Changes in plasma thyroxine, triiodothyronine and cortisol associated with starvation in rainbow trout (Salmo gairdneri)

Robert S. Milne¹, John F. Leatherland¹ & Bruce J. Holub²

Departments of Zoology¹ and Nutrition², College of Biological Science, University of Guelph, Guelph, Ontario NIG 2W1, Canada

Keywords:
Trout, Thyroid, Glycogen, Lipid, Glucose, Liver glycerol-3-phosphate acyl transferase

Synopsis
Chronically starved rainbow trout (Salmo gairdneri) showed a significant fall in liver size, total liver glycogen, liver glycogen concentration and plasma glucose levels. Liver lipid concentration did not differ significantly from controls although total liver lipid reserves fell during the first 40 days of starvation but had partly recovered after 65 days of starvation. Plasma cortisol and T₃ levels did not show consistent changes concomitant with food deprivation over the 65 day period of the experiment. However, plasma T₄ levels in fish starved for 40 or 65 days were significantly lower than comparably fed animals. The involvement of T₄ in intermediate metabolic processes in salmonids is discussed.

Introduction
Compared with mammals, little is known of the endocrine control of intermediary metabolism in teleosts. Various hormones have been implicated in metabolic processes in teleosts including growth hormone, prolactin, melatonin, insulin, ACTH, cortisol, catecholamines and the thyroid hormones (Enomoto 1964, Nakano & Tomlinson 1967, Meier 1969, Swallow & Fleming 1969, Meier et al. 1971, Leatherland et al. 1974, de Vlaming et al. 1974, McKeown et al. 1975, de Vlaming & Pardo 1975, Epple & Lewis 1977, Leatherland et al. 1977, Narayanasingh & Eales 1975a, b, Whiting & Wiggs 1977, Leatherland & Holub 1978, Vernier & Sire 1978) and pituitary involvement in various aspects of metabolism has been suggested using hypophysectomized fish (Epple & Lewis 1977, Walker & Johnsen 1977). Much of the information gleaned from these studies is incomplete and confusing, consequently no clear pattern of endocrine control of intermediate metabolism in teleosts has emerged. This is possibly due to the tendency to search for homologies with the mammalian homeostatic processes. Because of the ectothermic nature of teleosts their metabolism differs fundamentally from that of mammals. One aspect of this difference in metabolic strategy is the ability of teleosts to withstand prolonged periods of food deprivation which, particularly at low temperatures, enables some fish to survive months or possibly years of starvation (Love 1970).

In this study the circulating levels of three hormones, thyroxine (T₄), triiodothyronine (T₃) and cortisol were examined in an attempt to correlate changes in plasma levels of these hormones with the lowering of metabolic reserves in starved rainbow trout, with the aim of examining their possible involvement in this aspect of intermediary metabolism in salmonids.

Materials and methods
Seventy eight rainbow trout (Salmo gairdneri) of both sexes (body weight ranging from 150–300 g) were obtained from Goosen’s Hatchery, Otterville, Ontario and maintained in a 800 l stock aquarium containing continuously aerated and running well water at 11 ± 1°C, under a 12 h light: 12 h dark photoperiod (07.00 to 19.00 h). A flow of water was provided by a submersible pump. The fish were fed daily with 1% of their wet body weight with a commercial trout chow (Martin’s Feed Mills, Elmira); the composition of the diet was described by Cho et al. (1974)*. All the food provided was consumed after two weeks acclimation and the fish were divided into two groups and transferred to separate aquaria, under identical conditions to those of the stock aquarium. After two weeks acclimation to the experimental aquaria and 27 h after the last feed three fish were removed from each group, killed, and samples taken. One group was then deprived of food for the remainder of the experiment, the second group continued to receive the pellet diet each day (1% of the

Received 4.8.1978 Accepted 1.1.1979

* The diet was 35% herring meal, 35% wheat middlings, 20% soybean meal, 6% soybean oil, 1% linseed oil, and 2% of a vitamin and 1% of a mineral premix.
Results

Liver weight, expressed as percent of body weight, fell significantly (p < 0.01) in fish starved for 10 days and remained significantly lower (p < 0.01) than the fed groups in subsequent samples. Percent liver weight was lowest after 20 days of starvation and remained close to this level in the 40 and 65 day starved groups. There was a significant interaction (p < 0.001) between the type of treatment and length of treatment for percent liver weight. Over the period of the experiment the percent liver weight of the fed fish remained relatively constant, whereas in the starved fish there was a significant drop. Similarly, a significantly lower (p < 0.01) liver glycogen level [expressed as mg equiv. of glucose per kg of liver (wet weight)] was evident in fish starved for 10 days and levels remained significantly lower than the fed fish after 20, 40 (p < 0.01), and 65 days of starvation (p < 0.05). Total liver glycogen reserves were significantly lower in starved compared with fed fish (p < 0.05) after three days of food deprivation (Table 1), and remained significantly lower (p < 0.001) than in fed fish for up to 65 days of starvation. There was a significant interaction (p < 0.001) between the type of treatment and length of treatment in both total liver glycogen and liver glycogen concentration. In the fed fish these values rose until 20 days after the start of the experiment and then fell, whereas in the starved fish the levels progressively declined over the first 20 days of the experiment and thereafter remained at a low level (Table 1).

Liver lipid levels, expressed as g per kg wet weight and liver glycerol-3-phosphate acyltransferase activity (expressed as pmoles per g of liver per h) in starved fish did not differ significantly from the fed fish at any time interval. However, total lipid reserves in fish starved for 10, 20 and 40 days were significantly lower than in comparable fed animals (p < 0.05 for 10 and 40 days, p < 0.01 for 20 days). After 65 days of starvation total liver lipid reserves were only marginally lower than in the comparable fed group (p < 0.02). There was a significant interaction (p < 0.001) between type of treatment and length of treatment for total liver lipid. In fed fish total liver lipid tended to rise, whereas in starved fish the levels fell during the first 20 days of starvation and then increased.

Plasma glucose levels were significantly lower in starved fish after 10 (p < 0.05), 40 and 65 days (p < 0.01) of starvation. Plasma glucose levels in the fed fish killed 1 (p < 0.05), 3 and 10 days (p < 0.01) after the start of the experiment were significantly lower than the initial control group.

Plasma cortisol levels in starved fish did not differ significantly from fed animals at any time interval. Plasma T4 values were similar in fed fish and in animals starved for 1, 3, 10 and 20 days but T4 levels in fish deprived of food for 40 or 65 days were significantly lower (p < 0.01) than in comparable fed fish.

There were no significant differences between