CHAPTER- 6

Rearing photoperiod and carbohydrate metabolism in post hatched RIR pullets.

Adult avian carbohydrate metabolism in relation to growth, reproduction and adjustments and adaptations to environmental situations has been studied in greater detail (Hazelwood, 1986). Carbohydrate metabolism during embryonic development has also been studied to a greater detail (Romanoff, 1967; Bell and Freeman, 1984). However, the significance of carbohydrate metabolism in the post embryonic development in relation to growth and maturation needs no emphasis and has received relatively lesser attention.

Dramatic changes in carbohydrate metabolism can be expected to occur during the period of transition from prenatal to neonatal stages in mammals and, at about the time of hatching in the chick and as such have been looked into (Raheja *et al.*, 1971a). Gluconeogenic enzymes increase in activity during the progressive development of a chick embryo and reach a maximum near the time of hatching (Okuno *et al.*, 1964; Felicioli *et al.*, 1967; Sheid and Hirschberg, 1967). The

Gluconeogenic system is poor or absent in mammalian foetal liver (Ballard and Oliver, 1963; 1965) and becomes active only after birth (Dawkins, 1963; Ballard and Hanson, 1967; Hahn and Greenberg, 1968). This is due to the fact that the mammalian foetus gets a constant Supply of glucose from the maternal circulation thus not dependent on gluconeogenesis of its own until after birth. However, in the avian species, the embryo develops as an isolated system without a constant supply of glucose from the maternal source, thereby necessitating active gluconeogenesis during embryonic development. Raheja *et al.* ,(1971a) based on their studies on the activities of enzymes involved in lipogenesis, gluconeogenesis and glycolysis in the chicks, concluded that, gluconeogenesis is active in early life and again after maturity, whereas, lipogenesis is minimal at day one, increases rapidly during the first week and declines rapidly after 3 weeks. Apparently, the post-hatch neonatal phase of avian species is marked by adaptive metabolic shifts preparatory to the establishment of adult pattern of metabolic homeostasis.

The RIR pullets mature and normally initiate egg laying between 5 and 6 months. In this context, the first 3 months of post-hatch development would be of crucial significance in establishing the characteristic adult pattern of carbohydrate homeostasis.

Rearing photoperiod has been shown to alter the age at first egg of poultry birds (Dunn *et al.*, 1990; Etches, 1996; Lewis *et al.*, 1996a, b; Sandoval and Gernat, 1996). Generally, long photoperiods are shown to be stimulatory and short photoperiods inhibitory in attainment of sexual maturity and initiation of egg lay (Morris, 1968; Spies *et al.*, 2000,). Previous studies from this laboratory on RIR breed have shown a delayed sexual maturity under a long photoperiod during the rearing period and early maturity by a short photoperiod during the rearing period (Devkar, 1998; Dandekar, 1998; Chapter-1). It is also shown that body weight gain and organ growth are also altered by variations in rearing photoperiod (Devkar *et al.*, 1998, 2000; Dandekar *et al.*, 2001; Chapter-5). Obviously these alterations in body and organ growth as well as attainment of maturity and sexual functions brought about by different rearing photoperiods should have underlying endocrine modulations. Past studies have shown not only an alteration in thyroid, adrenal and ovarian hormones but also favourable or unfavourable influence of endocrine manipulations involving the thyroid and adrenals in RIR pullets (Devkar *et al.*, 1999; Dandekar *et al.*, 2000; Chapter-4). The involvement of hormones in modulating growth kinetics and metabolic features have been clearly elucidated by the past studies involving manipulations leading to adreno-

cortical excess or deficiency in RIR pullets (Devkar *et al.*, 1999; Dandekar *et al.*, 2000; John *et al.*, 1996).

It is in this background and as there is no information available regarding the relationship between photoperiod and metabolism that, the present study on carbohydrate metabolism has been undertaken in RIR pullets reared under a normal, short or long photoperiodic regimen from the day of hatch till 90 days.

Results:

Blood Glucose:

The blood glucose level in 30 day old pullets was found to be significantly higher under long photoperiod (LP) and significantly lower under short photoperiod (SP) compared to normal photoperiod (NP). All the three groups of pullets showed decrement in glucose level at 90 days with the lowest in SP and highest in LP chicks. Relatively, the LP birds had the highest glucose levels followed by SP and NP birds at 90 days (Table: 6.2.; Fig: 6.4).

Hepatic and muscle glycogen contents:

The hepatic glycogen content of all the three groups of pullets showed a gradual increase from 30-90 days. Both the SP and LP groups showed similar levels of hepatic glycogen contents at 30-

60-90 days. At 90 days, though the hepatic glycogen content was elevated in all the three groups, the levels of SP and LP birds were significantly higher than that of NP birds. The muscle glycogen content also showed a similar increase from 30-90 days in both SP and NP birds with significantly higher level in the latter. The LP pullets however, showed a continuous decrement in muscle glycogen content from 30-90 days (Table: 6.1, 6.2; Fig: 6.1, 6.5).

Hepatic and muscle phosphorylase activity:

A decrement in hepatic phosphorylase activity was noted from 30-90 days in all the groups of birds with a significantly lower level in SP and LP compared to NP. The muscle phosphorylase activity showed a steady decline from 30-90 days in both NP and SP birds while the muscle phosphorylase activity in LP birds showed a consistent increase from 30-90 days. (Table: 6.1, 6.2; Fig: 6.2, 6.6)

Hepatic glucose-6-phosphatase activity: In general, glucose-6-phosphatase activity shows a continuous decrease from 30-90 days in all the three groups. However, the LP pullets have the highest levels of G6Pase activity. (Table: 6.1; Fig: 6.3)

Table 6.1: Hepatic glycogen content and phosphorylase and glucose-6-phosphatase activities in RIR pullets at different photoshedule

Treatment	Glycogen			Phosphorylase			G-6-Pase		
	Age in Days			Age in Days			Age in Days		
	30	60	90	30	60	90	30	60	90
(NP) LD (12:12)	0.0493 ±0.0017	0.0591 ±0.0118	0.1109 ±0.0296	16.03 ±0.77	16.19 ±0.06	14.16 ±0.73	0.218 ±0.017	0.157 ±0.015	0.196 ±0.002
(SP) LD (6:18)	0.1751^{c} ±0.0116	0.1446^{b} ±0.0117	0.2421^{b} ±0.0025	13.61^{a} ±0.456	13.44^{a} ±0.822	11.83^{a} ±0.472	0.271^{a} ±0.0002	0.156^{c} ±0.015	0.138^{c} ±0.012
(LP) LD (18:6)	0.1816^{c} ±0.021	0.1607^{b} ±0.0187	0.2575^{b} ±0.0025	12.86^{a} ±0.496	9.94^{c} ±0.409	10.85^{a} ±0.33	0.434^{c} ±0.015	0.274^{c} ±0.017	0.315^{c} ±0.024

NP: Normal photoperiod; SP: Short photoperiod; LP: Long photoperiod

Values expressed as Mean ± S.E, n=6; a: $p \leq 0.05$, b: $p \leq 0.02$, c: $p \leq 0.001$

Table 6.2: Blood glucose levels and muscle glycogen content and phosphorylase activity in RIR Pullets at different photo schedule

Treatment	Blood Glucose			Muscle Glycogen			Muscle Phosphorylase		
	Age in Days			Age in Days			Age in Days		
	30	60	90	30	60	90	30	60	90
(NP) LD (12:12)	143.53 ±2.42	125.93 ±2.64	120.34 ±2.39	0.070 ±0.009	0.325 ±0.0104	0.399 ±0.058	20.18 ±0.698	18.57 ±2.66	15.98 ±1.53
(SP) LD (6:18)	125.83^{c} ±2.89	125.08 ±2.18	116.83 ±6.57	0.253^{c} ±0.030	0.339 ±0.009	0.442 ±0.020	18.90 ±1.004	13.13 ±0.689	12.00 ±1.12
(LP) LD (18:6)	160.85^{c} ±2.94	130.07 ±2.00	133.27^{b} ±2.52	0.377^{c} ±0.034	0.363^{b} ±0.0074	0.209^{c} ±0.0217	13.27^{c} ±0.296	14.19 ±0.397	22.27^{b} ±0.879

NP: Normal photoperiod; SP: Short photoperiod; LP: Long photoperiod

Values expressed as Mean ± S.E, n=6; a: $p \leq 0.05$, b: $p \leq 0.02$, c: $p \leq 0.001$

Fig. 6.1: Hepatic glycogen contents in RIR pullets at different photo periods

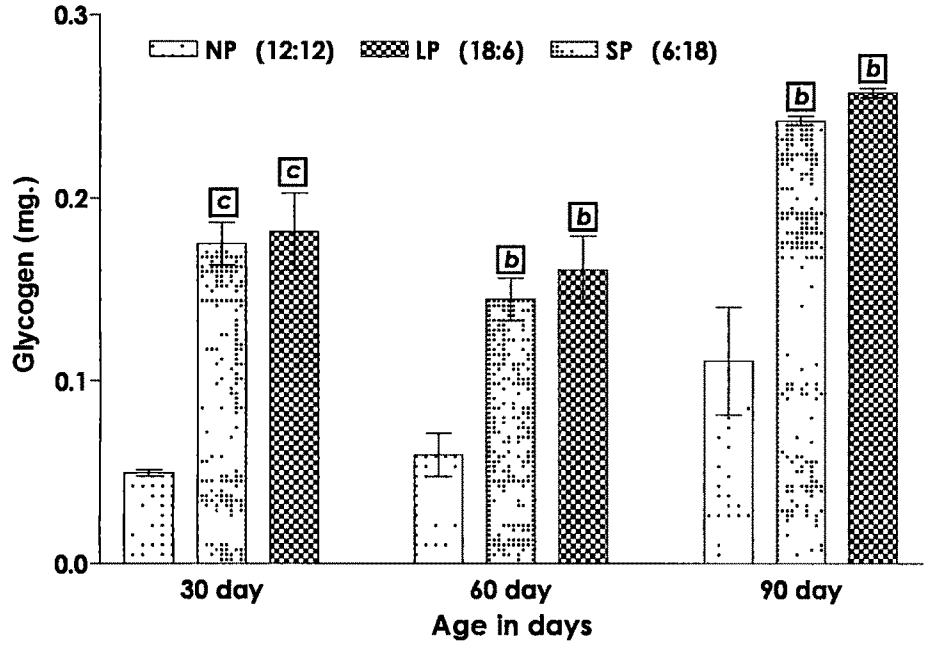
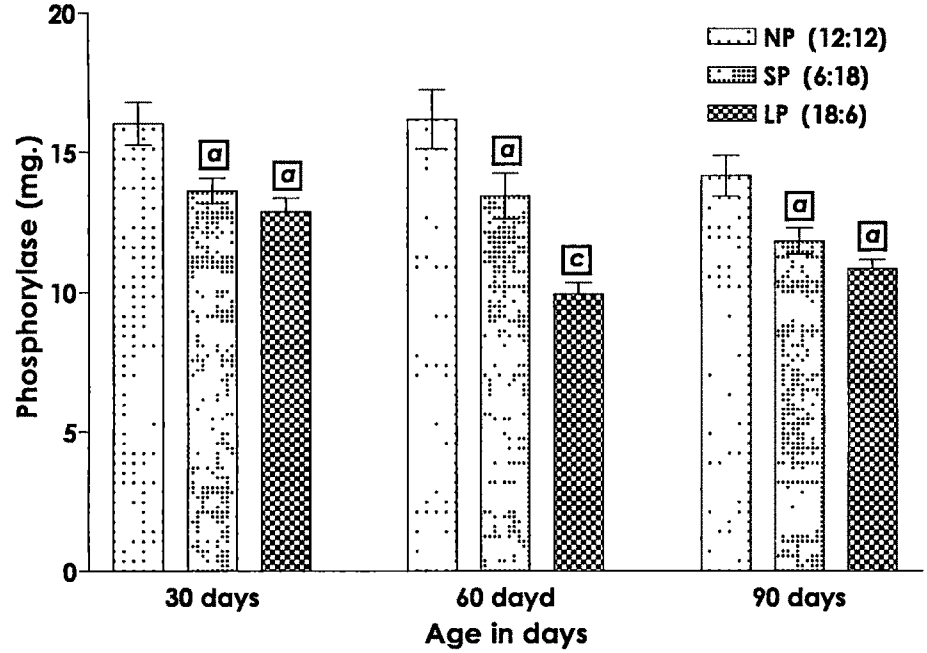


Fig. 6.2: Hepatic phosphorylase activity in RIR pullets at different photoperiods.



Control: Normal photoperiod, SP: Short photoperiod, LP: Long photoperiod
a: $p \leq 0.05$, b: $p \leq 0.02$, c: $p \leq 0.001$ of 6 animals

Fig. 6.3: Hepatic G-6-Pase activity in RIR pullets at different photoperiod

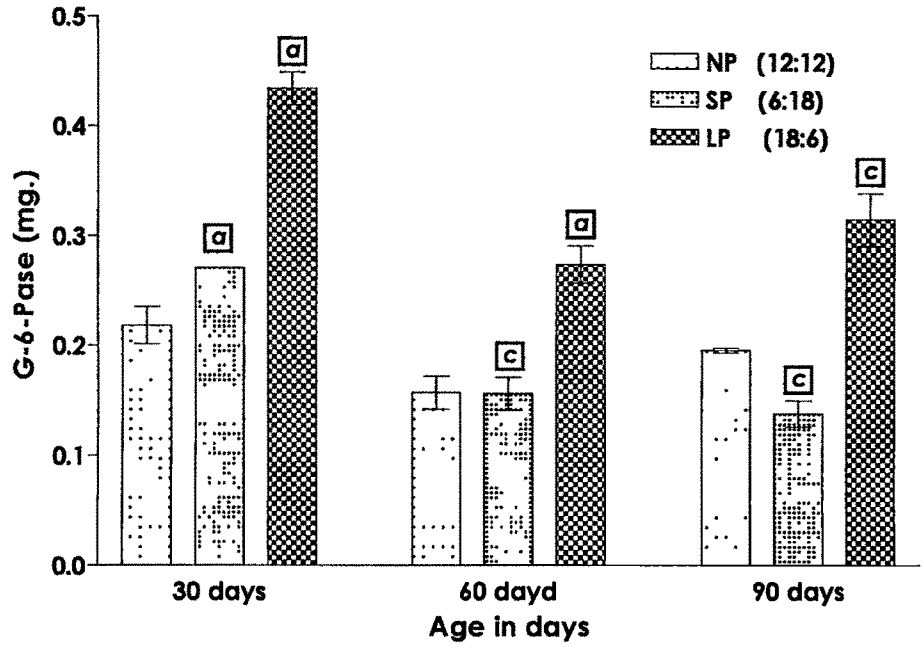
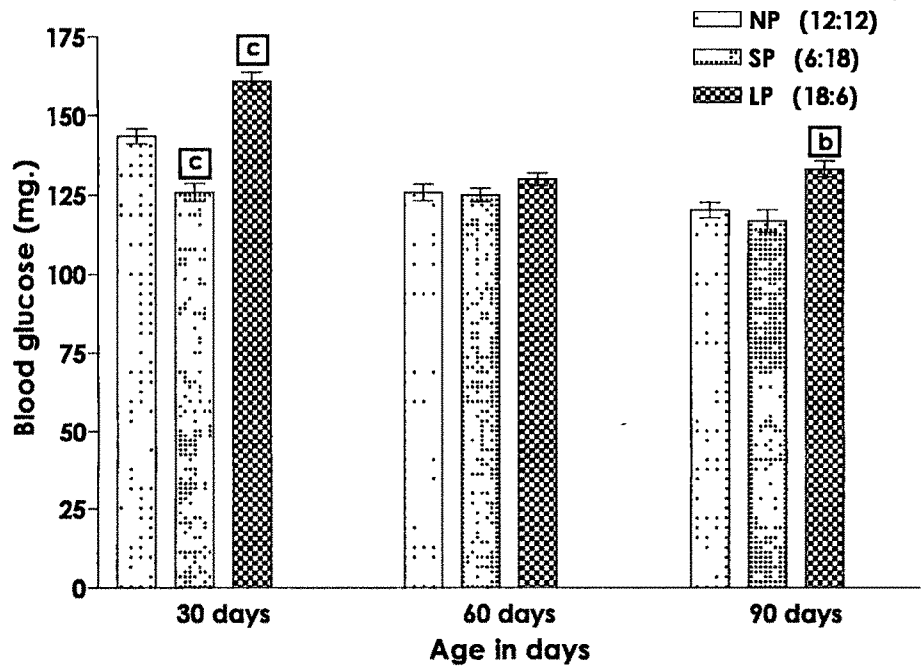


Fig. 6.4: Blood glucose levels in RIR pullets at different photoperiods



Control: Normal photoperiod, SP: Short photoperiod, LP: Long photoperiod
a: $p \leq 0.05$, b: $p \leq 0.02$, c: $p \leq 0.001$ of 6 animals

Fig. 6.5: Muscle glycogen content in RIR pullets at different photoperiods

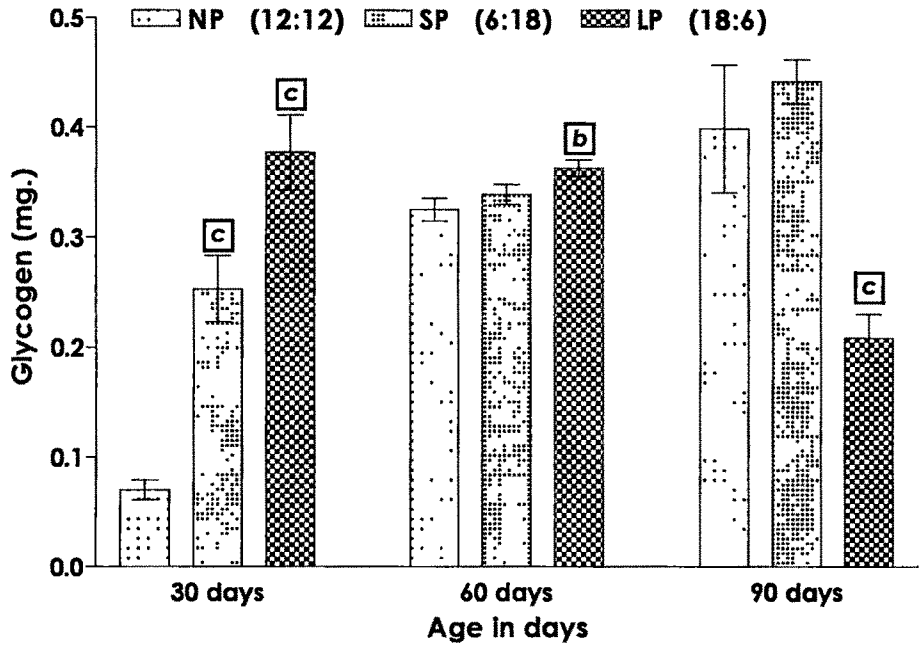
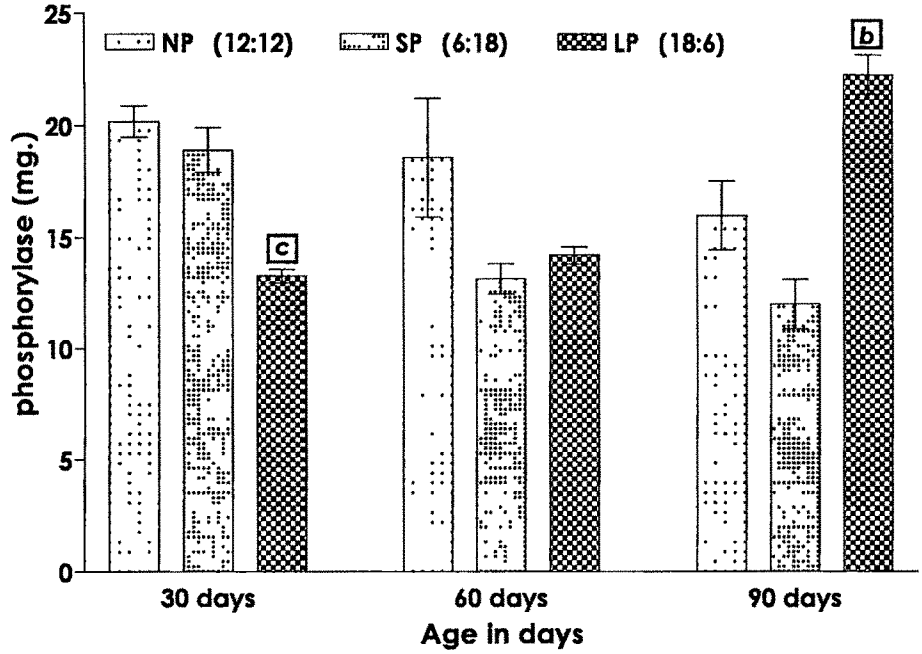


Fig. 6.6: Muscle phosphorylase activity in RIR pullets at different photoperiod



Control: Normal photoperiod, SP: Short photoperiod, LP: Long photoperiod
a: $p \leq 0.05$, b: $p \leq 0.02$, c: $p \leq 0.001$ of 6 animals

Discussion:

Unlike the case of mammals, in precocial birds like domestic hen, the post hatch phase of development is known for increased lipogenesis with simultaneously reduced gluconeogenesis (Raheja *et al.*, 1978). The importance of carbohydrates in this phase of development is although more important as, the chicks feed on a high carbohydrate diet and, their dietary carbohydrates serve as precursors for lipogenesis. Needless to say, many hormonal principles especially of the pancreas, adrenal and thyroid would be involved in regulating these metabolic transformations. Though the role of pancreatic hormones in the regulation of carbohydrate metabolism in birds has been studied to a greater extent (Hazel wood, 1986), the role of thyroid and adrenal hormones has also received some attention (Martin, 1961).

The present evaluation carried out essentially to evaluate the effect of rearing photoperiod on carbohydrate metabolism has provided some evidence for alterations in carbohydrate metabolism due to different lighting regimens. The initial blood glucose level which is lower in SP can be considered to be due to the hypoglycemic effect of melatonin as melatonin can be expected to be secreted in higher amounts due to short

photoperiod and, as melatonin has been shown to decrease blood glucose level in many species especially, the birds (Ramachandran, 2002). The hyperglycemic status seen in the LP pullets could considered to be essentially due to a stress induced corticosterone oversensitivity and the consequent increase in blood glucose. In this respect, corticosterone has been shown to induce hyperglycemia in birds especially white leghorn pullets (Ayyar *et al.*, 1999; Joseph and Ramachandran, 1993). A gradually increasing anabolic influence seems to be characteristic of the first trimester of post- hatched development as, the hepatic glycogen content increases continuously from 30-90 days through 60 days. Concomitantly, there is decreasing blood glucose level in all the three groups of pullets. The gradually decreasing blood glucose is paralleled by decreasing glucose-6-phosphatase activity. Whereas the higher glucose-6-phosphatase in the 1st month of NP chicks is understandable in the context of reported increased glucose sensitivity during this period as reported by Joseph *et al,* (1996), the significantly higher levels of the enzyme activity in SP and LP chicks could be explained as an additive influence of melatonin and corticosterone respectively as, both these hormones have been shown to be capable of inducing glucose-6-phosphatase activity (Joseph and Ramachandran 1992; Ayyar *et al.*, 1999). The decreasing blood glucose level and hepatic glucose-6-

phosphatase activity with concomitant increase in glycogen content in all the three groups of chicks suggest a gradually potentiating insulin action and consequent anabolic influence. Apparently the increasing glucagon responsiveness recorded in the 1st month of development (Joseph *et al.*, 1996) is being countered by an increasing insulin action during the 2nd and 3rd month of post hatch development in the domestic fowl. Where as the higher level of glucose, glucose-6-phosphatase activity and glycogen content observed in LP chicks, are explicable in terms of corticosterone induced gluconeogenic action, the lowest glucose-6-phosphatase activity and blood glucose level are consequences of the additive influence of melatonin. The changes seen in phosphorylase activity are very much in keeping with the inferred glycogenic *milieu* under an increased insulin release / action. These inferred changes are supported by the earlier reported decreased corticosterone and thyroid hormone levels in SP chicks and the reverse set of changes in LP chicks during their rearing from hatch to 90 days (Dandekar *et al.*, 2000, 2001).

The above inferred increasing insulin action during the second and third months is further substantiated by the observed increase in muscle glycogen content and decreasing phosphorylase activity in both NP and SP pullets. However, the LP

chicks show a reverse trend of decreasing muscle glycogen content and increasing phosphorylase activity which might suggest a decreased feed conversion ratio relative to increased feed intake and increased metabolic rate under a longer photoperiodic regimen. Such a possibility has been suggested by Hassanzadeh *et al.* (2003) based on their comparative study of metabolic parameters in broiler chicken reared under a continuous or intermittent lighting schedules.

Over all, the present study reveals an increasing insulin action during the first three months of chick development with consequent glycogenic effect and, the interactions of melatonin and corticosterone as additive or antagonistic/ resistant as insulin mediated homeostatic changes.

Summary:

Present study on carbohydrate metabolism has been undertaken in RIR pullets reared under a normal, short or long photoperiodic regimen from the day of hatch till 90 days. For the long-photoperiod, day old pullets reared under LD 18:6 photic schedules till 90 days of age and, for the short photoperiod, day old pullets were reared under LD 6:18 photic schedules till 90 days of age. The results obtained were; the blood glucose level in 30 day old pullets was found to be significantly higher under long photoperiod (LP) and significantly lower under short

photoperiod (SP) compared to normal photoperiod (NP). Hepatic phosphorylase activity was reduced from 30-90 days in all the groups of birds with a significantly lower level in SP and LP compared to NP. Over all the present study reveals an increasing insulin action during the first three months of chick development with consequent glycogenic effect.