CHAPTER VIII

Alterations in carbohydrate metabolism in intact and pinealectomized pigeons exposed to long photoperiod prior to recrudescent phase.

Seasonal variations in glycemic level and tissue glycogen contents in relation to breeding activities have been reported to occur in the feral pigeons (Patel et al.,1988). Further studies showed that pinealectomy as well as treatments with various methoxyindoles also exert significant effects on carbohydrate metabolism (Patel et al., 1988; Ramachandran and Patel, 1987; Chapter II,). Circannual biological rhythms have been by now clearly linked to cyclic changes in the environment. Of the various environmental factors, photoperiod has been recognised as the principle factor capable of synchronising /entraining the various seasonal biological and metabolic rhythms (Meier,1975). Though photoperiod has been purported to influence metabolic rhythms, no direct studies have been addressed to evaluate the influence of photoperoidic changes on metabolic parameters. However, one report has shown changes in liver and plasma metabolites under altered light schedules in the gold fish, Carrasius auratus, (Delahunty et al.,1978). Though, voluminous literatures are available on the role of photoperiod in gonadal cyclicity in birds (Singh and

Chandola, 1982; Kumar and Kumar, 1993), there is no information regarding the concurrent changes in the metabolic profile. Previously, it was shown that exposure of feral pigeons to long photoperiods in the pre-recrudescent phase does induce functional alterations in testes, adrenal and thyroid (chapter VII). The present study was designed in this context to assess the effects of long photoschedule on carbohydrate metabolism in intact and pinealectomised feral pigeons. The objective of this study was thought more pertinent as earlier evaluations had registered significant changes in carbohydrate metabolism in both PX as well as intact birds treated with methoxyindoles (Chapter II).

Materials and Methods :

Procurement and maintenance of birds-as outlined in chapter I;

Lighting Schedules and Experimental Set-ups-as outlined in Chapter VII;

Parameters and Methodology of evaluation - as outlined in Chapter III.

Results : (Tables 8.1a,b; Figs 8A-D)

Plasma Glucose and Liver and Muscle Glycogen :

Treatments	Blood Glucose (mg/dl)	Tissue Glycogen (mg/100mg Tissue)		Hepatic G-6-P'ase (u moles PO_4 released /mg Protein/15 min)	Hepatic Phosphorylase (ug PO_4 released/mg Protein/15 min)
		Liver	Muscle		
N 12:12	163.42 ± 18.71	6.71 ± 1.04	0.62 ± 0.04	0.74 + 0.08	12.71 ± 1.81
Px 12:12	149.46* ± 19.49	4.30* ± 0.97	0.19* ± 0.02	0.71 ± 0.06	8.36* ± 1.15
N 18:6	162.94 ± 18.30	4.71 ± 0.21	0.11 ± 0.05	0.80 ± 0.09	8.88 ± 1.40
Px 18:6	128.28* ± 17.11	4.28* ± 0.80	0.16* ± 0.06	0.50* ± 0.03	8.74 ± 1.34

Table 8.1a :Alterations in blood glucose, tissue glycogen contens and acivity levels of G-6-P'ase and phosphorylase in liver of intact and PX pigeons exposed to NLD or LD 18:6 in the months of Nov.-Dec.

(* = Significant at $P < 0.05$; values are $\bar{x} \pm SD$)

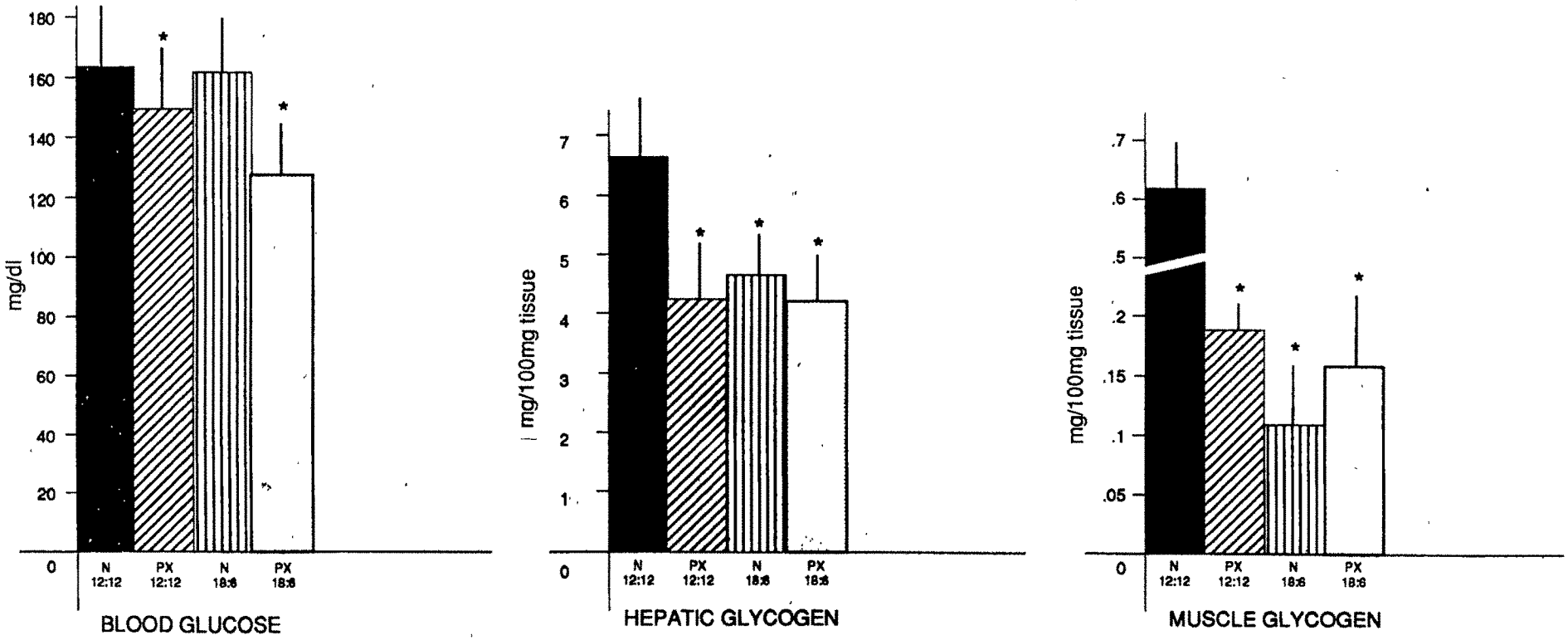

FIG. : 8 A : Alteration in blood glucose and tissue (hepatic and muscle) glycogen content of intact and PX pigeons exposed to NLD or LD 18:6 in the months of Nov. - Dec.
(* Significant at $p < 0.05$, values are $\bar{x} \pm SD$).

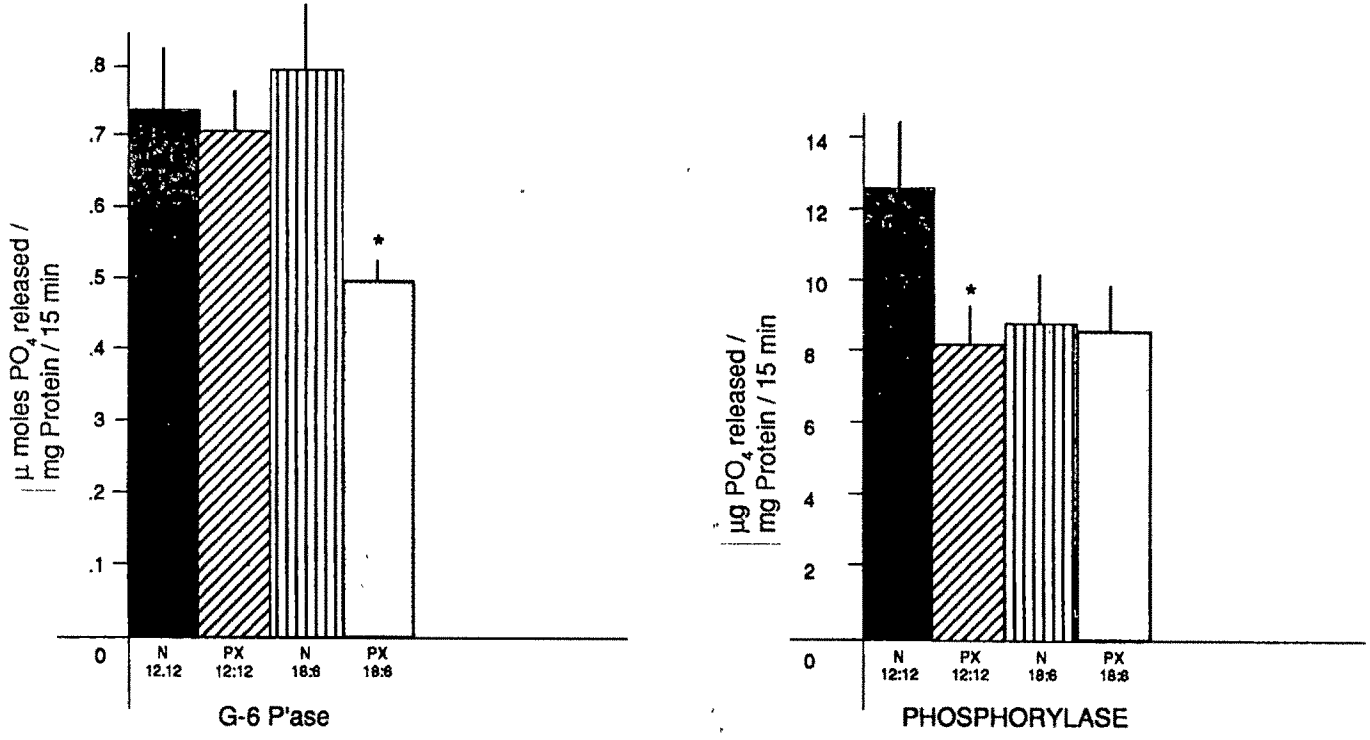

Fig. : 8 B : Alteration in activity levels of hepatic G-6-P'ase and phosphorylase of intact and PX pigeons exposed to NLDor LD 18:6 in the months of Nov. - Dec.
(* Significant at $p < 0.05$; values are $\bar{x} \pm SD$).

The hepatic and muscle glycogen contents of intact birds were very high during both Nov-Dec and Dec-Jan months. However, during the latter period, the contents were slightly lesser than in the former period. Pinealectomy in either period decreased the hepatic and muscle glycogen contents and there was no noticeable difference between the two periods. Exposure of birds to long photoperiod (LD 18:6) in both the time periods decreased the tissue glycogen contents. By far the decrease in the Dec.-Jan. group of birds was more pronounced. The glycemic level in intact birds tended to increase progressively as the Dec.-Jan. group of birds showed a higher level as compared to Nov-Dec. group. Pinealectomy caused decrease in the glycemic level and the degree of decrease was quite the same in both the time periods. Long photoperiod increased the glycemic level in the Dec.-Jan. group of birds while there was no change in the Nov-Dec group. Pinealectomised birds exposed to LD 18:6 showed very pronounced hypoglycemic status during both the time periods.

Hepatic Phosphorylase and G-6-P'ase :

Intact birds showed progressive decrease in phosphorylase activity and increase in G-6-P'ase activity from Nov.-Dec. to Dec.-Jan. Pinealectomy decreased the activity levels of both the enzymes in both the time period. The intact birds exposed to LD 18:6 depicted decreased hepatic phosphorylase

Treatments	Blood Glucose (mg/dl)	Tissue Glycogen (mg/100mg Tissue)		Hepatic G-6-P'ase (u moles PO_4 released /mg Protein/15 min)	Hepatic Phosphorylase (ug PO_4 released/mg Protein/15 min)
		Liver	Muscle		
N 12:12	199.42 ± 20.72	6.44 ± 1.33	0.52 ± 0.02	0.87 ± 0.05	10.83 ± 1.57
PX 12:12	175.46* ± 18.11	4.01* ± 0.72	0.19 ± 0.02	0.73* ± 0.04	7.66* ± 1.14
N 18:6	202.52 ± 22.27	1.61* ± 0.91	0.15 ± 0.01	1.64* ± 0.09	4.65* ± 0.98
PX 18:6	142.88* ± 18.83	3.95* ± 0.92	0.20 ± 0.02	0.61* ± 0.03	7.23* ± 0.70

Table 8.1b : Alterations in blood glucose, tissue glycogen contents and activity levels of G-6-P'ase and phosphorylase in liver of intact and PX pigeons exposed to NLD or LD 18:6 in the months of Dec.-Jan.
(* = Significant at $P < 0.05$; values are $\bar{x} \pm SD$)

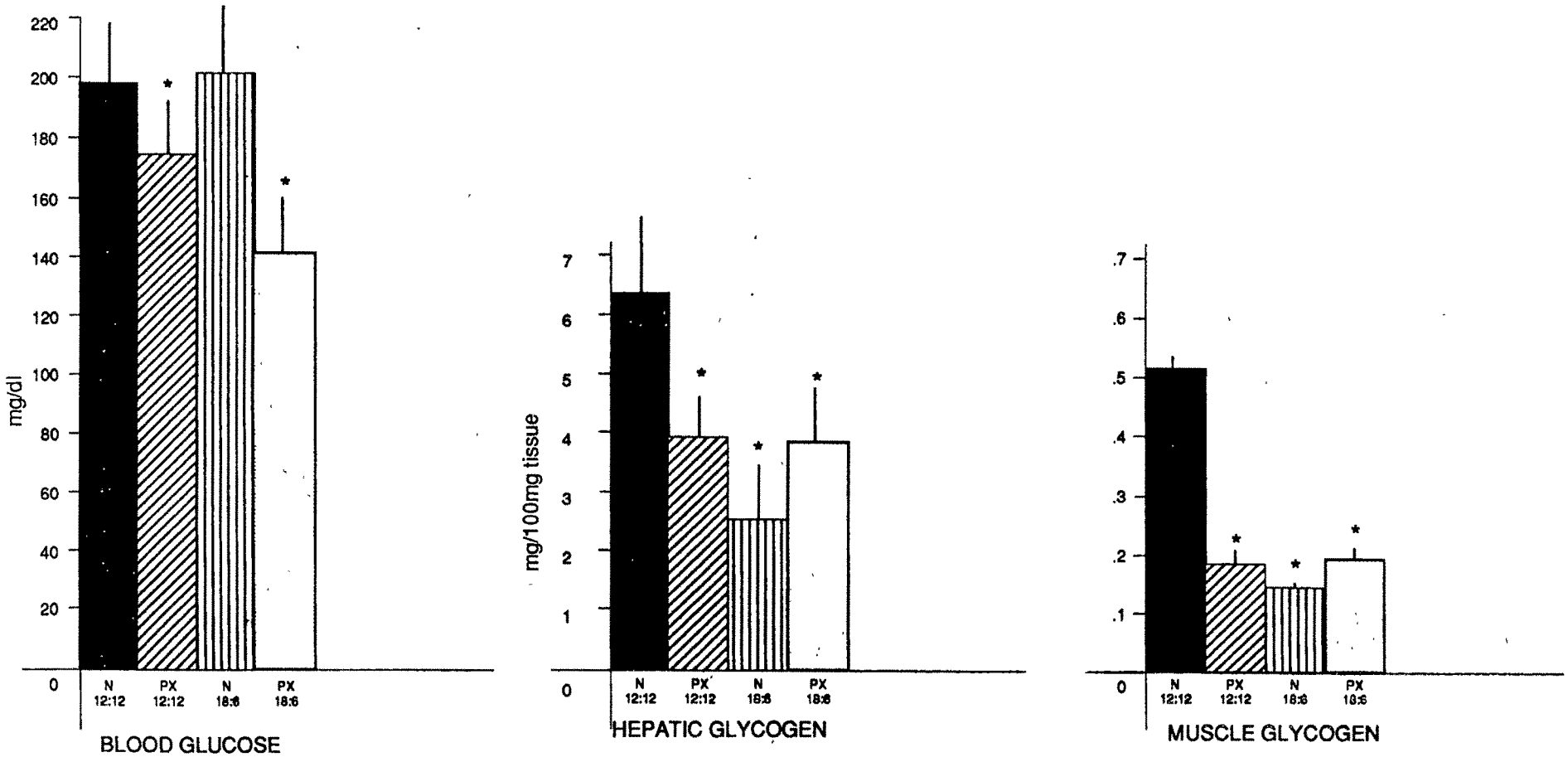

Fig. : 8 C : Alteration in blood glucose and tissue (hepatic and muscle)glycogen content of intact and PX pigeons exposed to NLD or LD 18:6 in the months of Dec. - Jan.
(* Significant at $P < 0.05$, values are $\bar{x} \pm SD$).

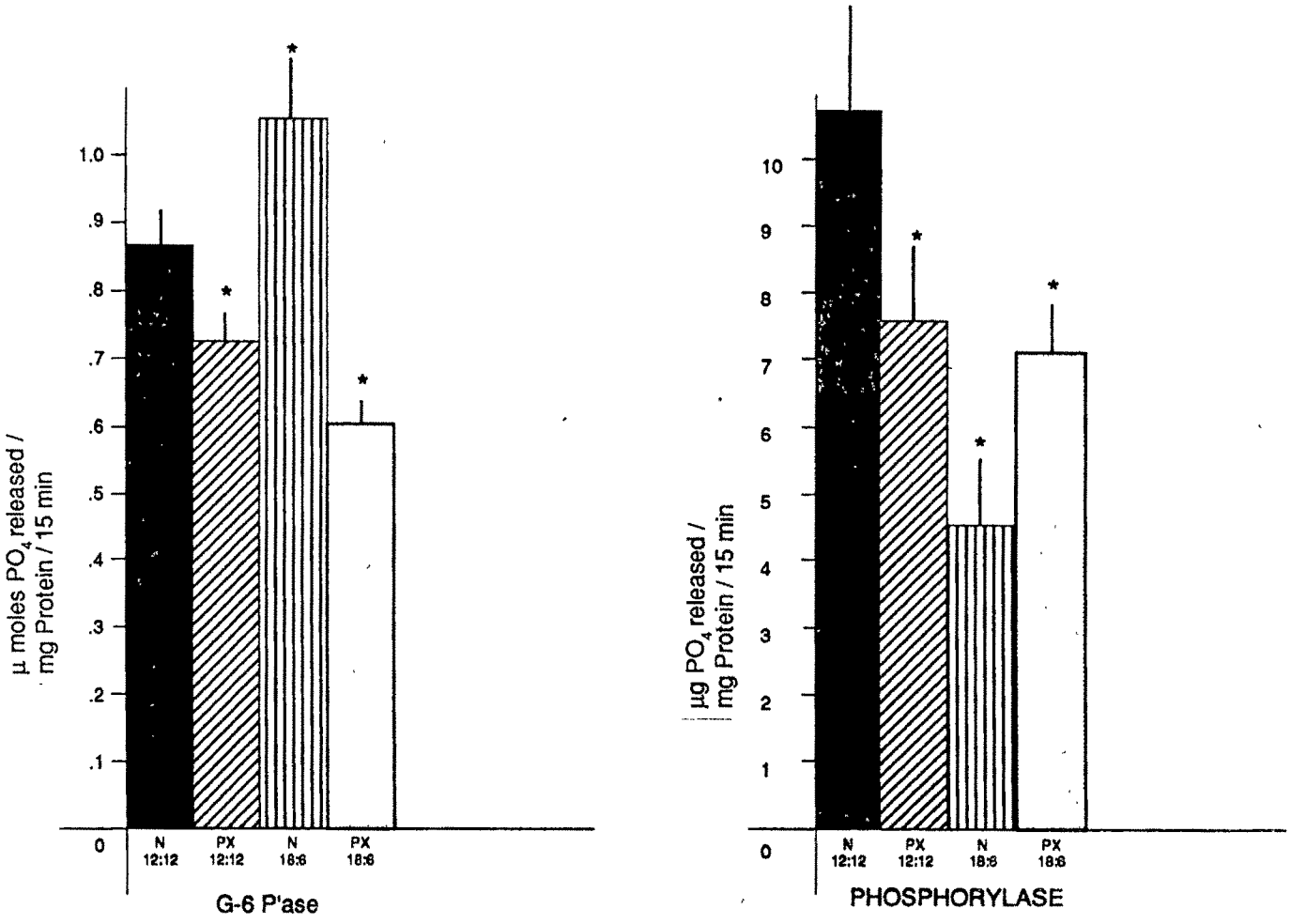

Fig. : 8 D : Alterations in the activity levels of hepatic G-6 P'ase and phosphorylase of intact and PX pigeons exposed to NLD or LD 18:6 in the months of Dec. - Jan.
(* Significant at $p < 0.05$; values are $\bar{x} \pm SD$).

activity during both the time periods but the decrease was of a greater magnitude in Dec.-Jan. The change in hepatic phosphorylase activity due to LD 18:6 in intact birds was not however evident in PX birds. On the other hand, the hepatic G-6-P'ase activity registered an increase in intact birds and a decrease in PX birds exposed to LD 18:6. The changes in both the groups were more pronounced in Dec.-Jan.

DISCUSSION :

The present findings taken with those of previous studies (Chapters II,IV,VI) reveal an invariable hypoglycemic and tissue glycogen depleting effect of PX through-out the year in feral pigeons. This is in contrast to the findings of Delahaunty et al. (1978) in the gold fish, Carrasius auratus. These workers reported the effect of PX on hepatic glycogen stores to vary with seasonal and acclimation conditions. The inability of long photoschedule to alter the decrease in hepatic and muscle glycogen, hepatic phosphorylase and G-6-P'ase activity and blood glucose in either Nov.-Dec. or Dec.-Jan. suggests a need for an intact pineal to modulate the photoperiod mediated changes in carbohydrate metabolism. This is consistent with the previous observations of the inability of PX birds to undergo testicular recrudescence even on exposure to long photoperiod (Chapter VII). In the above study, whereas long photoperiod activated HHG & HHA axes and

suppressed the HHT axis of intact birds, the same photic treatment was without any effect on HHG axis of PX birds. The present study was undertaken in this context to evaluate whether the changes in carbohydrate metabolism known to occur during testicular recrudescence can be induced by long photoperiod in intact and PX birds.

The findings clearly indicate that long day lengths can potentiate or hasten the characteristic elevation in plasma glucose and depletion in tissue glycogen occurring during the transition from the quiescent to recrudescent phase (see Table-8.1a, Fig-8A). However, it is noteworthy that the potentiating effect of long photoperiod was less evident in Nov-Dec as compared to Dec-Jan.Obviously, it is only the period closer to the transition from quiescent to redrudescent phase that is photosensitive while the earlier period appears to show some sort of photorefractoriness vis-a-vis adaptive alteration in carbohydrate metabolism. The changes obtained in the present study due to LD 18:6 are slightly different from those of PX (Chapter IV). While PX was marked by tissue glycogen depletion and hypoglycemia, exposure to LD 18:6 is marked by tissue glycogen depletion and hyperglycemia. The higher plasma glucose level (Characteristic of recrudescent and breeding phases) is supported by the increased hepatic G-6-P'ase activity. These differential effects caused by pinealectomy and long

photoperiod appear to be due to altered phase relationships between the metabolically important hormones like prolactin, corticosterone, T4 and even pancreatic hormones. In fact, altered phase relationship between prolactin and corticosterone has been shown to influence seasonal fattening and reproductive changes in birds and mammals (Meier and Cincotta,1993). Since it is shown previously that long photoperiod differentially alters the HHT and HHA axes (Chapter VII) and as photoperiod is known to effect prolactin release (Amador et al.,1988), the inter-relationships between these hormones are likely to form a component of the neuroendocrine regulation of carbohydrate metabolism in the pigeon. Besides, the modulatory influence on pancreatic hormones also cannot be discounted as alterations in the secretion of insulin and glucagon have been shown to occur either after pinealectomy or M administration. In this context, it can be presumed that altered phase relationships between these hormones form a neuroendocrine basis for carbohydrate metabolism in birds as has been inferred for lipid metabolism (see Meier and Cincotta,1993).

The increased hepatic G-6-P'ase activity normally occurring during transition from quiescent to the recrudescent phase and which is potentiated on exposure to long photoperiod can be correlated with the increased corticosterone secretion caused by the activation of HHA axis (Chapter VII).The

ability of corticosterone to induce G-6-P'ase activity is clearly known (Joseph and Ramachandran,1992). However, the significantly decreased hepatic glycogen content together with decreased phosphorylase activity seem paradoxical. It may be speculated that in the early periods following exposure to long photoperiod, there is increased phosphorylase activity leading to glycogen depletion and consequent to that in the later period the enzyme activity decreases thereby maintaining a steady low level of glycogen content. This could form an explanation for the observed contradiction.

Based on exhaustive studies on the tree sparrow, Wilson (1991) suggested the possibility of extra-pineal, extra-ocular encephalic photoreception in modulating annual gonadal cycles in PX and enucleated birds on a long term basis. Apparently, pineal-hypothalamic, retino-hypothalamic (Oishi, 1991) and direct encephalo-hypothalamic pathways seem to be the three heirarchial levels of photoreceptive mechanisms in birds. In the previous report it was surmised that PX pigeons are not able to respond to photoperiod-induced testicular activation in the immediate post-PX phase as alternate mechanisms involving retino-hypothalamic or encephalic-hypothalamic pathways need some latent time period to come into operation (Chapter VII). Hence,the unresponsiveness of PX pigeons to long photoperiod in terms of carbohydrate metabolism observed

herein is related to the above fact. Overall, from the results obtained in the present study it can be concluded

1. Adaptive alterations in carbohydrate metabolism related to testicular recrudescence and breeding phase occur gradually during the period of transition from quiescence to recrudescence at about winter solstice coinciding with gradually increasing day length.
2. Long photoperiod can potentiate these changes only during a photosensitive phase during the fag end of the quiescent phase.
3. Pinealectomised birds are unable to show these adaptive changes in the immediately ensuing phase of gonadal cyclicity as the activation of alternate mechanism needs some latent period.