CHAPTER - III

SEASONAL ALTERATIONS IN CARBOHYDRATE METABOLISM AS REVEALED BY TISSUE GLYCOGEN CONTENTS AND BLOOD GLUCOSE LEVELS OF NORMAL AND PINEALECTOMISED DOMESTIC PIGEONS, (*COLUMBA LIVIA*)

Majority of the vertebrates referred to as seasonal breeders attune their breeding activities to a particular period of the year whence favourable conditions condusive to the procreational aspects are at their optimum. Such season specific breeding activities once ingrained in a species proceeds by means of not only an established internal rhythm but also by the aid of many proximate and ultimate factors provided by the environment and which remain more or less constant (of course within certain limits of variations) from year to year. Characteristically such annual rhythms of reproductive activity involve cyclicity of reproductive organs in the form of activation and regression of the primary sexual organs-the gonads. Quite a few of the avian species have such well defined periods of reproductive activity while the domesticated varieties have other ill defined periods of breeding activities too, apart from the well defined period, while yet others like chicks which are totally domesticated breed more or less continuously.

All physiological activities involve energy expenditure, and seasonal breeding activity is no exception requiring metabolic adaptation programmed to meet the exigencies of gonadal activation and functioning. Metabolic reserves of the body are generally built up prior to such seasonal activities to be expended during the process. Carbohydrates are by far the immediate and the most important metabolic reserve utilized by animals for various activities. Glycogen stores of the tissues though can sustain small scale local requirements, hepatic and muscle glycogen stores are the general pools which are depleted during large scale protracted periods of requirement. Seasonal breeding activities of animals are reported to bring about alterations in hepatic and other tissue glycogen stores along with the glycemic level (Delahunty et al., 1978; Patel, 1982). Such alterations are no doubt mediated by endocrine secretions of which the pancreatic hormones, insulin and glucagon together with thyroxine and corticosteroids can be ascribed the pivotal roles. Recently pineal's role in carbohydrate metabolism is gaining attention and its extirpation is reported to cause both hypo and hyperglycemia (Mihail and Giurgea, 1979; Delahunty et al., 1978). Alterations in glycogen content of liver too are known to occur in a season specific fashion after pinealectomy (Delahunty et al., 1978; Patel, 1982). In a previous study from this laboratory pinealectomy in wild pigeons was shown to induce more dramatic changes in carbohydrate metabolism during the breeding season. The present study on the effect of pinealectomy on the glycogen content of liver, muscle and gonads and glycemic level in domestic pigeons, Columbia livia during breeding and non-breeding periods of the year was undertaken in this light to provide more information on the role of pineal in seasonal metabolic modulations.

MATERIAL AND METHODS

Adult domestic pigeons procured from the local animal dealer and maintained in the aviary on grains and water *ad libitum* were used for the study. Birds were brought into the experimental set up after allowing a fortnight's acclimation. Surgical removal of the pineal was done as per the technique in Chapter-I. They were maintained in the aviary with suitable post operative care to be used 30, 45 and 60 days post-pinealectomy. Corresponding sham operated pigeons with intact controls were also maintained simultaneously. During the two periods (i.e. breeding and non-breeding) pigeons of either sex (4 males and 4 females) from each of the three groups (Pinealectomised- PX, sham operated- PN intact controls-C) were used at the end of the three experimental time periods. The birds were decapitated under mild anaesthesia and a piece of (Pectoralis) breast muscle, and a piece of liver and the gonad were excised, blotted free of tissue fluids and blood and used for the estimation of glycogen by the method of Seifter *et al.* (1950). The estimation of blood glucose was carried out according to the micro-method of Folin and Malmros (1929).

RESULTS

The seasonal changes in the tissue glycogen contents and glycemic level of normal and pinealectomised birds are represented in Table-1, Figs. 1 to 4.

SEASONAL CHANGES IN NORMAL BIRDS:

During the breeding period, both the hepatic and gonad glycogen contents were very much reduced and the blood glucose level tended to be higher. The muscle glycogen content was however higher during the breeding period. In the non-breeding period the hepatic and gonad glycogen contents increased tremendously with the percentage increase being 95 % and 137 % respectively. The glycemic level was reduced by about 13 % and the muscle glycogen was 25 % below the breeding level.

PINEALECTOMY INDUCED CHANGES:

Birds pinealectomised in the breeding season depicted increased glycogen content in liver and gonad which was at an average 68 % and 144 % respectively. In contrast, the muscle glycogen content was reduced by about 36 % and the blood glucose level was higher by 5 % . Pinealectomy in the non-breeding period brought about depletion of glycogen content from liver and gonad to the tune of 56 % and 50 % respectively. Concurrently the muscle glycogen content was less by 26 % and the blood glucose level decreased by about 12 %.

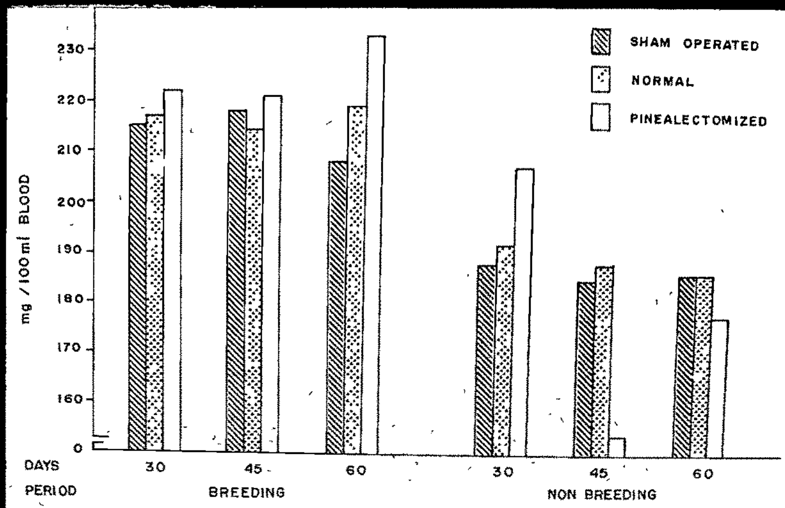

FIG. 1 ALTERATIONS IN BLOOD GLUCOSE POST PINEALECTOMY IN DOMESTIC PIGEON

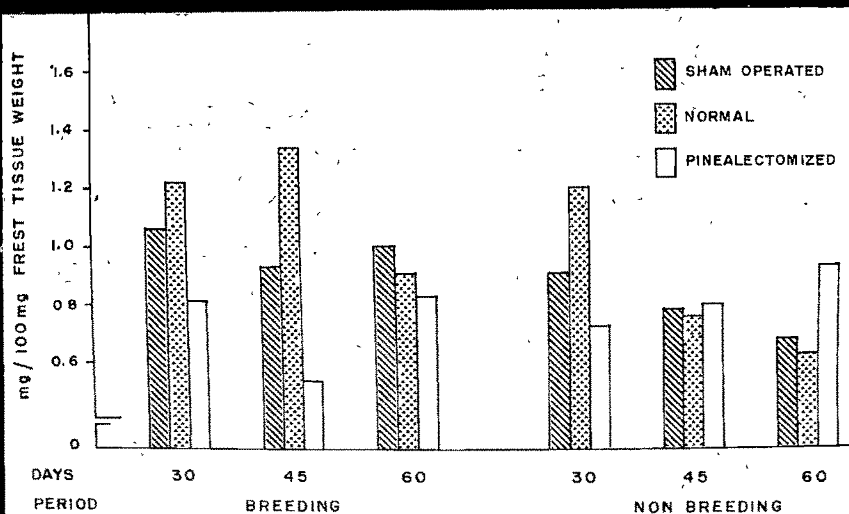

FIG. 2 CHANGES IN MUSCLE GLYCOGEN CONTENT POST PINEALECTOMY IN DOMESTIC PIGEON

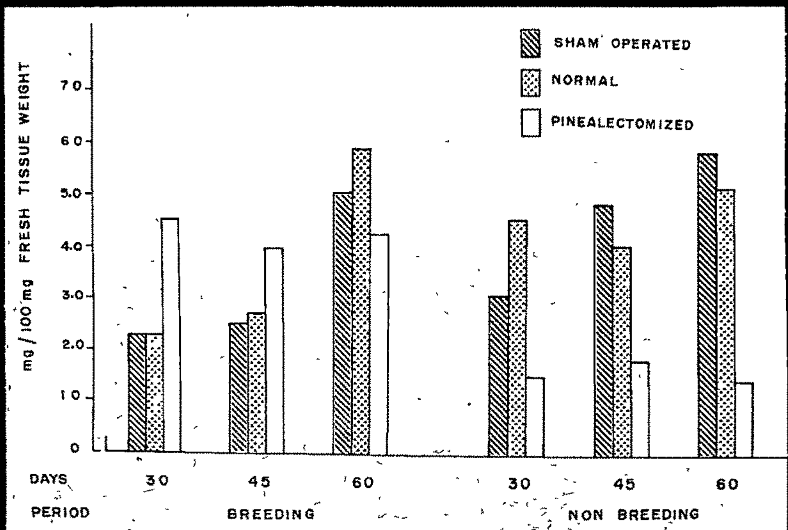

FIG 3 CHANGES IN HEPATIC GLYCOGEN CONTENT POST PINEALECTOMY IN DOMESTIC PIGEON

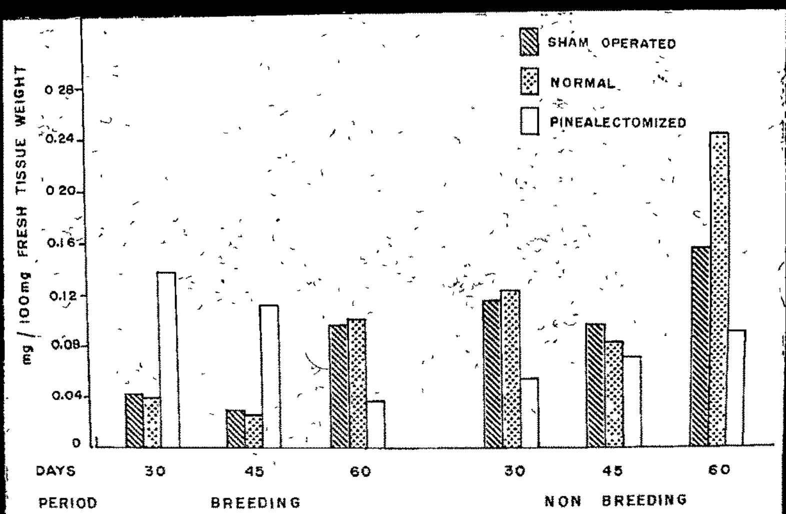

FIG.4 CHANGES IN GONAD GLYCOGEN CONTENT POST PINEALECTOMY IN DOMESTIC PIGEON

DISCUSSION

From the results obtained it is surmisable that the breeding season is marked by increased energy expenditure as reflected by the depleted glycogen content of the gonads and liver. Concurrently the glycemic level tended to be slightly higher. Similar studies carried out on wild pigeons (Ramachandran et al., 198c) have also indicated the utilization of hepatic glycogen during the breeding season. However, the glycemic level in wild pigeons was not very high unlike as noted for the domestic pigeons in the present case. Whereas the depletion of hepatic glycogen in the wild pigeons was only to the tune of about 20 % , in the domestic pigeons it was as high as about 50 % . This might easily account for the differences in the glycemic level of the two species. A comparison reveals the tendency of muscle glycogen content to be higher during breeding than during non-breeding. The availability of more glucose during breeding might be responsible for the increased deposition of glycogen in the muscle. The increased glycogen content noted in the gonads during the regression period is again indicative of the seasonal alteration affecting the carbohydrate reserve of the gonads too. Apparently, in the post breeding period the gonad glycogen content increases due to reduced utilization. It is unfortunate that there are no adequate studies on seasonal alterations in carbohydrate metabolism of birds which precludes more effective discussion of the data.

Pinealectomy induced differential alterations in the hepatic content of glycogen as well as in blood glucose level during breeding and non-breeding phases. Whereas in the breeding period both the hepatic glycogen content as well as blood glucose level were increased due to pinealectomy, both the parameters showed a decrease during the non-breeding period. These changes are paralleled by gonadal suppression and activation respectively. Surmisably, gonadal activity is marked by reduced hepatic glycogen reserve. This is applicable to the gonadal content of glycogen too as pinealectomy induced gonadal regression during the breeding period was marked by increased glycogen content, and the pinealectomy induced gonadal activation during the non-breeding by reduced glycogen content. Whereas the glycogen content of the liver and gonads did show diametrically opposite pattern of changes in pinealectomised birds as compared to the controls, the blood glucose level instead showed effects augmenting the features characteristic of the intact control birds in the two seasons. This is shown in the form of increased hyperglycemic tendency during the breeding period and increased hypoglycemic tendency during the non-breeding period.

These changes are indicative of differential hormonal interactions occurring post-pinealectomy affecting liver glycogen stores and blood glucose differently in the two seasons. Except for the study of Delahunty et.al. (1978) on gold fish, there is no other report on the effect of pinealectomy on tissue glycogen levels. The above study had shown decrease in hepatic glycogen level post pinealectomy in spring and summer but not in the fall. Though this report enlightens the season specific relation of pineal in carbohydrate metabolism, the results obtained are slightly at variance with the present results. However, it is in agreement with our previous studies on wild pigeons, where pinealectomy was noted to show reduced hepatic glycogen stores in the breeding season (Patel,1982). In the present study on domestic pigeons, pinealectomy induced increased glycogen content during the breeding season (regressed gonads) and reduced store in the non-breeding season (active gonads), changes which are characteristic of control animals during non-breeding and breeding respectively. Apparently glycogenolytic activity is promoted during periods of gonadal activation; and accordingly pinealectomy in the breeding season does bring about an inhibition to this activity thus leading to increase in glycogen content, while pinealectomy in the non-breeding season enhances glycogenolytic activity thus leading to glycogen depletion. In contrast to hepatic glycogen content, alterations in plasma glucose level due to pinealectomy or melatonin administration are studied better. Some of the pertinent reports are of John et al. (1980) on Rainbow trout showing no effect of melatonin injection on plasma glucose, of Mckeown et al. (1975) on pigeon showing significant increase in plasma glucose post-melatonin injections and on Mihail and Giurgea (1979) on domestic pigeons showing hypoglycemic influence of pineal extracts. It is obvious that the action of pineal on glycemic level is not uniform and may be synergistic or antagonistic to insulin or insulin action. Moreover, the time period during a circadian cycle at which melatonin is injected and the dose of melatonin used can all have profound variation in the glycemic response (Mckeown et al., 1975). The previous study from this laboratory had indicated an antiinsulinic and antiavian pancreatic polypeptide role of pancreas in wild pigeons (Patel, 1982), In contrast, Mihail and Giurgea (1979) had shown a synergistic action of pineal with pancreas in domestic pigeons. However, in the present case the tropical domestic pigeons appear to project a different pineal-pancreas relationship. Though it is as yet difficult to think of either a synergistic or antagonistic interaction between pineal and pancreas in domestic pigeons, some sort of altered interaction either direct or indirect on insulin post-pinealectomy may be inferred. Since the glycemic level during breeding period is more than that in the non-breeding period in intact birds, an antiinsulinic role of pineal can be presumed to be more in action in the breeding phase than in the non-breeding phase. In this light, and the known antagonistic influence of adrenalin on insulin action coupled with the observed decreased cortico-medullary ratio during breeding, and increased ratio during non-breeding in pinealectomised birds (Chapter-I), are self explanatory of the herein observed hyperglycemia and hypoglycemia respectively in the experimental birds. It is also worth noting the fact that increased muscle glycogen content during breeding and reduced content during non-breeding in intact birds are paralleled by decreased and increased adreno-medullary activity respectively. Similarly in pinealectomised pigeons too, decreased muscle glycogen content during the breeding phase and increased muscle glycogem content during the non-breeding phase are paralleled by increased and decreased adreno-medullary activity respectively. These changes in muscle glycogen are in agreement with the purported role of adrenalin on inducing muscle glycogenolysis.

Thus it could be stated that pinealectomy induced seasonal shift in gonadal activity is accompanied by corresponding phase shift in carbohydrate metabolism.