CHAPTER 5

GLYCOGEN METABOLISM IN BREEDING AND NON-BREEDING JUNGLE BABBLERS

INTRODUCTION~

Carbohydrate is an essential nutrient for all the animals. Glucose- the most abundant and common carbohydrate, acts as a major energy source for all cells and these cells in turn depend on the blood stream for its steady supply. The liver plays a central role in this process by balancing the uptake and storage of glucose via glycogenesis and the release of glucose via the glycogenolysis and gluconeogenesis. The general pathways of the glycogen synthesis and glycogenolysis are identical in all tissues and the glycogen metabolizing enzymes in the liver enable it to act as a lever of blood glucose and to store and mobilize glycogen according to the peripheral needs for later metabolic use (Bollen *et al.,* 1998). The prime effector of hepatic glycogen deposition is glucose which blocks glycogenolysis and promotes glycogen synthesis in various ways. The several substrates cycles in the major metabolic pathways of the liver play key roles in the regulation of glucose production (Nordlie *et al.,* 1999). The regulation of glucose synthesis, storage, mobilization and catabolism is

elaborate and sensitive to the immediate and long term energy needs of the organism. The glycogen metabolism is controlled according to the cellular needs which involve enzymic as well as hormonal control. The enzymes and hormones also affect the rate of transport and synthesis as well as the overall metabolism of carbohydrate, fats and proteins (Spannhake, 1976).

The opposing processes of glycogen synthesis and degradation, and of glycolysis and gluconeogenesis are reciprocally regulated *i.e.* one is largely turned on while the other is largely turned off (Voet *et al.,* 1998) (Chart 2). Glycogenolysis require three enzymes of which one of the important one is glycogen phosphorylase (GP) which catalyses glycogen to yield glucose-1-phosphate which can be used for the production of ATP (Biorn and Graves, 2001). GP plays a strategic role in glycolytic pathway. It leads to phosphorylative degradation and utilization of glycogen and the glycogen phosphorylase levels in the tissue would apparently indicate the rate of glycolysis of the tissue. Increased activity of the GP is associated with the increased glycogenolysis and it also indicates that the tissue is depending upon carbohydrate as the chief fuel for activities (Cahill *et al.,* 1957).

Glucose-6-phosphatase is a crucial enzyme of glucose homeostasis since it catalyses the ultimate biochemical reaction of both glycogenolysis and gluconeogenesis (Plewka *et al.,* 2000). Liu *et al.,* (1993) have shown that G-6-Pase activity is inversely proportional to the microsomal glycogen content. It allows the gluconeogenic

tissues, in which it is specifically expressed to release glucose in blood. Glucose-6-phosphatase plays an important role in the glucose release by the liver and the kidney through mechanisms involving either gene expression and/or biochemical inhibitions of its enzymatic activity (Haber *et al.,* 1995; Minassian *et al.,* 1996; Mithieux *et al.,* 1996). The glucose-6-phosphate produced by glycogen breakdown continues along the glycolytic pathway in liver, and is made available to other tissues but since G-6-P cannot pass through the cell membrane, to yield glucose, it is first hydrolyzed by G-6-Pase. Therefore, G-6-Pase is an enzyme which generates glucose in the liver.

The increased or decreased intensity of aerobic glycolysis, TCA cycle and ATP usage could be inferred from the activities of the enzymes such as Succinate dehydrogenase (SDH) and Adenosine triphosphatase (ATPase). SDH and ATPase both are actively involved in cell metabolism, wherein SDH keeps up the supply of energy rich substrate ATP molecules for ATPase. ATPase generally carries the catabolic reactions to yield energy rich ATP. SDH catalyses the stereo specific dehydrogenation of Succinate to Fumarate and is a key enzyme of the TCA cycle which usually functions as an index of oxidative metabolism. The capacity of citric acid cycle to generate energy for cellular needs is regulated by the availability of the substrate and the demand for the ATP by the cell / organism (Voet *et al.,* 1998). Being an important enzyme of TCA cycle, the quantitative measurement of SDH activity is one of the reliable indices of oxidative

metabolism and the production of ATP molecules of any metabolically active organ.

An active synthesis of ATP and its enzymic hydrolysis is the characteristic feature of the metabolically active tissue and the ATPase is actively involved in high energy phosphate metabolism. The total activity of ATPase indicates active transport of Na^+ and K^+ ions as well as essential metabolites like glucose and amino acids in tissues and also their involvement in the energy metabolism (Patel, 1982).

As birds face tremendous stress during breeding, the energy requirement of these birds should vary and should be indicated by the variations in the enzyme activities of the tissues during different breeding states. Thus, apart from glycogen (Chapter 3), the enzyme involved in glycogenolysis *viz.* Glycogen phosphorylase and Glucose-6-phosphatase, enzyme of citric acid cycle *viz.* SDH and adenosine triphosphatase (ATPase) were also assayed in the three extra gonadal tissues in the breeding and non – breeding males and females and helper females of Jungle Babbler, a social sub-tropical bird with long favorable breeding period.

MATERIAL AND METHODS~

Normal and healthy Jungle Babblers of both the sexes were obtained from the local animal dealer from the wild in breeding and non-breeding states. They were housed in an aviary providing food and water *ad-libitum*. Before sacrificing they were weighed and specific parts of liver, kidney, and intestine (duodenum) were taken out and blotted free of blood and tissue fluids and weighed for individual quantitative biochemical estimation of glycogen and the above mentioned enzymes.

Glycogen- As in chapter 4.

Glycogen phosphorylase (EC: 2.4.1.1)

Phosphorylase activity was assayed by a modification of the method of Cori *et al.,* (1943) and adapted by Cahill *et al.,* (1957). Homogenate was prepared in chilled distilled water in chilled mortar and pestle. 0.5ml homogenate of all the tissues were taken and to which incubation medium containing 0.1M $_{P}$H 5.9 Sodium citrate buffer (0.2ml), 0.15M Potassium fluoride (0.3ml) and 0.2M Glucose-1-phosphate [(disodium salt, Sigma Chem. Co.), (0.05ml)] used as substrate, was added. The tubes were than kept for incubation at 37°C for 30 minutes. At the end of the incubation 1ml 10% TCA was added and the contents were centrifuged for 10 minutes. Later the supernatants were collected and to this 0.4ml of 10N H_2SO_4 and 0.8 ml

of 2.5% Ammonium molybdate were added. After that the tubes were kept at room temperature for 10 minutes. 0.4ml ANSA was added and the volume was made to 10ml with redistilled water. The tubes were again kept for 20 minutes at room temperature to release the inorganic phosphate which was measured according to the method of Fiske and Subbarow (1925). The intensity of the color developed was measured at 660nm on the spectrophotometer. The enzyme activity was expressed as µg of phosphorous released/ mg protein/ 10 minutes.

Glucose-6-phosphatase (EC: 3.1.3.9)

G-6-Pase was estimated by the method described by Harper (1963). Homogenate of only liver was prepared in cold 0.1M citrate buffer at pH 6.5. From this 0.5ml aliquotes were taken to which 0.1ml of Glucose-6-phosphate (disodium salt) was added which is used as a substrate. The tubes were incubated for 15 minutes at 37°C. At the end of 15 minutes incubation 2ml of 10% TCA was added and centrifuged and the clear supernatant was used for the phosphate determination. To this 5ml of Ammonium molybdate, 1ml of ANSA was added and kept at room temperature for 10 minutes. Inorganic phosphate released was measured employing the method of Fiske and Subbarow (1925). The intensity of the color developed was measured at 660nm on a spectrophotometer and the activity of the enzyme was expressed as µg phosphorous released/ mg protein/ 15 minutes.

Succinate dehydrogenase (EC: 1.3.99.1)

SDH activity was assayed by the method described by Kun and Abood (1947). Tissues were homogenized in a clean and chilled mortar pestle with ice cold 10ml distilled water. 1 ml homogenate was collected in a test tube and incubation medium (containing 0.5 ml 0.1M phosphate buffer, 0.5 ml 0.5M sodium Succinate, 2.0mg/ ml 0.2% INT) was added. Tubes were shaken well and kept for incubation at 37°C for 15 minutes. At the end of the incubation 7ml acetone was added to each tube to stop the reaction and then the tubes were centrifuged for 3 minutes at 3000 RPM. The clear supernatant was drawn off in another tube and the intensity of the color was read at 440nm on a spectrophotometer. The enzyme activity is expressed as µg formazon formed/ mg protein/ 20 minutes.

Adenosine triphosphatase (EC: 3.6.1.3)

ATPase activity was measured quantitatively adapting the method of Umbriet *et al.,* (1957). Homogenates (0.2ml) of all the tissues were taken in the separate test tubes and to this incubation medium containing 100mM NaCl (0.1ml), 20mM KCl (0.1ml), 5mM $MgCl_2$ (0.1ml), EDTA (0.1ml), Adenosine-5-triphosphate [(disodium salt, Sigma Chem. CO.), (0.1ml)] used as a substrate and Tris buffer (0.1ml) was added. The tubes were incubated for 10 minutes at 40°C.

Then 1ml of 6% TCA was added and tubes were centrifuged for 10 minutes. Later 1ml of the supernatant was taken to which 0.4ml of 10N H_2SO_4, 0.8ml of 2.5% Ammonium molybdate, 0.4ml of ANSA were added and the volume made to 10ml by adding redistilled water and kept at room temperature for 20 minutes. Inorganic phosphate released was estimated according to the method of Fiske and Subbarow (1925). The readings were taken at 660 µm on a spectrophotometer. The enzyme activity was expressed as µg of phosphorous released/ mg protein/ 10 minutes.

Table 1: **Variations in the levels of glycogen and some metabolizing enzymes (*viz.* GPase, G-6-Pase, SDH, and ATPase) in male Jungle Babblers.**

	Glycogen			Glycogen Phosphorylase			SDH			ATPase			G6Pase
	Liver	**Intestine**	**Kidney**	**Liver**	**Intestine**	**Kidney**	**Liver**	**Intestine**	**Kidney**	**Liver**	**Intestine**	**Kidney**	**Liver**
Breeding	0.122 ± 0.012	0.067 ± 0.008	0.051 ± 0. 007	22.05 ± 0.7	20.16 ± 0.75	18.00 * ± 0.72	5.55 ± 0.8	6.75 ± 0.9	5.05 ± 0.74	144.68 ± 0.72	138.23 ± 0.84	138.06** ± 0.63	2.25 ± 0.5
Non-Breeding	0.088 ± 0.013	0.041 ± 0.007	0.062 ± 0.007	18.09** ± 0.65	19.04 ± 0. 8	19.89 ± 0.66	4.55 ± 0.7	5.83 ± 0.82	5.78 ± 0.79	140.8*** ± 0.61	136.08 * ± 0.75	140.56 ± 0.73	3.1 ± 0.65

* P< .05 ** P < .005 *** P < .0005

Table 2: Variations in the levels of glycogen and some metabolizing enzymes (*viz.* GPase, G-6-Pase, SDH, and ATPase) in female Jungle Babblers

	Glycogen			Glycogen Phosphorylase			SDH			ATPase			G6Pas
	Liver	**Intestine**	**Kidney**	**Liver**	**Intestine**	**Kidney**	**Liver**	**Intestine**	**Kidney**	**Liver**	**Intestine**	**Kidney**	**Liver**
Breeding	0.126 ± 0.018	0.076 ± 0.012	0.056 ± 0.017	30.16 ± 0.55	28.18 ± 0.82	27.89 * ± 0.7	5.75 ± 0.64	6.95 ± 0.9	5.05 * ± 0.64	145.23 ± 0.81	133.69 ± 0.73	125.05 ± 0.7	2.3 ± 0.6
Non-Breeding	0.028 ± 0.008	0.041 ± 0.005	0.057 ± 0.007	27.14 ** ± 0.65	26.72 ± 0.74	29.89 ± 0.82	4.9 ± 0.62	5.6 ± 0. 8	6.75 ± 0.68	143.31 * ± 0.75	130.2** ± 0.75	126.45 ± 0.8	3.3 ± 0.7
Helper	0.156 ± 0.017	0.056 ± 0.011	0.047 ± 0.005	28.15 # ± 0.67	26.79 ± 0.88	28.65 ± 0.76	4.5 ± 0.7	5.1 ± 0. 7	5.23 ±0.69	142.65 # ± 0.85	130.75## ± 0.8	124.35# ± 0.82	2.5 ± 0.6

* NB/BR # BR/helper */#P<0.05 **/##P<0.005 ***/###P<0.0005

Figure 1: Glycogen, GP, G-6-Pase, SDH and ATPase levels in extra-gonadal tissues of breeding and non-breeding male Jungle Babblers

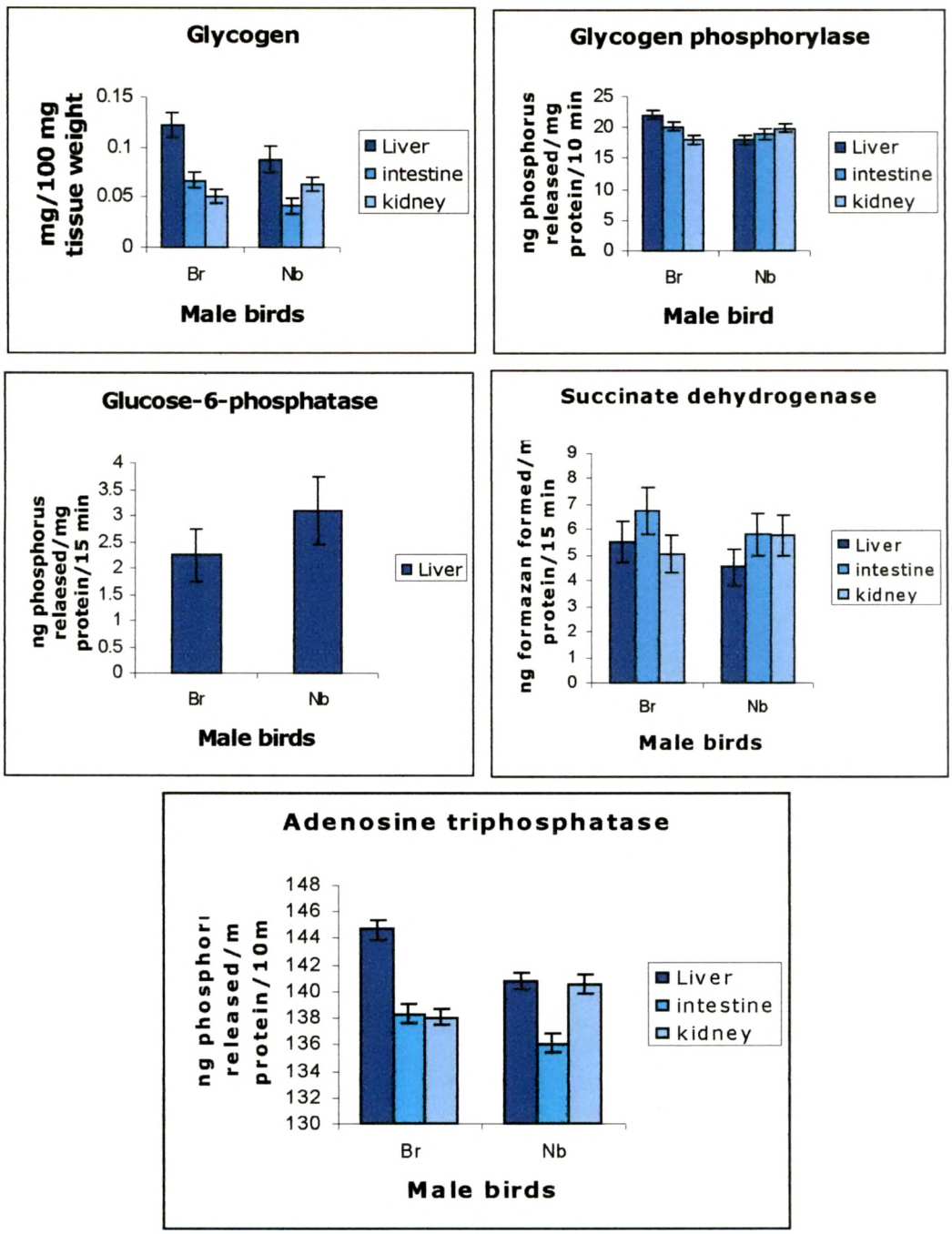
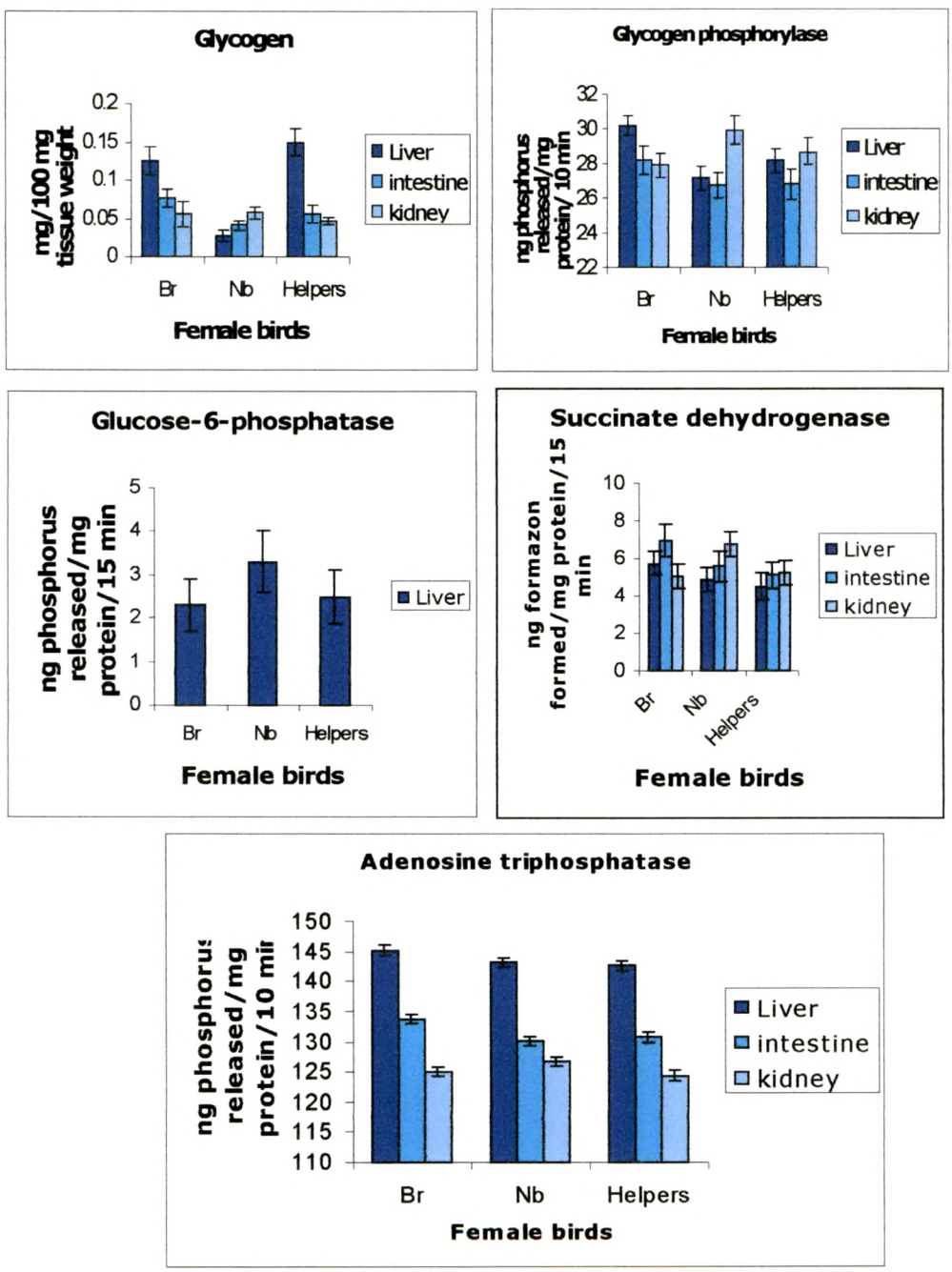


Figure 2: Glycogen, GP, G-6-Pase, SDH and ATPase levels in extra-gonadal tissues of breeding, non-breeding and helper female Jungle Babblers



RESULTS~

Male Jungle Babblers

The Glycogen, Glycogen phosphorylase (GP), Glucose-6-phosphatase (G-6-Pase), Succinate dehydrogenase (SDH) and Adenosine triphosphatase (ATPase) for male Jungle Babbler are given in Table 1, Fig. 1.

Glycogen

Among the three tissues studied after the liver (organ for storing glycogen), intestine had the higher glycogen content followed by the kidney in the breeding males whereas among the non-breeding males kidney had higher glycogen content than the intestine. The mean hepatic glycogen level in breeding males was 0. 122 $\pm$ 0.012 (mg glycogen/100 mg tissue wt) which decreased non-significantly in the non-breeding males to 0.088 $\pm$ 0.013 mg. The glycogen content in the intestine of the breeding males was at 0.067 $\pm$ 0.008 mg which also decreased non-significantly in non-breeding males to 0.041 $\pm$ 0.007 mg, whereas in kidney it was low at 0.051 $\pm$ 0.007 mg in breeding birds which increased non-significantly in the non-breeding males to 0.062 $\pm$ 0.007 mg (glycogen/100 mg tissue wt).

Glycogen phosphorylase (GP)

The hepatic GP in breeding males was significantly higher at 22.05 ± 0.7 (µg of phosphorous released/ mg protein/ 10 minutes) while in the non-breeding males it was significantly low at 18.09 ± 0.65 µg. Intestinal GP in breeding males was high at 20.16 ± 0.75 µg while in the non-breeding males it was non-significantly lower at 19.04 ± 0.8 µg whereas renal GP levels in breeding males were 18.00± 0.72µg and significantly high in the non-breeding males at 19.89 ±0.66 µg.

Glucose-6-phosphatase (G-6-Pase)

As G6Pase is mainly present in liver, hence, it was estimated only in the liver. The hepatic G6Pase was significantly lower in the breeding males at 2.25 ± 0.5 (µg of phosphorous released/ mg protein/ 15 minutes) which increased to 3.1 ± 0.65 µg in the non-breeding males.

Succinate dehydrogenase (SDH)

Mean hepatic SDH level in breeding males was 5.55 ± 0.8 (µg of formazan formed/ mg protein/ 30 minutes) and in non-breeding males, it was non-significantly lower at 4.55 ± 0.7 µg. Intestinal SDH levels in breeding males were also high at 6.75 ± 0.9 µg which decreased non-significantly in non-breeding males to 5.83 ± 0.82 µg whereas in kidney the SDH levels were almost maintained at 5.05 ±

0.74 µg and 5.78 ± 0.79 (µg of formazan formed/ mg protein/ 30 minutes) respectively.

Adenosine triphosphatase (ATPase)

Hepatic ATPase levels in breeding males was significantly high at 144.68 ± 0.72 (µg of phosphorous released/ mg protein/ 10 minutes) compared to the non-breeding males at 140.8 ± 0.61 µg ($p<0.0005$). In intestine also ATPase was significantly higher at 138.23 ± 0.84 µg in the breeding males compared to the non-breeding males at 136.08 ± 0.75 µg ($p<0.05$). However renal ATPase in breeding males was significantly lower ($p<0.005$) then in the non-breeding males at 138.06 ± 0.63 µg and 140.56 ± 0.73 (µg of phosphorous released/ mg protein/ 10 minutes) respectively.

FEMALE JUNGLE BABBLERS

The Glycogen, Glycogen phosphorylase (GP), Glucose-6-phosphatase (G-6-Pase), Succinate dehydrogenase (SDH) and Adenosine triphosphatase (ATPase) for breeding, non-breeding and helper female Jungle Babblers are given in Table 2, Fig. 2.

Glycogen

The mean hepatic glycogen in breeding females was equal to that found in breeding males *i.e.* 0.126 ± 0.018 (mg glycogen/100 mg

tissue wt) which decreased significantly in the non-breeding females to 0.028 ± 0.008 mg. The decrease was sharp in the female Jungle Babblers as compared to the male Jungle Babblers. Helper females showed non-significantly higher levels than the breeding females at 0.156 ± 0.017 mg. Intestinal glycogen in breeding females was 0.076 ± 0.012 mg which decreased non-significantly in the non-breeding females to 0.041 ± 0.005 mg while in the helper females intermediate level at 0.056 ± 0.011 mg was noted. However compared to males renal glycogen levels in females were maintained both in breeding and non-breeding females at 0.056 ± 0.017 mg and 0.057 ± 0.007 mg respectively, while the helper females had 0.047 ± 0.005 (mg glycogen/100 mg tissue wt).

Glycogen Phosphorylase (GP)

Hepatic GP in breeding female Jungle Babblers was higher than the breeding males and significantly higher than the non-breeding females. In breeding females in liver it was 30.16 ± 0.55 (µg of phosphorous released/ mg protein/ 10 minutes) and in non-breeding females had 27.14 ± 0.65 µg, while in the helper females it was at intermediate level at 28.15 ± 0.67 µg. Intestinal GP level in breeding females was non-significantly higher at 28.18 ± 0.82 µg compared to the non- breeding females and helpers. These two later groups had equal GP content at 26.72 ± 0.74 µg and 26.79 ± 0.88 µg respectively. Breeding females had significantly low GP activity in

kidney compared to the non-breeding females in which it was 27.89 ± 0.7 µg and 29.89 ± 0.82 µg respectively, while helpers showed intermediate levels at 28.65 ± 0.76 (µg of phosphorous released/ mg protein/ 10 minutes).

Glucose-6-phosphatase (G-6-Pase)

The hepatic G-6-Pase was significantly lower in the breeding females at 2.3 ± 0.6 (µg of phosphorous released/ mg protein/ 15 minutes) which increased non-significantly to 3.3 ± 0.70 µg in the non-breeding females while in the helper females it was almost equal to that of the breeding females at 2.5 ± 0.6 (µg of phosphorous released/ mg protein/ 15 minutes).

Succinate dehydrogenase (SDH)

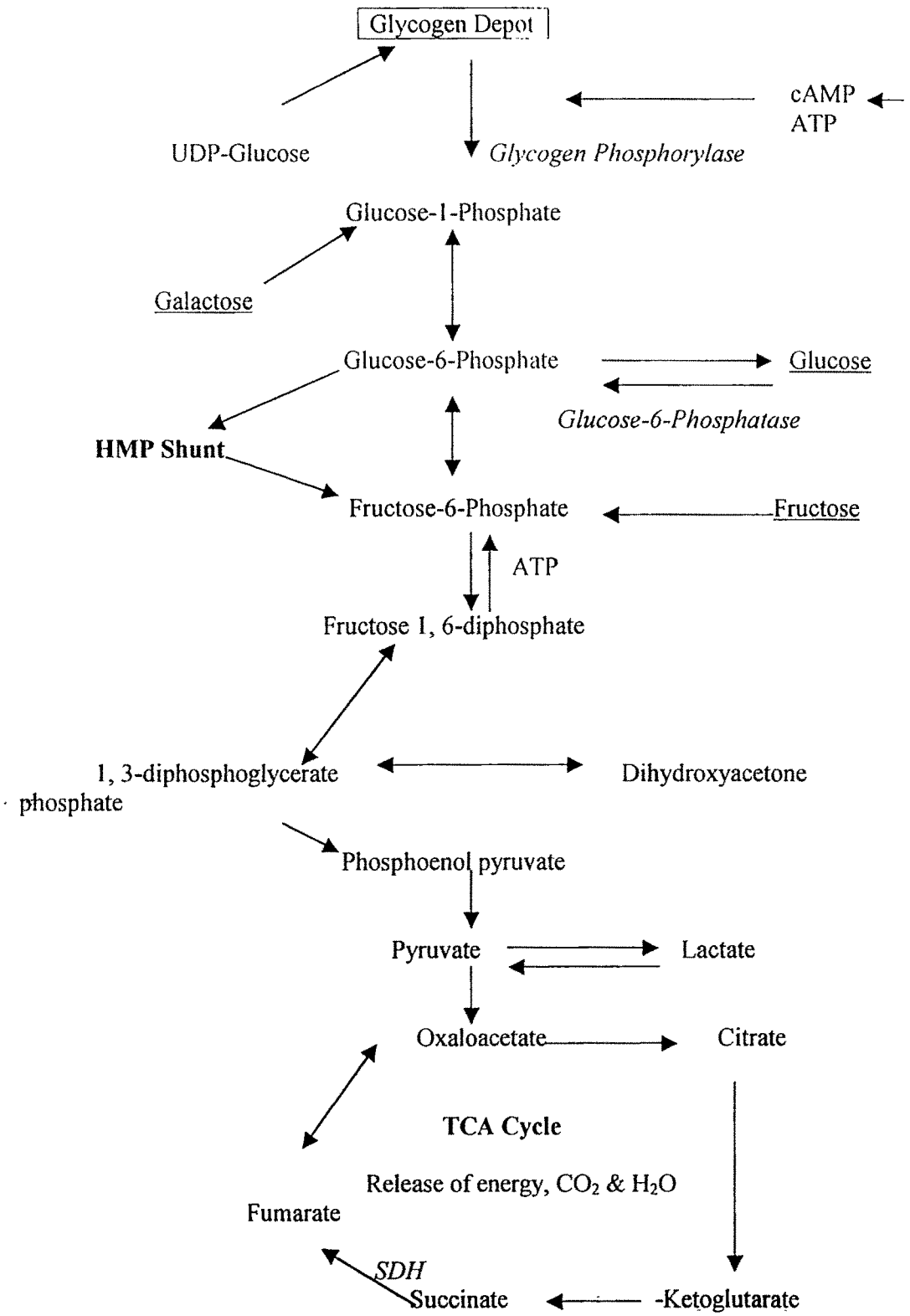
The breeding females had non-significantly higher hepatic SDH at 5.75 ± 0.6 (µg of formazon formed/ mg protein/ 30 minutes) compared to the non-breeding females and helper females which had 4.9 ± 0.62 µg and 4.5 ± 0.7 µg respectively. Similarly intestinal SDH levels in the breeding females was non-significantly higher at 6.95 ± 0.9 µg compared to the non- breeding females and helpers at 5.6 ± 0.8 µg and 5.1 ± 0.7 µg respectively. The renal SDH levels were significantly low at 5.05 ± 0.64 µg in the breeding females which increased to 6.75 ± 0.68 µg in non-breeding females. In helper females the levels were almost equivalent to those of the breeding

females at 5.23 ± 0.69 (µg of formazon formed/ mg protein/ 30 minutes).

Adenosine triphosphatase (ATPase)

Compared to the breeding females, in non- breeding females the hepatic ATPase levels were significantly lower at 143.31 ± 0.75(µg of phosphorous released/ mg protein/ 10 minutes) nearly equal to the helpers at 142.65 ± 0.85 µg. The breeding females had 145.23 ± 0.81 µg ATPase in the liver. The intestinal levels of ATPase were equal and significantly lower at 130.2 ± 0.75 µg and 130.75 ± 0.8 µg respectively in non- breeding and helper females when compared to the breeding females which had 133.69 ± 0.73 µg. The renal ATPase activity in all the three females *i.e.* breeding, non-breeding and helpers showed nearly equal levels at 125.05 ± 0.7 µg, 126.45 ± 0.8 µg and 124.35 ± 0.82 (µg of phosphorous released/ mg protein/ 10 minutes) respectively.

Metabolism of Glycogen and simple Sugars



DISCUSSION~

The metabolic effects associated with the reproductive cycle of birds are associated with dietary variables as well as with the demand for the egg formation (Hazelwood, 1972). Birds derive all the energy from the food they eat and to release this energy from the food, catalytic action of certain enzymes is required. The increased enzymic activities could denote a generalized increase in the body metabolism and the activity which corresponds with the different breeding activities (Patel, 1982).

As shown in Table 1 and 2, the hepatic as well as intestinal glycogen levels in breeding Jungle Babblers were high; correspondingly, the glycogen phosphorylase activity was also high in both the sexes indicating that the enzyme activity is modulated parallel to that of the metabolite load. This indicates that carbohydrates are consumed as well as degraded at equal rates. This is possibly complemented by the kidney as it shows opposite trend to that of liver and intestine. Avian kidney is extensively involved in gluconeogenic activities (Krebs and Yoshida, 1963). In Jungle Babbler it seems that carbohydrate metabolism slows down in the liver and intestine of the non –breeding birds of both the sexes and the involvement of kidney in carbohydrate metabolism increases during this time as is reflected by increase in GP activity which had maintained low profile in breeding Jungle Babblers. Kidney becomes a

major gluconeogenic organ during prolonged starvation (Mehta, 1985). The non-breeding state of the Jungle Babblers coincides with the colder months of the year with shorter days and many crops like Pigeon pea are grown which are known to be heavily infested with *Helicoverpa armigera* and other insect pest. Jungle Babblers are reported to feed more on insects, rich in protein, during these months (Dhindsa *et al.,* 1994; Gaston, 1978), hence, the carbohydrate consumption decreases influencing the kidney to become the prominent gluconeogenic organ. This is reflected in higher glycogen levels as well as higher GP in the non-breeding kidney. This needs further investigation with the variations in the enzymes like Phosphoenol pyruvate carboxykinase involved in gluconeogenic pathways.

In the helper females which share the domestic duties, the energy is not utilized probably equal to that of the breeding birds as they have non-significantly higher glycogen in liver and lower GP in all the three tissues studied. Intestinal glycogen in helpers is non-significantly higher than the non-breeding females but non-significantly lower than the breeding females.

Many birds start their reproductive phase with large energy reserves which is not true for all birds (Thomas, 1982) and these birds enter their reproductive season with low levels of glycogen and fat depots and therefore relying on the daily food supply (Whittow, 1983).

Jungle Babblers are social birds wherein the few birds called helpers forgo their breeding in order to help the breeding pair in all the reproductive activities except the egg formation and egg laying. Thus, the load of the energy expenditure is shared by all the members of the flock; therefore storage of energy is not required. This is reflected in the simultaneous absorption and breakdown of carbohydrate by intestine and storage of glycogen in the liver in these birds during breeding. Also the higher glycogen phosphorylase activity in liver and kidney of breeding birds indicates simultaneous breakdown of glycogen for energy required for various breeding activities.

The extent of glycogen accumulation is inversely related to the glucose-6-phosphatase which is a rate limiting glycogenolytic enzyme (Raheja *et al.,* 1980). This is reflected by non-significantly lower G6Pase in liver of breeding and helper females which show accumulation of glycogen too. The helper females showed the intermediate levels. The progressive increase in the liver glycogen concentration is associated with a concomitant decrease in the hepatic glucose-6-phosphatase activity (Raheja *et al.,* 1980).

According to the energy need of the body, the increased or decreased rate of Kreb's cycle and the oxidative phosphorylation (for release of energy from ATP), could be inferred from the activities of the enzyme such as SDH and ATPase respectively. The high levels of hepatic and intestinal SDH and ATPase intensities observed in the

bre[illegible] Jungle Babblers compared to the non-breeding birds are suggestive of an active synthesis as well as hydrolysis of ATP to provide energy in order to fulfill the increased energy demand to carry out several metabolic processes during the breeding state. Both the enzymes are active in breeding male and female Jungle Babblers. Energy released during the process is required for the synthesis of different metabolites as well as for all the physical activities carried out during reproduction. Non-significantly lower SDH and ATPase activities in all the three tissue of the helper females indicate lower energy demands compared to breeding birds. As discussed earlier these birds share almost all the activities except egg laying, hence, non-significantly lower differences. Further, no prominent differences are noted in the kidney too.

On comparison with the earlier work done in our laboratory on Brahminy Myna (*Sturnus pagodarum*) and Bank Myna (*Acridotheres ginginianus*) (Padate, 1990; Datta unpublished data) lower glycogens as well as enzyme levels are noted in Jungle Babblers. Brahminy Myna is a solitary hole nester wherein all the breeding activities including the defense of the territory / nest and care of the young ones is carried out by the breeding pair only, hence, accumulation as well as utilization of glycogen occur in these birds which is reflected by high enzymic activities. In case of Bank Myna, which is a colonial nester, breeding activities are performed by the pair but defense of the colony is a combined effort, so accumulation of glycogen for instant energy

supply is probably low with low enzyme activities. In case of Jungle Babblers which are social birds, all the energy demanding breeding activities are performed by the whole flock which consists of a breeding pair and assistants called helpers, the energy expenditure is distributed amongst the flock members and hence, storage of energy in the form of glycogen or lipids is lowest. They rely on the daily supply of food which is reflected in their foraging behavior, wherein they spend their maximum time in search of food. The degree of maintenance of the enzyme activity reflects the physiological role of these enzymes *i.e.* the physiological need for keeping an animal active. Generally, the enzymes involved in the energy production are preferentially maintained (Szepsi, 1976). It is evident from the present work that the biochemical changes that take place in the body of Jungle Babbler depend on the physiological requirement to obtain energy for maintaining vital functions of the body as well as for the different activities during reproduction.