INTRODUCTION

In recent years, considerable information has accumulated on the ecological and physiological aspects of bird migration. The migration is an annual periodic process necessitating the birds to travel sometimes even a very long distance between the wintering and breeding areas. Various factors, such as climatic, genetic and food supply were suggested to cause this regular movement of entire population of several species of birds. The environmental factors like, light, temperature etc., act either as a direct stimulus to migrate or as 'time markers' by which they adjust themselves to migrate in appropriate period of the year. However, while the environmental changes provide the stimulus to migrate, the physiological adjustments in the body are essential to carry the birds through such an ordeal. It could then be stated that the physiological changes are set in pace by the direct or indirect influence of environmental factors. The earliest response to the changing environmental conditions, is shown by the neuroendocrine system. The humoral factors then bring about other physiological adjustments in the body of the migrant. One of the most striking features connected with their preparation for migration is the enormous build up of fat reserves in the body. This adaptive hyperlipogenesis that never leads to any pathological conditions as in obesity is a matter of great interest. Almost all metabolic processes have the roots in the liver, which being the vital organ wherein the various pathways meet. Therefore a detailed study of this organ was found to be most desirable in understanding the physiological basis of migration. Such a study employing histochemical and biochemical techniques forms the main part of this thesis. Certain other tissues such as muscle, kidney and blood were also studied for a better and integrated understanding of various processes.

The present investigations were carried out on a migratory starling, Rosy Pastor (Sturnus roseus). They arrive in Baroda (India) about July/August and leave for their breeding grounds (probably U.S.S.R. or Asia Minor) in April/May. July to September were arbitorarily designated as the post migratory period while February to April form the premigratory period of this bird. Other birds were also taken for a comparative study.

These starlings arrive in India at a period when the crops are ready for harvest. They descend in large flocks upon these fields. Although they consume their share of grains, their main diet consists of harmful insects that pester these crops (Dharmakumarsinhji, 1954). From the observations on the captive birds, it was also found that these birds feed mostly on insects when there is an ample supply. However, from February to April they feed much upon the fruits chiefly that of Pithaglobium dulce. These fruits are rich in carbohydrates (about 16 to 17%) and contain very little fat (0.4%). This change of diet was not due to the non-availability of insects in these periods but due to some inborn urge to take carbohydrate rich food so as to divert excess of it for the synthesis of fat.

It is well known that, fat is utilized when these birds undertake long sustained migratory flight (George and Berger, 1966). The large build of fat in the body, prior to migration, is then to, ensure unrestrained supply of fuel. Since they consume carbohydrate food during premigratory period, the fat that gets stored in the adipose tissue is synthesized de novo. Assessment of diurnal variation of fat and glycogen in the liver was carried out with a view to understand more about the lipogenesis from carbohydrates (Chapter 1).

It has been observed that concurrent with an increase in the amount of fat in tissue, there is a decrease in water content. Water plus fat weight is more or less constant. This change in the water content may precede the fat deposition or the fat displaces the water in the cells. The movement of water may bring about corresponding movements of ions such as sodium and potassium. The changes in the water content and the amounts of sodium and potassium in the liver, muscle and kidney were therefore studied (Chapter 2).

The changes in the metabolic processes with regard to fat and glycogen necessarily reflect on the calcium and the phosphorus contents too. Calcium performs many functions such as the contraction of muscles, in the ionic exchanges in certain cells, in the metabolism of fat and as an activator of several enzymes. Phosphorus is an essential component of several intermediate compounds and enzymes. In bound forms phosphorus takes part in many intracellular processes, oxidation reduction reactions and in the metabolism of carbohydrates, fat and protein. Lipid phosphorus could indirectly show the content of the phospholipids. Hence, observations were also made on the calcium and phosphorus contents of liver and other tissues with a view to understand their roles in certain biological processes (Chapter 3).

It is well known that liver is the major organ that stores iron. Since very little of iron is lost from the body, the absorption is aslo balanced likewise. Then any changes in the stored iron concentrations in the liver show the rate of erythrocyte production or destruction. When there is an increase of iron uptake by the bone marrow due to an elevated erythropoiesis the reserve iron in the liver gets depleted. When a considerable haemolysis occurs more iron will be deposited in the liver. The iron content in the muscle could be taken as an index of myoglobin and other iron containing enzymes and compounds. An increased deposition of iron was observed in the liver during postmigratory period which was found mobilized during the premigratory period (Chapter 4). The iron level in the muscle was also studied (Chapter 4) during premigratory period.

Haematopoietic system was known to be influenced greatly by environmental, nutritional and physiological factors. As migratory birds are confronted with environmental and nutritional changes, important physiological changes take place in their body. Haematopoietic response may be observed in such circumstances. The studies on circulating erythrocyte number, bone marrow, haemoglobin level in the blood etc. showed marked rise in the erythropoiesis towards the time of migration. This rise in red cell number could be for an increased oxygen supply to the tissues during migratory flight, which means that during migration these birds have an increased number of erythrocytes than in normal conditions (Chapter 5). Then, after the completion of migration this extra number of R.B.Cs are to be brought to the normal level. Perhaps this is the reason for the observed large number of disintegrating cells in the liver during postmigratory period (Chapter 5), corresponding to which an increased deposition of iron in the liver was also noticed (Chapter 4).

An interesting phenomenon reported by George and Naik, (1964) was the occurrence of haematopoietic nodules in the liver of Rosy Pastor. In an attemt to find whether such nodules are present in the livers of other species, a few birds such as Pigeon, Mynas, Fowls etc., were studied. It was found that the Pigeon liver also contained several such nodules. When the number of nodules per unit area was determined it was found that these were present in large numbers in Pigeons where the adipose tissue and liver contained large amount of fat (Chapter 6) In the light of several findings that lymphocytes are capable of transforming themselves into erythrocytes, fat cells and mast cells,the increase of these nodules which contained mostly lymphocytes, could be interpreted as due to an increased demand of lymphocytes as stem cells for the production of these other types of cells. The spleen, where too lymphocytes are produced, was also found to enlarge along with the intensity of fat deposition in both Rosy Pastor and Pigeon (Chapter 6).

The observation, that the iron content in the liver varies in different migratory phases, stimulated the study of the ascorbic acid in this organ. Ascorbic acid participates in almost all major reactions in iron metabolism leading to its absorption, incorporation into proteins, release from such binding proteins, transport and utilization. An increased ascorbic acid was recorded towards the end of April (Chapter 7).

It was known that thyroid hormone regulates many physiological processes in the body such as oxygen consumption, erythropoiesis etc. The interest in thyroid gland was intensified with the report that the gland was hypertrophied and released its secretion in connection with the premigratory activities of Rosy Pastor (George and Naik,1964). In the light of recent reports that tyrosine level in the plasma can be taken as an index of thyroid activity (Malamos et al.,1966), the serum tyrosine level was determined in the Rosy Pastor during the premigratory period (Chapter 8) to find the nature and extend of thyroid activity during this period.

Cholinesterases (both specific and non-specific) were reported to be present in high concentration in the liver.

The acetylcholine- acetylcholinesterase complex as well as non-specific cholinesterase are believed to play an important role in the ionic permeability, mitotic activity, growth, bile secretion and fat metabolism. Since increased fat synthesis (Chapter 1), changes in the ionic concentrations (Chapter 2) and bile secretion was noticed in the liver of this migratory bird, both the cholinesterases were studied in the liver of Rosy Pastor as well as other non-migratory birds (Chapter 9).

It is now increasingly realized that the vertebrate muscle consists of different types of fibres that are biochemically (due to the differences in the contents of enzymes and metabolites) and morphologically (since the size and colour vary) distinct between each other. The pectoralis muscle of Rosy Pastor and House Sparrow have one thing in common; both of them have fibres of equal size and shape. But, while in Sparrow muscle there were no biochemical or morphological differences between fibres, in that of Rosy Pastor two types, namely red and white/intermediate fibres, could be distinguished. In Sparrow, however, a regional differentiation was observed with superficial layer containing more glycogen and enzymes of ~~in~~ the anaerobic pathways, while deeper layer containing more fat and oxidative enzymes (George et al.,1964). In the Rosy Pastor muscle, the intermediate or the glycogen utilizing fibres were seen aggregated in ~~to~~ the superficial part. Studies were carried out to establish the adaptive feature, which would form a basis in interpreting the functional significance of such regional differences due to the presence of glycogen utilizing fibres predominantly in the superficial part of the muscle of both Rosy Pastor and House Sparrow. The shivering actions for thermogenesis are supposed to be a glycogen utilizing activity where the fibres that depend on carbohydrate for the energy may be more active. In such cases a selective activity of such fibres could be visualised. With this view in mind, estimations of glycogen and activities of several enzymes were made in both superficial and deeper layers of House Sparrows that were exposed to low temperature for a short duration. It was observed that superficial layer is more active during cold exposure which denotes a selective functioning of such fibres that are not only characterized as glycogen utilizing but also as those which bring about quick contractions of the muscle (Chapter 10).