	1,826 ± 284	53.74 ± 3.60	2,753 ± 722
Whole fish (not including digestive tract)	51.68 ± 3.46	829 ± 408	53.55 ± 3.99	1,416 ± 210	52.50 ± 3.71	2,157 ± 651

[1]18 fish were divided into 3 groups, each group contained 6 fish reared in 3 aquaria. Data is expressed as mean ± SD.

Table 3. Absorption of ^{65}Zn by tilapia *Oreochromis niloticus x O. aureus* from diet or/and water 24 h after treatment[1]

Tissue	^{65}Zn supplied by diet only		^{65}Zn supplied by water only		^{65}Zn supplied by diet and water	
	Sample weight (g)	Specific radioactivity of tissue (cpm/g)	Sample weight (g)	Specific radioactivity of tissue (cpm/g)	Sample weight (g)	Specific radioactivity of tissue (cpm/g)
Digestive tract	3.60 ± 0.84	4,645 ± 477	3.84 ± 1.64	68,423 ± 17,555	3.44 ± 0.57	85,518 ± 25,267
Blood	0.76 ± 0.16	1,519 ± 713	0.78 ± 0.11	6,892 ± 1,858	0.76 ± 0.10	10,735 ± 2,460
Kidney	0.15 ± 0.06	1,086 ± 452	0.12 ± 0.03	5,622 ± 1,598	0.12 ± 0.03	7,688 ± 1,652
Other viscera	1.65 ± 0.63	1,000 ± 622	1.18 ± 0.28	7,433 ± 4,526	1.32 ± 0.28	8,047 ± 2,763
Gill	1.93 ± 0.22	525 ± 212	2.14 ± 0.30	3,580 ± 981	2.11 ± 0.16	4,998 ± 571
Muscle + skin + scale	1.12 ± 0.17	133 ± 57	1.14 ± 0.16	511 ± 173	1.07 ± 0.08	458 ± 23
Remaining carcass	50.52 ± 3.88	221 ± 97	53.68 ± 2.99	1,104 ± 251	51.26 ± 4.15	1,404 ± 274
Whole fish	59.73 ± 4.10	532 ± 119	62.88 ± 3.21	5,523 ± 1,851	60.08 ± 4.09	6,769 ± 2,138
Whole fish (not including digestive tract)	56.13 ± 3.67	255 ± 118	59.04 ± 3.44	1,287 ± 200	56.64 ± 4.23	1,725 ± 352

[1]18 fish were divided into 3 groups, each group contained 6 fish reared in 3 aquaria. Data is expressed as mean ± SD.

Table 4. Absorption of ^{65}Zn by grass carp *Ctenopharyngodon idelus* from diet or water 24 h after treatment[1]

Tissue	^{65}Zn supplied by diet only		^{65}Zn supplied by water only	
	Sample weight (g)	Specific radioactivity of tissue (cpm/g)	Sample weight (g)	Specific radioactivity of tissue (cpm/g)
Digestive tract	1.51 ± 0.25	1,890 ± 823	1.74 ± 0.27	33,139 ± 8,063
Blood	0.89 ± 0.17	535 ± 56	0.68 ± 0.17	6,050 ± 850
Kidney	0.13 ± 0.04	980 ± 232	0.11 ± 0.01	7,525 ± 1,348
Other viscera	1.54 ± 0.60	532 ± 163	1.10 ± 0.21	5,111 ± 1,544
Gill	1.75 ± 0.30	645 ± 78	1.34 ± 0.17	7,897 ± 1,787
Muscle + skin + scale	1.13 ± 0.22	141 ± 27	0.94 ± 0.18	1,144 ± 268
Remaining carcass	49.04 ± 6.49	227 ± 27	42.22 ± 4.72	1,735 ± 305
Whole fish	55.99 ± 7.45	298 ± 38	48.13 ± 5.29	3,184 ± 612
Whole fish (not including digestive tract)	54.48 ± 5.52	228 ± 31	46.39 ± 4.89	1,950 ± 340

[1]12 fish were divided into 2 groups, each group contained 6 fish reared in 2 aquaria. Data is expressed as mean ± SD.

of ^{65}Zn by fish from diet, and the relative absorption rate of ^{65}Zn from diet between common carp and other fishes. It is clear that common carp absorbed 3-6.8 times more ^{65}Zn than other fishes.

Relative absorption rate of ^{65}Zn from water

The concentraction factors of ^{65}Zn from water to whole fish could be obtained by comparing their specific radioactivities. Table 7 indicates the concentration factors and the relative absorption rates of the fishes. The relative absorption rate of ^{65}Zn from water between common carp and tilapia, grass carp, and silver carp were found to be 100 to 90, 137, and 82 respectively. The value for common carp was within the fishes, differences were not too large.

Table 5. Absorption of ^{65}Zn by silver carp *Hypophthalmichthys molitrix* from diet or water 24 h after treatment[1]

Tissue	^{65}Zn supplied by diet only		^{65}Zn supplied by water only	
	Sample weight (g)	Specific radioactivity of tissue (cpm/g)	Sample weight (g)	Specific radioactivity of tissue (cpm/g)
Digestive tract	0.95 ± 0.35	1,341 ± 450	1.01 ± 0.17	38,518 ± 11,080
Blood	0.77 ± 0.14	251 ± 63	0.72 ± 0.09	4,002 ± 568
Kidney	0.17 ± 0.10	311 ± 118	0.12 ± 0.02	4,278 ± 1,336
Other viscera	0.96 ± 0.23	304 ± 79	0.97 ± 0.26	3,558 ± 1,140
Gill	1.57 ± 0.30	415 ± 18	1.59 ± 0.24	9,938 ± 1,772
Muscle + skin + scale	0.88 ± 0.14	66 ± 22	0.76 ± 0.19	966 ± 242
Remaining carcass	39.93 ± 6.76	78 ± 32	40.95 ± 5.26	857 ± 416
Whole fish	45.24 ± 7.78	126 ± 23	46.04 ± 5.96	2,114 ± 395
Whole fish (not including digestive tract)	44.29 ± 6.53	89 ± 28	45.03 ± 5.52	1,162 ± 408

[1]12 fish were divided into 2 groups, each group contained 6 fish reared in 2 aquaria. Data is expressed as mean ± SD.

Table 6. Relative absorption rate of ^{65}Zn from diet between common carp and other fresh water fishes

Fish	^{65}Zn ingested (cpm/g fish) (A)	^{65}Zn in whole fish (not including digestive tract) (cpm/g fish) (B)	% of absorption of ^{65}Zn (B/A)[1]	Relative absorption rate of Zn from diet
Common carp	1,596	829 ± 408	51.9 ± 25.6[a]	100
Tilapia	1,472	255 ± 118	17.3 ± 8.0[b]	33.3
Grass carp	1,483	228 ± 31	15.4 ± 2.1[b]	29.7
Silver carp	1,168	89 ± 28	7.7 ± 2.4[c]	14.8

[1]Data is expressed as mean ± SD. Values within a column not sharing a common superscript letter differ significantly ($p < 0.05$), determined by unpaired *t*-test.

Table 7. Relative absorption rate of ^{65}Zn from water between common carp and other fresh water fishes

Fish	Specific radioactivity of ^{65}Zn in whole fish (not including digestive tract) (cpm/g) (A)	Specific radioactivity of ^{65}Zn in rearing water (cpm/ml) (B)	Conc. factor (A/B)[1]	Relative absorption rate of Zn from water
Common carp	1,416 ± 210	260	5.45 ± 0.8[a]	100
Tilapia	1,287 ± 200	260	4.95 ± 0.8[a]	90
Grass carp	1,950 ± 340	260	7.50 ± 1.3[b]	137
Silver carp	1,162 ± 400	260	4.47 ± 1.6[c]	82

[1]Data is expressed as mean ± SD. Values within a column not sharing a common superscript letter differ significantly ($p < 0.05$), determined by unpaired *t*-test.

Relative absorption rate of zinc between diet and water in a species of fish

Assuming all stable zinc in the diet and water react like the tracer ^{65}Zn, then the total zinc absorbed by the fish from diet and water can be calculated. The amount of Zn absorbed from diet was calculated as follows: amount of Zn absorbed from diet = amount of diet consumed per fish x Zn concentration in the diet ÷ fish weight x percent of absorption rate of ^{65}Zn from diet. Actual values were: common carp, 0.230 μg/g; tilapia, 0.068 μg/g; grass carp, 0.065 μg/g; and silver carp, 0.040 μg/g.

The amount of Zn absorbed from water was calculated as follows: amount of Zn absorbed from water = Zn concentration in the rearing water x concentration factor (of ^{65}Zn in fish/in water). The values were: common carp, 0.014 μg/g; tilapia, 0.012 μg/g; grass carp, 0.018 μg/g; and silver carp, 0.011 μg/g.

Table 8 shows the amount of zinc absorbed from diet only, from water only, and the relative absorption rate between diet and water in a species of fish. Under the present experimental conditions, common carp absorbed 95% of its zinc from diet; tilapia, grass carp and silver carp absorbed 85%, 78% and 78% of zinc from their diet, respectively. Spry et al. (1988) pointed out that dietary zinc is normally the primary source for zinc absorption in fish. This conclusion is also true for all the 4 kinds of fishes studied here.

Absorption channel of ^{65}Zn from water

Results shown in Table 9 indicated that the 2 fish which were exposed to ^{65}Zn in the head compartment had "whole fish" specific radioactivities of 995 and 1,897 cpm/g, respectively; while the 2 fish which were exposed to ^{65}Zn in the body compartment had "whole fish" specific radioactivities of 128 and 161 cpm/g, respectively. Apparently, the gill was the major channel for absorption of zinc from water.

DISCUSSION

Most of the studies about absorption of zinc from water by fish derived from the concern of environmental pollution. It is either because ^{65}Zn is one of the most abundant neutron-induced isotopes released from nuclear reactors (Saiki et al. 1955, Hoss 1964), or because zinc is an industrial pollutant (Hellawell 1988). But since the high concentration of zinc in common carp is a natural phenomenon (Jeng et al. 1974 1981), not because of polluted water or the quality of diet. In this experiment, the dietary zinc concentration was established at 28.3 ppm, which has been shown to be within the adequate range of zinc concentration for common carp (Ogino et al. 1979, Jeng et al. 1981). The zinc concentration in the rearing water was 2.5 μg/l which is low compared to the zinc concentration commonly encountered in natural water (<10 μg/l) (Spry et al. 1988).

Absorption rate of an isotope from natural food by fish studies are sometimes rather difficult because the food must be both one that will accumulate and retain the desired isotope and readily available (Hoss 1964). Usually, a natural food was maintained for a period in the radioisotope containing water, and the food was then supplied to the fish (Tomiyama et al. 1956, Hoss 1964). Since the fish studied in this experiment, i.e., common carp, and silver carp, all showed a good growth by using artificial diets in previous studies (Ogino et al. 1979, Jeng et al. 1981), artificial diet was used in this experiment. ^{65}Zn in the form of $^{65}ZnCl_2$ was added to the diet before pellet formation. Since all food pellets offered were ingested, the amount of food consumed was known precisely.

In a previous paper (Jeng et al. 1981), com-

Table 8. Relative absorption rates of Zn between diet and water in common carp and other fresh water fishes

Fish	Amount of Zn absorbed from diet (μg/g fish)	Amount of Zn absorbed from water (μg/g fish)	Relative abosrption rate of Zn between diet and water diet:water
Common carp	0.230	0.014	95: 5
Tilapia	0.068	0.012	85:15
Grass carp	0.065	0.018	78:22
Silver carp	0.040	0.011	78:22

Table 9. The ^{65}Zn radioactivity (cpm/g) in the tissues of common carp which the head with gill part or the surface excluding head part were exposed to ^{65}Zn supplementing water for 24 h

Tissue	Head compartment		Body compartment	
	Fish 1	Fish 2	Fish 3	Fish 4
Gill	20,459	40,335	191	133
Eye	601	728	—[1]	—
Scale	2,430	1,533	1,005	1,659
Skin	625	1,007	—	153
Muscle	278	118	—	—
Vertebra	626	2,176	76	—
Fins	1,126	2,465	1,525	934
Blood	2,282	3,612	164	53
Kidney	9,613	21,300	905	217
Digestive tract	3,563	5,139	199	134
Spleen	8,078	5,716	—	—
Hepatopancreas	1,206	3,581	87	39
Heart	1,622	4,531	—	—
Gonad	571	699	45	7
Air bladder	975	699	—	—
Gall bladder	736	2,364	—	—
Remaining carcass	378	838	117	101
Whole fish	995	1,897	128	161
Fish weight	78.23 g	80.27 g	78.17 g	82.72 g

[1]—, not detected.

mon carp and silver carp were fed the same diet from hatching till adult for a period of 250 days, and it was found that no matter whether the feed was natural food or artificial feed, the zinc concentration in common carp was several times higher than that in silver carp. It was concluded that the zinc absorption rate for common carp was higher than that of silver carp. Still, since zinc could be obtained either from food or from water, it was not clear which route makes the difference. Table 6 indicates that common carp absorbed 6.8 times more zinc from diet than silver carp. Table 7 shows that common carp and silver carp have similar absorption rate of zinc from water, although the common carp's is a little higher. Since diet is the major zinc absorption route for these fishes, it is the absorption rate from diet that makes the difference.

In adequate dietary zinc concentrations and unpolluted water, our results indicated that the fishes absorbed ^{65}Zn from diet in the descending order of common carp , tilapia , grass carp , and silver carp (Table 6). In previous reports (Jeng et al. 1973 1974), it was found that the whole body zinc concentration of common carp was around 76 ppm, around 30 ppm in tilapia , around 19 ppm in grass carp, and around 13 ppm in silver carp. It is very interesting to find that the order of absorption rates of ^{65}Zn from diet generally coincide with the order of zinc concentrations in the whole body. The different zinc concentrations in the whole bodies of the fishes seem to reflect the different zinc absorption rates from diet.

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鯉魚與其他淡水魚對鋅吸收率之比較

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爲知鯉魚與其他淡水魚類對鋅之吸收如何不同，乃添加^{65}Zn至飼料或水中，測定各種魚類對鋅之吸收率。實驗結果發現鯉魚由飼料吸收鋅之比率，爲吳郭魚之 3 倍，草魚之3.4倍，鰱魚之6.8倍。但由水中，鯉魚對鋅之吸收率與其他魚類相差不大。由此可知，鯉魚比其他魚類含有較高濃度鋅之理由，爲其能自飼料中吸收較多之鋅所致。在現行實驗條件下，鯉魚之鋅有95％來自飼料；吳郭魚、草魚及鰱魚則分別有85％、78％及78％之鋅來自飼料。飼料係此等魚類鋅之主要來源。鯉魚自水中吸收鋅之途徑經研究後，發現主要係經鰓而進入魚體。

關鍵詞：鋅, 鯉魚, 鋅之吸收。