PHOTOENDOCRINE MANIPULATION, A NOVEL PARADIGM FOR POTENTIATING POULTRY PRODUCTIVITY:

EFFECT OF TIMED STEP-UP PHOTOPERIOD AND MILD HYPO./HYPERCORTICALISM IN DOMESTIC FOWL

(Summary)

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CONCISE SUMMARY

Poultry production in India was a backyard venture till 1960's and now it has emerged as an encouraging enterprise for rural folks, especially for small farmers, landless labourers and educated unemployed and, also for big enterpreuners maintaining birds on a large scale in thousands. In general, the poultry industry sounds a very important part in converting grains and other products into eggs and poultry meat and contributes to the overall economy. In this respect, the development of breeds of hens with the ability to ovulate larger number of eggs and development of sophisticated feeding and management strategies with application of 20^{th} century science have taken the poultry industry of various countries. To raise poultry to the maximum possible potential many aspects have to be tackled. Apart from breed and genetic aspects, many environmental variables such as nutrition, disease control and management practices are also important as they can interact with the genetic background to modulate and influence on the ultimate potential expressed.

Environmental lighting and temperature are the tow major variables which can influence poultry productivity through neuroendocrine mechanisms. An understanding of influence of photoperiod on reproductive functions in domestic birds led to a gradual realization that photoperiodic manipulations could be a powerful management tool in economically useful species of birds like the broilers, laying hens and turkeys. Number of aspects of

reproductive potential in poultry birds can be influenced by such practices like, the age of onset of lay (AFE), the rate of lay, the timing of lay, shell quality, egg size and feed efficiency. Periods of light and dark are usually combined in three possible ways for commercial applications, the most common photoschedule is the conventional lighting regimen with a singly photophase (period of illumination) and a single scotophase (period of darkness) which together totals to 24 hrs, the second is skeleton, split or intermittent lighting regime with more than one photophase and scotophase within 24 hrs, with again symmetric or asymmetric intervals, and the third is ahemeral lighting regime with recurring periods of light and dark that in combination may be larger or shorter but not equal to 24 hrs in length. The greatest influence of photoperiod has been found to be in the immature stages and hence employment of various schedules of above mentioned lighting patterns has been attempted successfully to increase poultry productivity in the western countries. However, due to the differential interactions between photoperiod and laying performance and, also due to variability in responsiveness due to the genetic make up and environmental conditions, a universal optimal photic schedule cannot be chartered for the poultry birds. In this connection, to define the perfect photic schedule for productivity in individual breeds of poultry, different photic schedules have been employed. Lewis *et al*, (1992) showed that the age at first egg advanced in growing pullets from ISA Brown, when exposed to a long photoperiod and the degree of advancement can be modified by the size and timing of light change. Renden and Oates (1989) have shown that rearing pullets under long photoperiod or natural day length as against short days (8 hrs light per day) delays the onset of sexual maturity in meat strain pullets. Advancement in egg lay in pullets reared under a short day (8 hrs) regimen from day one Vs natural day length was shown by Abbaker *et al*, (1994). Evidences about minimum photoperiod

for maximum egg production, under a constant day length from 0-72 weeks of age, suggest that LD 10:14 is sufficient but LD 8:16 is not, for better egg laying performance in the fowl (Morris, 1979). The sensitivity of the young pullets to an increasing photoperiod varies with age, and it is maximum between 9-12 weeks as, increasing the photoperiod soon after 18 weeks has little or no effect on age at 50% lay (Morris, 1963; Lewis, 1992). The scan of literature thus show that no such experimental evaluation has been forthcoming from the Indian subcontinent and the general poultry practice in India is to employ the lighting regime from the day of hatch, which is based on a schedule borrowed from the western management practice. There is a need to evaluate different photic schedules in the Indian breeds or under Indian conditions (tropical) as the response to photic manipulations is likely to be altered in relation to the genetic status of the breed as well s the climatic conditions.

Besides photoperiod which influences productivity by modulating neuroendocrine mechanisms, even direct hormonal manipulations are also capable of influencing sexual maturity and egg yield. Though studies involving interactions of non-classical hormones of reproduction have formed the subject matter with reference to many avian species, the poultry birds have not come under the purview of such investigations. The few studies with regard to corticosterone and thyroxine have remained restricted to metabolic features in terms of fattening and fat metabolism (Blivaise, 1947; Voitekevich, 1966; Bastov *et al.*,1980 a,b; Bestob, 1982; Davison *et al.*,1983; Buyse *et al.*, 1987). There have been some attempts to relate these hormones with gonadal functions and reproductive activity (Herrich and Firierly, 1945; Hewitt, 1947; Taber *et al.*, 1956; Sols and Freeman, 1945; Greenman and Zarrow, 1961). Unfortunately due to the differential nature of the studies, both favourable as well as unfavourable

influences of corticosterone and thyroxine on reproduction have been reported in poultry birds (Falconer, 1971; Wells and Weight, 1971; Sturkie, 1986). Though, poultry scientists have deciphered some sort of nexus between the ovary and the adrenal glands in domestic hen, the exact nature of this nexus has to date remained elusive (Etches, 1996).

The avian egg represents a microscopic female germ cell with heavy investment of nutrients to the energy needs of a developing embryo and also with an outer calcarious porous shell to withstand desiccation conditions of the external atmosphere and as such, studied widely as a closed biological system (Freeman and Vince, 1974). Though the general organisation and chemical make up are quite similar in the eggs of birds in general, some differences in terms of chemical composition occurs in relation to altricial or precocial mode of development (Ricklefs, 1977; Roca *et al.*, 1982,1984). The physical features and chemical composition of eggs are a consequence of metabolic status of the bird and are to a greater extent dependent on the metabolic capacities of liver, ovary and oviduct. In this connection, factors in the external environment as well as in the internal milieu of the bird are capable of influencing the metabolic activity of these organs. The influence of some external factors like season, age and diet have been well documented to exert modulatory influences on the chemical composition of eggs (Curickshank, 1941; Gutteridge and O'Neil, 1942; Everson and Sounders, 1957; Patton and Palmer, 1958; Cunningham *et al.*, 1964; Edwards, 1964; Chun and Stadelman, 1965; Marion *et al.*,1965; Hamilton, 1978; Sibbald, 1979; Washburn, 1979; Sainz *et al.*,1983; Winton, 1993; Panda, 1995; Etches, 1996). The hormones, on the other hand, are powerful internal factors affecting physiology, metabolism and behaviour of animals. However, the influence of hormones especially the metabolic hormones (thyroid

hormones and adrenocorticoids), have not been studied in relation to egg laying or egg composition.

Based on the studies initiated in the last few years in pigeon, have provided some definite evidences for the involvement of pineal in maintaining gonadal functions in the breeding season. Based on the pinealectomy studies, it has become evident that the pineal is progonadal during the breeding season and antigonadal during the non-breeding season in domestic pigeons (Ramachandran and Patel, 1988). Further, these studies have also revealed parallel pineal-adrenal and inverse pineal-thyroid axis (Ramachandran and Patel, 1986; Ramachandran *et al.*,1987; Patel and Ramachandran, 1992).

A preliminary study undertaken in this laboratory in this light, showed a retardatory influence of corticosterone on testicular growth and differentiation in 30 day old white leghorn cocrkeals (Joseph, 1990; Joseph and Ramachandran, 1992). Based on the above theme, experimental period and, adrenocortical activity in the initial phases of post-hatch development were considered pertinent. The rationale behind the present experiments was to test the consequences of manipulations involving one or the other or both on the egg laying performance and biochemical composition of eggs laid by these birds. Hence, in the present study, attention has been focused on the possible effects of rearing pullets from day of hatch till 90 days of age under short photoperiod of LD 6:18 (SP) and then shifting them to the normal photoperiod of LD 12:12 (NLD which together qualifies as a step-up photoschedule. Further, the influence of mild hypercorticalism (HPR) or hypocorticalism (HPO) during the rearing stage (day 1 to day 90) has also been investigated

In the present study, day old RIR chicks were procured from the government poultry, Baroda and adult hens of 72 weeks were procured from government poultry, Dahod. Tow different photic schedules were employed, *ie*. Normal light and dark-NLD (LD 12:12) and short photoperiod-SP (LD 6:18) for rearing the pullets from day 1 to day 90 or adult hens towards the end of the first lay from 72-76 weeks. Chronic mild hypercorticalism or hypocorticalism was induced by implanting bees wax pellets containing corticosterone or metyrapone respectively in pullets or adult hens as the case may be. The birds were fed with allocated amount of feed which was provided twice a cay. Chicks from day one till 56 days were fed 30 gms of chick mash/bird/day. From day 57 till initiation of egg laying, they were fed with grower mash at an average of 90 gms/bird/day. From the day of initiation of egg laying the birds were fed on layer mash provided twice a day at an average of 110 gm/bird/day.

In order to assess the impact of short photoperiod on the reproductive performance of Indian RIR breed, the freshly hatched pullets were exposed to SP from day one to day 90 and then transferred to NLD (step-up photoschedule). The SP birds showed an overall improved laying performance marked by significantly earlier initiation of egg laying (by 58 days) and higher yield and better laying performance (by 15%) in the form of monthly egg production with higher clutch size and shorter oviposition interval. The present study also shows that a rationed diet which is at an average 19.4% less than the feed consumption data obtained from the government poultry has no adverse effect on egg production, which is apparent from observed 2.96 Kg. to 3.65 Kg. of feed consumed by NLD birds, as compared to 4.23 Kg. of feed consumed for 12 eggs /bird in government poultry. The poor second cycle performance of Indian RIR breed is evident from the presently observed yield of meagre 96 eggs per hen by NLD birds and a complete cessation of egg laying in SP birds.

Overall, it can be suggested that, a step-up photoperiod between brooding and growing periods (58-60 days) can greatly enhance the productivity during the first lay in RIR birds despite a restricted rationed diet.

The manipulation involving adrenocortical status by induction of mild HPR or HPO in pullets from day one to day 90 showed a tendency for slightly increased egg yield in HPR and a significantly lower egg yield in the HPO hens. All the 3 groups of birds revealed no difference in the age at first egg, however, the termination of lay was slightly delayed in HPO hens and occurred earlier in HPO hens, thereby resulting in increased duration of lay in the former and reduced duration of lay in the latter. The course of second cycle of lay was marked by significantly increased laying performance by HPR hens (by 15%) and significantly lesser number of eggs (by 22%) in the HPO hens. The data on feed consumption does not reveal any marked difference as the total feed consumption as well as feed per dozen eggs was more or less same in all the three groups.

The influence of HPR or HPO in pullets reared under short photoperiod has revealed an additive influence of HPR on the SP induced favourable responses; on the contrary HPO tended to minimize the favourable influence of SP. All the three groups of birds initiated early egg laying by 4 months though there was a slight delay (by 9 days) in HPO birds. The annual egg production was better under HPR status whereas HPO recorded negative influence on the same. In terms of feed consumption, HPR birds consumed 1 Kg. per bird less feed while HPO birds consumed 1.5 Kg. per bird more feed as compared to the controls.

The impact of photoperiodic manipulations and / or induction of HPR or HPO during rearing stage of pullets has been assessed in terms of

physical features and chemical composition of eggs produced by such birds. There was no significant effect of SP on physical and chemical components of eggs on an overall basis, though, there are some alterations in the same from early to late phases. However, there is a definite increase in protein, lipid and cholesterol contents in the eggs of SP hens. The nutritive value was higher by 14% in the eggs of SP hens as compared to the eggs of NLD hens.

Influence of mild hyper / hypocorticalism in the rearing stage under NLD and SP condition and the consequential effects on egg composition and structure have been evaluated. Under NLD condition, the eggs of HPR hens, in general, showed increased protein and glucid contents and decreased lipid and cholesterol contents in the albumen and increased lipid and cholesterol contents in the yolk. The eggs of HPO hens, in contrast, showed significant alterations in yolk and albumen contents during early to late phases of lay, which indicates an overall favourable influence on the protein loading capacity of the oviduct. The lipid contents in both, yolk and albumen were increased in HPO eggs. In terms of calorific value, both HPR and HPO showed increment by 27% in the former and by 14% in the latter compared to the eggs of control hens. The HPR or HPO conditions under SP has no significant overall effect on neither egg composition nor on the calorific value of the eggs. However, there are some subtle alterations in terms of protein, carbohydrate and lipid contents in yolk / albumen during the course of laying period.

Effect of rearing pullets of RIR breed, under short - photoperiod (SP; LD 6:18) from d1 till d90 and, thereafter under normal photoperiod (NLD; LD 12:12), on histomorphology and adrenal, thyroid and ovarian hormone and, growth rate of adrenal, thyroid, ovary, oviduct, liver and lymphoid organ is

carried out. The body weight and growth index of SP pullets were less as compared to NLD pullets. Except for the ovary, which recorded marginal increment, weights and growth indices of thyroid, adrenal and oviduct were decreased under SP. The weights of liver and all the lymphoid organs ware higher at 30d, and were similar at 90 days in SP pullets as compared to NLD. The histometric data suggest that the transition from small to big follicles was slower in ovary of SP pullets and further, reduced degree of follicular atresia was also noted in SP pullets. Except for the higher corticosterone level at 30 days and higher progesterone level at 30 and 60 days, relative levels of all the hormones at all the ages were lower in SP pullets.

Influence of mild hypercorticalism (HPR) or hypocorticalism (HPO) in RIR pullets reared under normal photoperiod (NLD; LD 12:12) during first 90 days of post-hatched development showed that there was no effect of HPR on body weight, while body weight of HPO chicks was lesser at 90 days as compared to controls. The absolute and relative weights of thyroid, adrenal, ovary and oviduct were higher in both HPR and HPO chicks throughout the period of study. The relative weight and growth indices of liver and lymphoid organs were higher in HPR pullets and, lower in HPO pullets at 90 days. The relative levels of corticosterone and T_3 were higher in HPR and lower in HPO chicks, while the levels of progesterone were lower in both HPR and HPO chicks, while that of T_4 remained similar in all the three groups. In the ovary the rate of transition from small to big follicles was slightly higher in HPR pullets, and the same was retarded in HPO pullets. In general it is concluded that, HPO during rearing stage of pullets has some negative influence and, HPR has some subtle favourable influence on ovarian functions.

Influence mild hypercorticalism (HPR) or hypocorticalism (HPO) and short photoperiod (SP; LD 6 :18) in RIR pullets during first 90 days of post-hatched development showed that the body weights of both, HPR and HPO chicks was significantly greater than the control chicks at 90 days. The organ weights and growth rate of thyroid, adrenal, ovary and oviduct showed significant increment throughout the period of study in HPO chicks while, HPR chicks showed increased weight and growth rate only between 60 and 90 days. Favourable influence of HPR on growth of liver, and that of HPO, on growth of lymphoid organs, is marked by higher relative weight of liver in HPR chicks, and that of lymphoid organs in HPO chicks at 90 days. The relative level of corticosterone was similar in all the three groups of chicks. However, the serum hormone levels of T_3, T_4 and progesterone showed significant increment in HPR and HPO chicks. Rate of transition from small to big and big to large follicle was similar in the ovary of all the three groups of chicks. From the present study it can be concluded that there are subtle influences of HPR and HPO under SP on organ weights and serum hormone levels studied and that, these alterations may exert modulatory influence on SP induced intra-ovarian molecular mechanisms. The methodology employed for the present investigation and results obtained have been discussed elaborately in the thesis.