CHAPTER 4

CHANGES IN THE LIPID CONTENT OF THE LIVER AND GONADS OF *H. ILISHA* DURING VARIOUS STAGES OF LIFE CYCLE

Many changes occur in the lipid metabolism of fish during maturation and migration. Variation in the lipid content of fish during different stages of gonadal development has been observed by several investigators (c.f. Tarr, 1959). These workers have noted the increase in the lipid content before maturation of gonads and decrease after spawning.

In many fishes like the eel and salmon the gonadal development is accompanied by migration. Fishes undertaking migration has been observed to accumulate large stores of fat in the muscle and liver (c.f. Robertson and Wexler, 1962; Joseph, 1967) and depletion of fat during migration has been reported by Tarr (1959) and Joseph (1967). Lipids serve as a convenient store of energy, which could be utilized for the energy expenditure during migration, and also for gonadal development.

Since *H. ilisha* does not feed during the spawning migration, the energy requirements must be met by the reserves, lipids and proteins. Since liver is one of the chief lipid storing organs, lipid variation in this organ was studied, quantitatively and histochemically, in migratory *H. ilisha* during different stages of development of the gonads. Changes in the lipid content of the gonads were also studied.

Estimations of the fat content of the liver and gonads were also made in certain stages of the non-migratory H. toli for comparison.

MATERIAL AND METHODS

The stages of gonadal development in the fish were decided by using the classification of Bowers (1954). During stage II and III gonads are developing and maturation begins. These are immature gonads. During stage IV, maturation of the gonads continue and they occupy more or less 2/3 of the body cavity. The migration of H. ilisha begins at this stage. Stage V indicate ripe gonads. Stage VI is running or spawning during which milt or eggs are easily extruded by slight pressure on the flanks of the fish. In many cases eggs were seen oozing out of the vent when fishes were taken on board.

The live fish were decapitated and the liver and gonads were removed immediately. Small pieces were fixed in calcium-formol and lipids were demonstrated in gelatin sections by staining with Sudan Black B according to the improved method of Baker (1956).

For quantitative estimations pieces of liver and gonads were dehydrated at 60°C in an hot air oven till constant weight was obtained. Total lipid was estimated from the dry weights before and after a 24 hr Soxhelt extraction with 1:1 ethanol-ether mixture. In case of gonads, lipid estimation was done separately for three different regions viz. anterior,

middle and posterior and the mean value of these results was taken as the lipid value of the particular individual.

RESULTS

Table I presents the data obtained on the lipid content of the liver and gonads of H. ilisha during various stages of development.

From the table it can be noted that there was a decrease in the mean liver lipid value, of both male and female fish, as the maturation and migration proceeded.

The fish undertakes migration when gonads are maturing (Stage IV). The lipid content of the liver and gonads of female non-migratory H. toli were found to be 37.6 ± 6.8 (4)* and 52.9 ± 1.5 (4)* respectively. Similarly the values for male H. toli for liver and gonads were 32.6 ± 5.6 (5)* and 18.8 ± 2.0 (5)* respectively. Thus it is clear that male and female migratory H. ilisha showed a higher lipid content in the liver when compared to H. toli of the same stage of maturity (Stage IV). The gonads of H. ilisha and H. toli in this stage (IV) showed a more or less similar lipid content.

The lipid content of the liver, in both male and female decreased more rapidly from mature (Stage V) to spawning (Stage VI) and post-spawning (Stage VII) period.

Female gonads showed continuous increase in lipid content whereas the male gonads showed no such increase after attaining stage IV of maturity.

* Figures in parenthesis denote the number of estimations.

Table. I. Lipid content of the liver and gonads of H. ilisha at successive stages of Maturation

STAGE	FEMALE		MALE	
	Liver	Gonad	Liver	Gonad
II-III	66.6±6.5 (5)	28.9±5.6 (4)	-	-
IV	59.0 (1)	50.3 (1)	55.0±7.2 (5)	21.1±3.8 (5)
V	46.3±6.4 (9)	54.3±3.1 (9)	45.6±2.8 (10)	20.5±4.4 (10)
VI	26.8±4.9 (7)	55.6±6.7 (7)	24.5 (1)	14.1 (1)
VII	24.6±3.3 (5)	13.9±3.2 (5)	21.2 (1)	10.5 (1)

' ± ' Standard deviation.

Figures in parentheses indicate the number of fishes analysed.

A recovering spent H. ilisha captured from sea showed a lipid content of 50.5% in the liver and 19.7% in the gonads.

The accumulation of large stores of fat in the liver cells before the spawning migration was also shown histochemically by staining with Sudan Black B (Fig. 1). Developing and immature ova showed no fat, whereas mature ova contained large globules of lipid, almost filling the ovum, as revealed by Sudan Black staining (Fig. 2).

DISCUSSION

From the results obtained it is seen that the lipid level in liver decreases as the lipid level in the gonads is increasing. The fish must be drawing upon materials required for the formation of the gonadal tissue partly from the lipid reserves of the liver.

In the female, gonadal lipids increase continuously upto spawning (stage VI), whereas in male there was no increase in gonadal lipid after attaining stage IV ie. before migration. Similar observations have been reported by Tarr (1959) also.

In both sexes of H. ilisha rapid fall in the liver lipid level during and after spawning (stages V & VI) was observed. Joseph (1967) has observed that the subcutaneous lipid depot in H. ilisha had the highest lipid content before migration, this value being much more higher in comparison to the one observed in non-migratory H. toli. This subcutaneous fat depot more or less completely disappeared during spawning

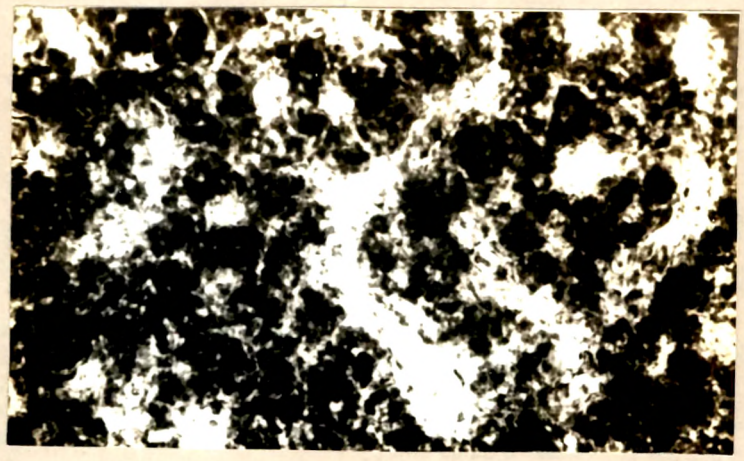

Fig. 1

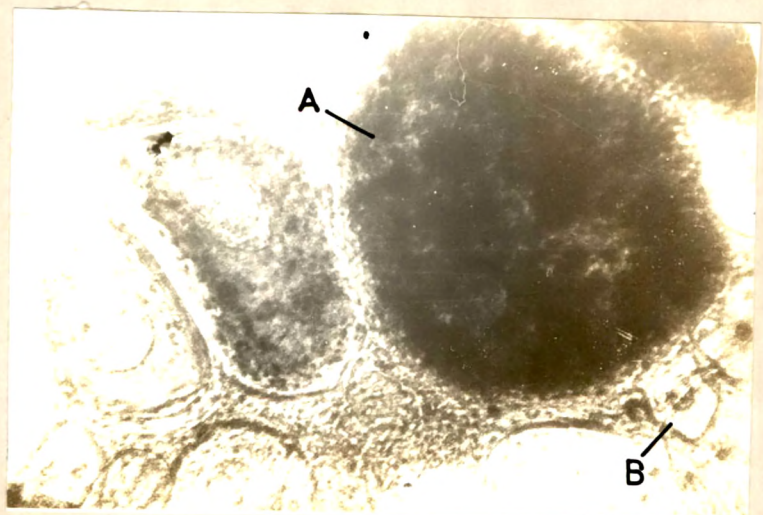

Fig. 2

Fig. 1. Liver of immature H. ilisha showing large amount of fat. Sudan Black B. X630.

Fig. 2. T.S. of ovary of mature H. ilisha showing lipids in mature ovum (A) and developing ovum (B) shows no lipids.
Sudan Black B. X250

in river. Thus, now the fish might draw upon the energy from visceral reserves like liver etc. The rapid decrease of lipid level in the liver during and after spawning leads to this conclusion.

George and Vallyathan (1964) reported a decrease in the FFA level of liver and adipose tissue after sustained activity of breast muscle in pigeon. They concluded that the liver release FFA into blood under high energy demand. H. ilisha indulging in similar active swimming may draw upon energy from the liver lipid, especially when the main subcutaneous fat depot has been more or less completely depleted.

Chang and Idler (1960) studying variations in the liver glycogen of migrating sockeye salmon found an initial decrease in the glycogen but recorded an increased level during post spawning. Since the fish is starving during migration they suggested the possible gluconeogenesis from non-carbohydrate source. In view of the above, it can be speculated that the rapid fall in the liver lipid content in the post spawning H. ilisha might be partly due to gluconeogenesis from liver lipids.

In post spawning H. ilisha of both sexes the liver lipid content was much lower than the initial value before maturation of gonads. Chanon and Saby (1932) have also reported that the post spawning value of the fatty acid in liver decreases to a small fraction of the initial value.

With regard to the abundance and the general distribution of fatty reserves among teleosts, Vague and Fenasse

(1965) list four categories. Of these H. ilisha and H. toli falls under the group of fat-fleshed fishes with fatty stores in liver as well as in muscle and subcutaneous adipose tissue. In the abdomen, adipose tissue is found around swim-bladder. This adipose tissue is present in immature fish. In mature fish it is absorbed, probably by the developing gonads. Epinephrine and related amines have been shown to increase acutely and markedly the circulating non-esterified fatty acids in plasma, probably by directly stimulating hydrolysisof adipose tissue (as reviewed by Weil, 1965). In H. ilisha chromaffin tissue is in active state in maturing fish. There is hyperplasia of this tissue, with the cell nuclei showing mitotic division. Such hyperplasia is mild in H. toli. From this it can be assumed that more catecholamines like epinephrine are released. This amines would help the mobilization of depot lipid required for development of gonads. Thyroid is most active in immature fish before migration. Thyroid hormone would thus potentiate the action of lipolytic agents like epinephrine, growth hormone etc. (as reviewed by Weil, 1965). How far epinephrine affects thyroid activity is not yet fully known (Gatton, 1965).

Pituitary secreting ACTH and growth hormone (GH), is very active in immature (stages II & III) and also in mature spawning H. ilisha in river. GH and ACTH are known to be lipolytic hormones (Weil, 1964, '65); Gh has been considered to be the pituitary principle regulating the metabolism, according to the physiological needs of the animal, in response to lack of utilizable glucose as in starvation (Weil, 1965). Thus when

H. ilisha in river is not feeding during spawning migration, GH must be playing an important role in mobilizing lipids from liver, especially when subcutaneous fat depot has been depleted.

The lipid content of migrating H. ilisha in sea before migration (stage IV) in both sexes showed higher level than those of non-migratory H. toli of same stage of maturity. This can be interpreted as a part of the mechanism to supply energy required for migration. Hormone system must be playing important role in mobilization of these lipid. The special stimulus for lipid storage in organs like liver must be absent in non-migratory H. toli.

In liver only lipid variation could be studied. The results obtained tell only a part of the story of the complex mechanism of fat utilization and fat metabolism in the migratory fish.