

THE EFFECT OF THYROID HORMONES ON THE GROWTH OF GOLDFISH, *CARASSIUS AURATUS* (L.)

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ABSTRACT. — Synthetic thyroid hormones increase the efficiency of food conversion in the goldfish, *Carassius auratus* (L.). However, preparations of parrot fish thyroid gland capable of producing increased oxygen consumption in laboratory mice fail to increase efficiency of food conversion in goldfish.

During experiments designed to study the morphogenic effects of thyroid hormones on the normal epidermis, the regeneration of scales, and the healing of superficial wounds of goldfish, it was found that prolonged administration of synthetic thyroid hormones temporarily increased the efficiency of food conversion in the goldfish, *Carassius auratus*, a natural hypothyroid. This effect was investigated.

MATERIALS AND METHODS

Linebred F₃ xanthic goldfish, *C. auratus* (L.), obtained from Ozark Fisheries, Inc., Stoutland, Missouri, were used in two experiments in which thyroid hormones were administered to goldfish thoroughly conditioned to laboratory life prior to treatment. Although all fish were less than one year old, it was possible to distinguish the males from the females by the presence of breeding tubercles on the first pectoral fin ray of the males. Fish were assigned to treatment in random fashion.

Experiments were conducted in 57 liter glass aquaria equipped with an airstone and airlift filter provided with glass wool and activated charcoal. The pH of the conditioned aquarium water was maintained at approximately 7.5 and oxygen content of the water was always above 6.0 ppm. Temperature was maintained at 21 ± 1.0 C. Daylight fluorescent lamps illuminated the aquaria 10 hours daily.

Hormones were administered by intra-abdominal injection on days 2, 5, 7, and 10 of each 10-day period. Fresh solutions, made each week in 0.65% saline, were buffered (Sorensen's phosphate) at pH 7.5 and stored in the freezing compartment of a refrigerator. Solutions were made so that, regardless of treatment, the total volume of injected fluid was the same for all animals of the same weight. Injection volumes were adjusted at 10-day intervals according to weight changes of individual fish. Fish were weighed to the nearest 0.05 gm on a triple beam balance accurate to ± 0.01 gm after excess water was lightly blotted with paper toweling. Standard and total lengths were recorded to the nearest 0.5 millimeter. Fish were anesthetized in MS 222 (Sandoz Chemical Co., New York, N. Y.) prior to handling. Individual

fish were identified by small electrocautery marks made on the operculum.

Regeneration of a "key scale", the seventh from the first row above the lateral line on the left side of the body was followed, and at necropsy, the original scale, its regenerate, and its opposite number from the right side of the body were compared.

Fish were fed an average of 1.7% of their body weight per day of a commercially prepared pelleted diet (Perk Foods Co., Chicago, Illinois) to which a bit of raw minced beef liver (less than 5% dry weight of the ration) was added on alternate feeding days. Actual food intake per feeding day was approximately 3% of the body weight per tank of fish, as fish were not fed on days when injections or measurements were scheduled. Food was added to aquaria throughout a feeding day to insure a minimum of waste. There was no mortality during this investigation. Specific growth was calculated from the formula

$$\frac{\log_e W_1 - \log_e W_0}{t_1 - t_0} \times 100$$

where W = weight and t = time.

Coefficients of growth were calculated from the formula

$$\frac{\text{food consumed}}{\text{gain in wet weight}} \times 100$$

Data were tested for statistical significance using the Kruskal-Wallis one-way analysis of variance by ranks (Siegel, 1956, p. 184). The level of significance chosen was alpha (α) = 0.05.

RESULTS

An unexpected advantage in increments in weight and in standard length in fish treated with synthetic thyroid hormones occurred during the first 20 days of the two independently conducted experiments. Mean initial weights, mean percentage increases in weight, mean specific growth per day in weight, coefficients of growth, and mean absolute and percentage increases in standard length for the first twenty days of the two experiments are summarized in Table 1. Experiment two (females), January, was not begun until experiment one (males), October through December, was completed.

The males were maintained 70 days and showed no significant differences in the coefficient of growth between treated and untreated fish during the last 40 days of treatment ($p > 0.50$). The statistical tests were based upon the first three and the last four 10-day periods of the test because there is no good way of comparing two values from each of four treatments. The data for days 1 to 10 and 11 to 20 appeared significant. However, the hormonal effects were insignificant after the first 20 days, probably because of the well known pituitary-thyroid feedback mechanism, and adding a third 10-day interval in order to make a statistical test allows only a marginal rejection of the null hypothesis ($p < 0.10$ but > 0.05). In all intervals, fish treated with desiccated parrot fish thyroid grew at rates comparable to saline controls.

New circuli added at the margins of normal scales of males treated

TABLE 1.—Growth Responses of Goldfish to Treatment with Thyroid Hormones for the 20 days Following Initiation of Treatment.

Item	Treatment						
	Thyroxin	Synthetic Hormones				Parrot Fish Thyroid	Saline
		2 μ g/gm body weight	2 μ g/gm body weight	10 μ g/gm body weight	5 μ g/gm body weight		
Sex	male	male	female	female	male	female	
Number of Fish	7	7	5	5	7	5	
Mean Initial Weight (grs)	7.40	7.45	10.45	10.85	7.35	10.35	
Mean Percentage Increase in Weight	15.8	15.4	15.6	16.0	11.5	11.6	
Mean Specific Growth per day	0.65	0.61	0.62	0.60	0.47	0.48	
Coefficient of Growth	44.4	43.9	44.0	44.9	32.7	33.0	
Mean increment in Standard Length (cm)	0.21	0.25	0.32	0.33	0.14	0.22	
Mean Percentage Increase in Standard Length	3.7	4.3	5.0	5.0	2.5	3.5	
					0.16	2.8	

with thyroxin or triiodothyronine were more numerous after 70 days than in the saline control or parrot fish thyroid treated animals; seven males treated with thyroxin averaging 3.3 circuli, and seven males treated with triiodothyronine averaging 3.1 new circuli. In contrast, seven saline controls averaged 2.6 new circuli and seven fish treated with parrot fish thyroid extract averaged only 1.9 new circuli.

DISCUSSION

Ideally the coefficient of growth should be based upon individual fish maintained in individual aquaria. The growth results were so unexpected that no provision for such analysis had been made in the design of experiments. Nothing in the literature at the time the experiments were conducted suggested the apparent increase in the efficiency of conversion of food observed here. The decision not to feed *ad libitum* was made to prevent overfeeding and consequent disease problems. Unfortunately the recent experiments of Gross, Fromm, and Roelofs (1963), the only published report of a similar effect of the thyroid on efficiency of food conversion in fish, were not idealized either.

The efficacy of the parrot fish thyroid powder used in these experiments was tested by Kenner, Bjorklund, and Gasdorf (1964), and found to significantly increase oxygen consumption in white laboratory mice. With this established, maturing goldfish were maintained two months in aquarium water containing desiccated parrot fish thyroid 1:38,000.

No growth or morphogenic responses were obtained even after goldfish were seen to swallow additional bits of parrot fish thyroid gland mixed with moistened pellets of the commercial food preparation. Therefore, neither processing of the glands nor dosage level appear to have caused the failure of the fish thyroid extract to elicit significant growth or morphogenic responses.

Despite the indications that thyroid hormones may be involved in promoting growth of fishes, decisive experiments using individual aquaria and including hypophysectomized fish treated with thyroid and growth hormones singly and in combination are very much in order. Chemical analysis of desiccated parrot fish thyroid gland collected at various times of the year using desiccated mammalian glands and synthetic thyroxin as reference standards would also be helpful.

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