CHAPTER 4

REARING PHOTOPERIOD AND EGG COMPOSITION : DIFFERENTIAL EFFECTS OF NORMAL (LD 12:12) AND SHORT - PHOTOPERIOD (LD 6 :18) IN RIR HENS.

The avian egg represents a microscopic female germ cell with heavy investment of nutrients to support the energy needs of a developing embryo and also with an outer calcareous porous shell to withstand desiccating conditions of the external atmosphere and as such, studied widely as a closed biological system (Freeman and Vince, 1974). The egg of domestic fowl has received more attention on nutritional basis due to its significance as a major component of human diet (Everson and Souders, 1957; Svensson, 1964; Parkinson, 1966; Lahiri and Baliga, 1970; Froning, 1971; Cotterill *et al.,* 1977; Sibbald, 1979). Due to this, the structure and composition of the egg of domestic hen have been studied in greater detail. The egg consists of three main parts; yolk, albumen and shell and, the composition of both yolk and albumen in terms of either protein and lipid contents has been investigated (Riemenschneider *et al.,* 1938; Cruickshank, 1941; Shorland, 1951; Rhodes and Lea, 1956; Evans and Bandermer, 1961; Pattõn and Palmer, 1961; Parkinson, 1966; Christe and Moore, 1970, 1972; Edwards, 1974; Cunningham and Lee, 1978). Many factors can influence the size and composition of eggs such as nutritional status, age, body weight, genetic make up and conditions of maintenance (Cruickshank, 1941; Gutteridge and O'Neil, 1942; Everson and Sounders, 1957; Patton and Palmer, 1958; Cunningham *et al.*, 1960; 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). Egg weight and size have been shown to be dependent to a greater extent on genetic make up, age at sexual maturity and protein content of the diet besides photoperiodic conditions (see Etches, 1996). The egg composition, in terms of the major organic nutrients and the micronutrients has been considered to be fairly resistant to dietary manipulations and has been reportedly shown to remain constant due to their requirement for the specific purpose of the developing embryo (see Etches, 1996).

In the past, there have been many studies dealing with the evaluation of size and composition of the hens egg in different breeds under temperate conditions (Scanes *et al*., 1982, 1983; Roca *et al.*, 1984; Ricklefs, 1977) and even some breeds from Egypt (Amer 1972). Similar studies are not available with reference to tropical conditions and moreover the possible impact of photoperiodic manipulations on composition of eggs has not been attended to (as different photic schedules have been worked out to increase poultry productivity). Though the effect on egg size has been evaluated (Hutichnson and Taylor, 1957; Dunn *et al.*, 1990; Eitan and Soller, 1991; Sandavol and Gernat, 1996; see Etches, 1996). It is in this context that the present study has been undertaken to evaluate the physical features and chemical composition of eggs in the Indian RIR breed subjected to a step-up photoperiod in the immature stages, the consequences of which have already been reported in terms of productivity and various features of the laying performance (Chapter 1).

RESULTS

Physical features (Tables 1-2) :

The overall mean egg weight of SP hens was significantly less than the NLD hens. The eggs of NLD hens showed a gradual increment in weight from initial to late phase amounting to 4.5%, while the weight of eggs of SP hens was very low in the initial phase and showed a significant increment to a maximum in mid phase amounting to 17%. The overall height, width and volume of eggs did not reveal any significant difference between the eggs of NLD and SP hens. Neither the height nor the width characteristics of eggs showed any significant difference in SP and NLD hens from initial to late phase. However, the egg volume was significantly lower in the initial and late phases and significantly greater in the mid phase in SP hens compared to NLD hens. The overall shell weight was similar in both groups of birds with the shell weight increasing from initial phase to late phase in the SP birds and decreasing in NLD birds. The overall shell thickness was less in SP birds mainly due to significant difference in the initial and late phases. The absolute weight of yolk and albumen of eggs of SP hens was significantly less than those of the eggs of NLD birds. However, there was no significant difference in terms of percentage content of yolk or albumen between the eggs of SP and NLD groups of hens.

*Overall chemical composition (*Table 3; Fig.1 A - D) :

The percentage content of water and solids in albumen did not show any significant difference between the eggs of SP and NLD hens, while, in the yolk, there was a reverse trend of significantly higher water content and lower solid content in the eggs of SP hens compared to those of NLD hens. Both the absolute and percentage content of lipids and cholesterol in yolk and albumen were significantly higher in the eggs of SP hens, while the carbohydrate content was decreased in yolk and increased in albumen compared to the eggs of NLD birds.

Physical features (initial to late. Table 2*) :*

Both the absolute and relative weights of yolk showed a temporal increase in the eggs of both NLD and SP hens which was gradual and of lesser degree in the case of NLD (12.9%) and very pronounced in the case of SP (46.6%). However, during all the three phases the absolute and relative weights of yolk were lesser in the case of SP hens as compared to those of NLD hens. In contrast, the absolute and relative weights of albumen increased to a maximum in the mid phase and then decreased in the late phase in the eggs of both NLD and SP hens. Though the absolute weight was relatively less in the SP eggs in all the three phases, the relative weight was more in the initial and mid phases and low in the late phase. This difference in the relative weights of albumen is reflected in the lower yolk: albumen ratio during the initial and mid phases and an increased ratio in the late phase in the SP eggs compared to the NLD eggs.

Chemical composition (initial to late phase. Table 4; Figs. 2 A & B, 3 A & B) :

The percentage contents of water and solids in the albumen were similar in the eggs of both NLD and SP hens during the initial and mid phases while there was an increased water content coupled with decreased solid content in the albumen of SP eggs during the late phase. The percentage content of water in yolk showed a progressive increase from initial to late phase which was relatively more in absolute terms as well as in the degree of increase. The percentage solid content in yolk showed a generalized decline in the eggs of NLD hens, more pronouncedly from the initial to mid phase, while in the case of eggs of SP hens, it increased significantly from initial to mid phase and then decreased significantly from mid to late phase. Relatively, the solid content was significantly less in the initial and late phases. The protein content of both yolk and albumen showed an increase from initial to mid phase and then a decrease from mid to late phase in the case of NLD eggs. In contrast, in the eggs of SP hens, the protein content of yolk increased significantly in the late phase while the protein content in albumen tended to decrease from initial to mid phase with a slight increase from mid to late phase. Relatively, the protein content in yolk was significantly higher in the NLD eggs at mid phase and significantly greater in the SP eggs in the late phase. The protein content in albumen was significantly greater in the SP eggs during the initial and late phases while it was significantly lower in the mid phase. In general, the lipid content of both yolk and albumen depicted a generalized decrease from initial to late phase in the eggs of both NLD and SP hens. However, the lipid content in both the yolk and albumen of SP eggs was significantly more than the NLD eggs throughout. The cholesterol content of yolk tended to remain steady from initial to late phase in the eggs of both NLD and SP hens, though, the content was significantly higher in the SP eggs. There was a reverse trend of decreasing cholesterol content in the albumen of NLD eggs and an increasing trend in the eggs of SP hens from the initial to late phase. Relatively, the cholesterol content of albumen was significantly lower in the initial phase and higher in the mid and late phases in the eggs of SP hens. The carbohydrate content of yolk and albumen also showed a reverse trend with a gradual decline in the eggs of NLD hens and increase in the eggs of SP hens. Comparatively, the carbohydrate content of both yolk and albumen was significantly greater in the eggs of SP hens except for the initial phase when it was lower.

Table: 1 Overall physical features of eggs of NLD and SP hens.

	NLD		***SP***	
Egg weight (gms)	50.78 ±0.45		45.87 [c] ±0.89	
Egg height (mm)	5.36 ±0.26		5.46 ±0.28	
Egg width (mm)	4.30 ±0.06		3.83 ±0.08	
Egg Volume	40.95 ±0.18		40.30 ±0.97	
Shell weight (gms) & % of egg weight	5.54 ±0.11	10.9%	5.68 ±0.13	12.3%
Shell thickness (mm)	0.327 ±0.004		0.265 ±0.011	
Yolk weight (gms) & % of egg weight	16.31 ±0.23	32.1%	14.25 [c] ±0.63	31.0%
Albumen weight (gms) & % of egg weight	28.16 ±0.21	55.4%	25.76 [a] ±0.50	56.1%
Yolk : Albumen	0.57		0.55	
	Yolk	Albumen	Yolk	Albumen
% Water content	48.1 ±0.41	86.33 ±0.26	51.1 [a] ±0.69	86.38 ±0.59
% Solids	52.1 ±0.47	13.67 ±0.26	48.85 [a] ±0.69	13.01 ±0.13

Values : Mean, ±S.E, N= 12. [a]P < .05, [c]P < .0005

Table:2 Physical features of eggs laid during initial, mid and late phases by NLD and SP birds.

	Initial Phase		Mid Phase		Late Phase	
	NLD	***SP***	***NLD***	***SP***	***NLD***	***SP***
Egg weight (gm)	48.76 ±0.41	41.50 ±0.97 [c]	50.6 ±1.87	48.5 ±0.40	51.00 ±0.93	47.61 ±0.86 [a]
Egg height (mm)	5.14 ±0.18	5.17 ±0.03	5.44 ±0.05	5.52 ±0.13	5.50 ±0.48	5.71 ±0.30
Egg width (mm)	3.97 ±0.30	3.65 ±0.09	4.52 ±0.02	3.62 ±0.27	4.43 ±0.29	4.23 ±0.46
Egg volume	40.07 ±0.69	37.2 ±1.17 [a]	41.60 ±1.69	45.00 ±0.57 [a]	41.20 ±0.93	38.7 ±0.94 [a]
Shell weight (gm) & % of egg weight	6.11 ±0.46 (12.5%)	5.50 ±0.5 (13.2%)	5.31 ±0.26 (10.49%)	5.25 ±0.82 (10.8%)	5.20 ±0.39 (10.09%)	6.31 ±0.53 (13.25%)
Shell thickness (mm)	0.317 ±0.037	0.213 ±0.005	0.348 ±0.005	0.311 ±0.005	0.317 ±0.007	0.271 ±0.005
Yolk weight (gm) & % of egg weight	15.08 ±0.88 (31.13%)	11.25 ±0.61 [a] (27.1%)	16.6 ±0.70 (32.8%)	15.00 ±0.33 (30.92%)	17.15 ±0.58 (33.62%)	16.5 ±1.51 (34.65%)
Albumen weight (gm) and % of egg weight	27.18 ±0.47 (55.74%)	24.25 ±0.38 [a] (58.1%)	29.0 ±0.95 (57.3%)	28.25 ±1.02 (58.24%)	28.30 ±0.54 (55.49%)	24.80 ±0.96 [a] (52.08%)
Yolk:Albumen	0.55	0.46	0.57	0.53	0.60	0.66

Table: 3 Overall biochemical composition of NLD and SP eggs.

	NLD		*SP*	
	Units expressed as mg/100mg of yolk/albumen.			
	Yolk	**Albumen**	**Yolk**	**Albumen**
Protein	17.74 ±0.29	13.83 ±0.54	17.83 ±0.51	14.77 ±0.43
Glycogen	0.0864 ±0.0019	0.0153 ±0.0003	0.0496 [c] ±0.0031	0.0249 [b] ±0.0039
Lipid	20.14 ±0.54	0.2908 ±0.044	25.50 [c] ±0.30	0.390 [a] ±0.04
Cholesterol	1.47 ±0.67	0.0309 ±0.0009	2.943 [c] ±0.080	0.0234 [a] ±0.001
Cholesterol as % of lipid	7.2%	10.6%	11.5%	5.9%
Absolute content in yolk/albumen (gm).				
Protein	2.89	3.89	2.54	3.80
Glycogen	0.014	0.004	0.007	0.0064
Lipid	3.28	0.0816	3.63	0.1004
Cholesterol	0.239	0.0087	0.4193	0.0060

Values : Mean, ±S.E, N= 12. $^{a}P < .05$, $^{b}P < .005$, $^{c}P < .0005$

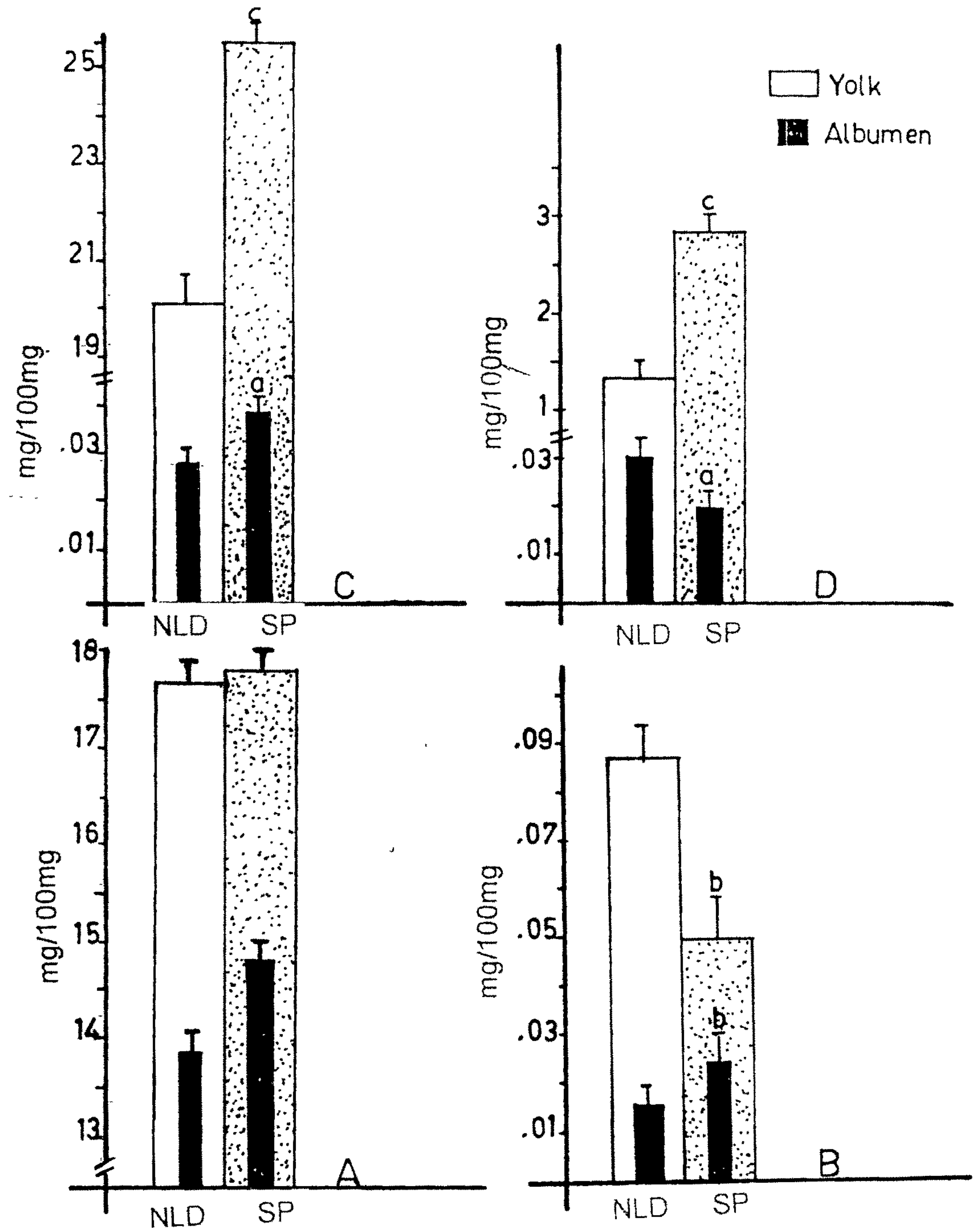

Fig. 1 (A - D) Figure showing biochemical composition of eggs of NLD and SP hens.

A. Protein **B.** Glycogen **C.** Lipid and **D.** Cholesterol

NLD - LD 12.12, SP - LD 6.18.

Values : Mean, ±S E, N= 12 **[a]P < .05, [b]P < .005, [c]P < .0005.**

Table: 4 Biochemical features of eggs laid during initial, mid and late phases by NLD and SP birds.

	Initial Phase				Mid Phase				Late Phase			
	NLD		*SP*		*NLD*		*SP*		*NLD*		*SP*	
	Yolk	Alb.	Yolk	Alb.	Yolk	Alb.	Yolk	Alb.	Yolk	Alb.	Yolk	Alb.
Units expressed as mg/100mg of yolk/albumen (*Values* : Mean, ±S.E, N= 12.[a]P < .05, [b]P < .005.)												
% Water content	46.10 ±0.71	87.11 ±0.23	51.11[a] ±0.82	86.56 ±0.07	48.74 ±1.29	86.88 ±0.15	48.23 ±2.49	89.43 ±0.75	49.50 ±1.12	85.02 ±0.38	54.11[a] ±0.90	88.01[b] ±0.10
% Solids	54.36 ±0.58	12.89 ±0.35	48.90[a] ±0.82	12.44 ±0.07	51.77 ±2.49	13.14 ±0.12	51.77 ±2.49	13.57 ±0.75	50.50 ±0.50	14.98 ±0.02	45.89[b] ±1.29	11.99[a] ±0.10
Protein	16.54 ±0.46	14.61 ±0.45	16.42 ±0.43	16.79[a] ±0.43	19.04 ±0.81	15.67 ±0.41	16.73[a] ±0.90	13.15[a] ±0.91	17.6 ±0.21	11.73 ±0.36	20.36[a] ±0.55	14.38[a] ±0.37
Glycogen	0.182 ±0.004	0.030 ±0.09	0.034[a] ±0.002	0.006[a] ±.0004	0.036 ±0.007	0.010 ±0.001	0.0602[a] ±0.001	0.0288[a] ±0.003	0.039 ±0.005	0.004 ±.0006	0.054[a] ±0.001	0.039[a] ±0.001
Lipid	22.74 ±2.27	0.501± 0.06	26.50[a] ±1.20	0.533 ±0.111	19.46 ±2.45	0.233 ±0.036	25.97[a] ±1.13	0.473[a] ±0.023	18.23 ±0.88	0.137 ±.0009	24.05[a] ±1.76	0.164 ±0.031
Cholesterol	1.78 ±0.07	0.078± 0.09	2.90[a] ±0.11	0.018[a] ±0.003	1.21 ±0.11	0.010 ±0.002	3.06[a] ±0.10	0.023[a] ±0.004	1.44 ±0.11	0.004 ±.0008	2.86[a] ±0.046	0.028[a] ±0.05
Absolute contents in gm												
Protein	2.51	3.97	1.84	4.40	3.16	4.54	2.56	3.71	3.01	3.31	3.35	4.02
Glycogen	0.025	0.008	0.003	0.001	0.006	0.003	0.009	0.008	0.006	0.0011	0.008	0.011
Lipid	3.45	0.136	2.98	0.139	3.23	0.067	3.89	0.133	3.12	0.038	3.96	0.046
Cholesterol	0.2708	0.021	0.326	0.004	0.201	0.002	0.459	0.006	0.24	0.001	0.472	0.008

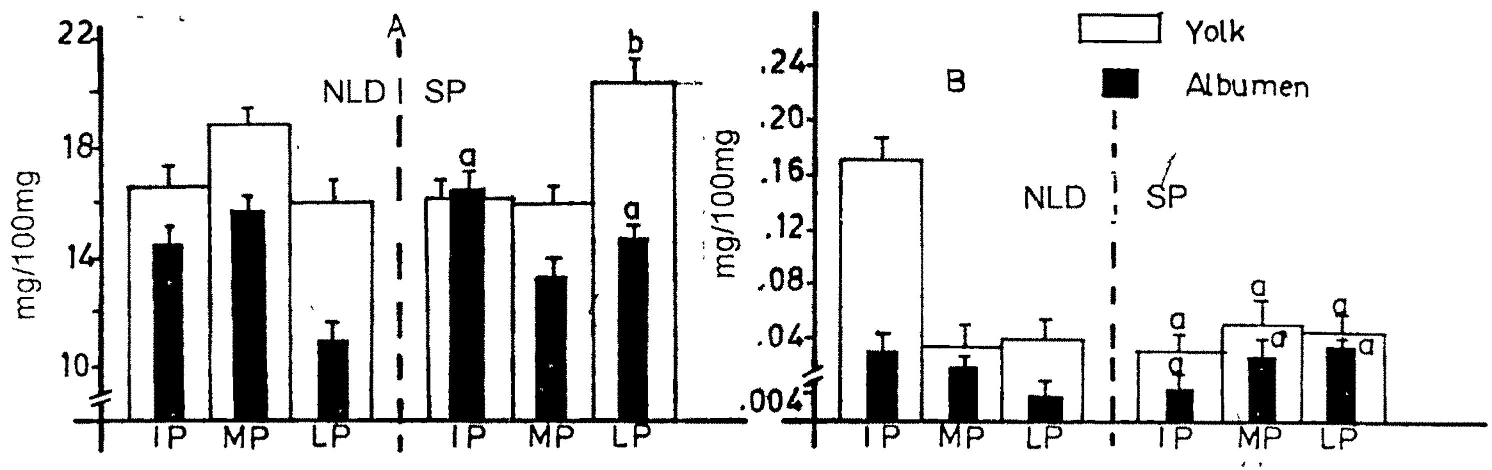

Fig. 2. Changes in egg composition from initial to late phase in NLD and SP hens. **A.** Protein **B.** Glycogen.

Values : Mean, ±S.E, N= 12 **$^{a}P < .05$, $^{b}P < .005$.**

NLD - LD 12:12, SP - LD 6:18

IP - Initial Phase, MP - Mid Phase, LP - Late Phase.

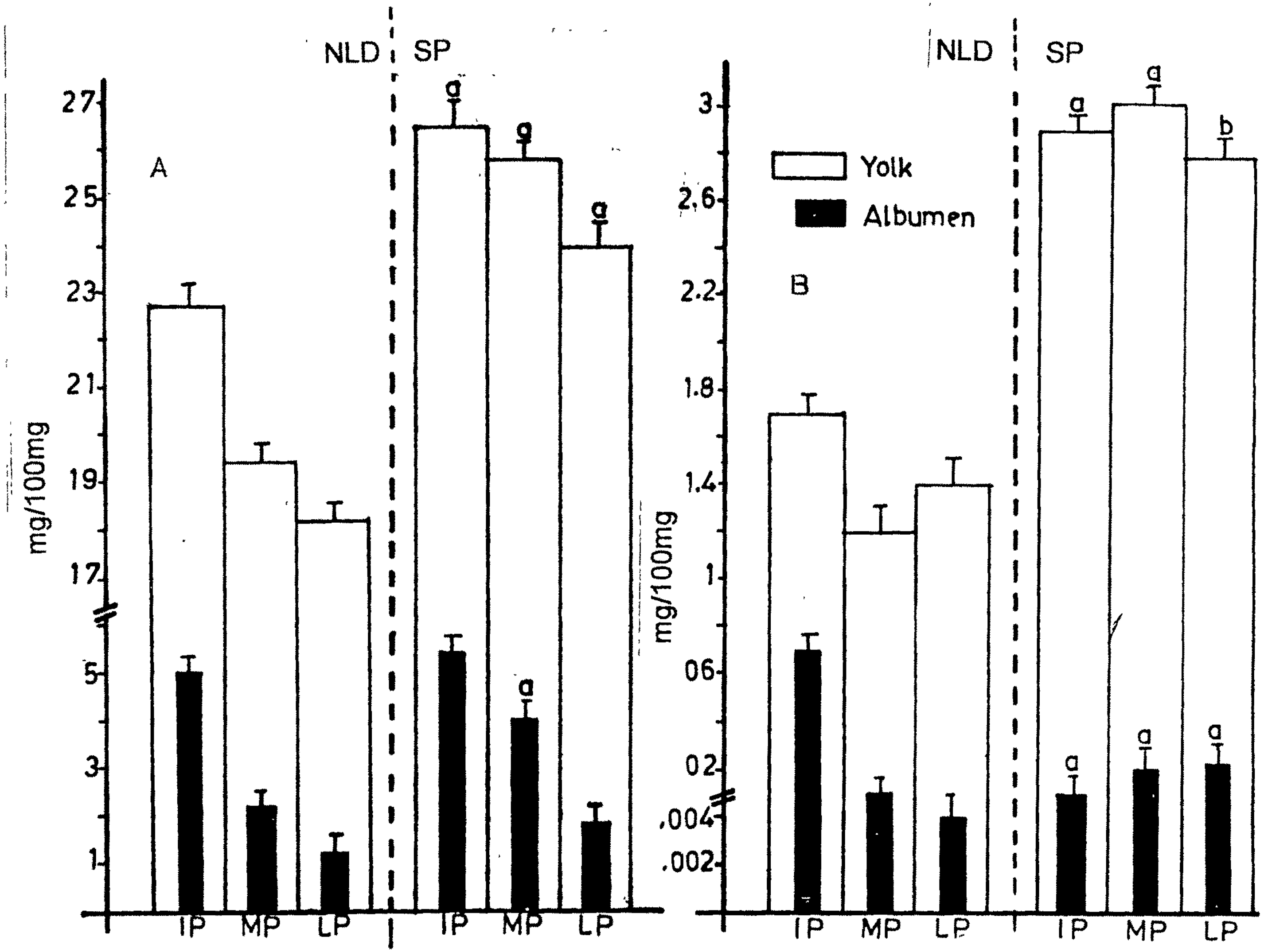

Fig. 3 Changes in egg composition from initial to late phase in NLD and SP hens.

A. Lipid **B.** Cholesterol. IP - Initial Phase, MP - Mid Phase, LP - Late Phase. NLD - LD 12:12, SP - LD 6:18.

Values · Mean, ±S.E, N= 12 **[a]P < .05, [b]P < .005.**

Table: 5a Table showing Total wt. of water, lipid, non lipid, and water and lipid indices in NLD / SP eggs.

	Initial Phase				Mid Phase				Late Phase			
	NLD		SP		NLD		SP		NLD		SP	
	Yolk	*Alb.*	*Yolk*	*Alb.*	*Yolk*	*Alb.*	*Yolk*	*Alb.*	*Yolk*	*Alb.*	*Yolk*	*Alb.*
Wt. of water	6.99	23.67	5.74	20.99	8.09	25.19	7.23	24.41	8.44	24.06	8.92	21.82
Total lipids	3.45	0.76	2.98	0.129	3.23	0.067	3.89	0.133	3.12	0.038	3.96	0.040
Non-Lipids	4.74	3.43	2.52	3.13	5.27	3.74	3.88	3.70	5.59	4.20	3.62	2.93
Water Index	1.47	6.90	2.27	6.70	1.53	6.73	1.86	6.59	1.50	5.72	2.46	7.44
Lipid Index	0.727	0.022	1.18	0.41	0.612	0.017	1.00	0.035	0.558	0.006	1.09	0.013

Table: 5b Table showing overall Wt. of water, lipid, non-lipid and water and lipid index of NLD/SP eggs

	NLD		SP	
	Yolk	Albumen	Yolk	Albumen
Weight of water	7.84	23.31	7.28	22.23
Total Lipids	3.28	0.084	3.63	0.021
Non-Lipids	5.21	3.76	3.32	3.25
Water Index	1.50	6.19	2.19	6.84
Lipid Index	0.629	0.005	1.09	0.006
Overall Calories in 100gm egg	129.14		147.41	

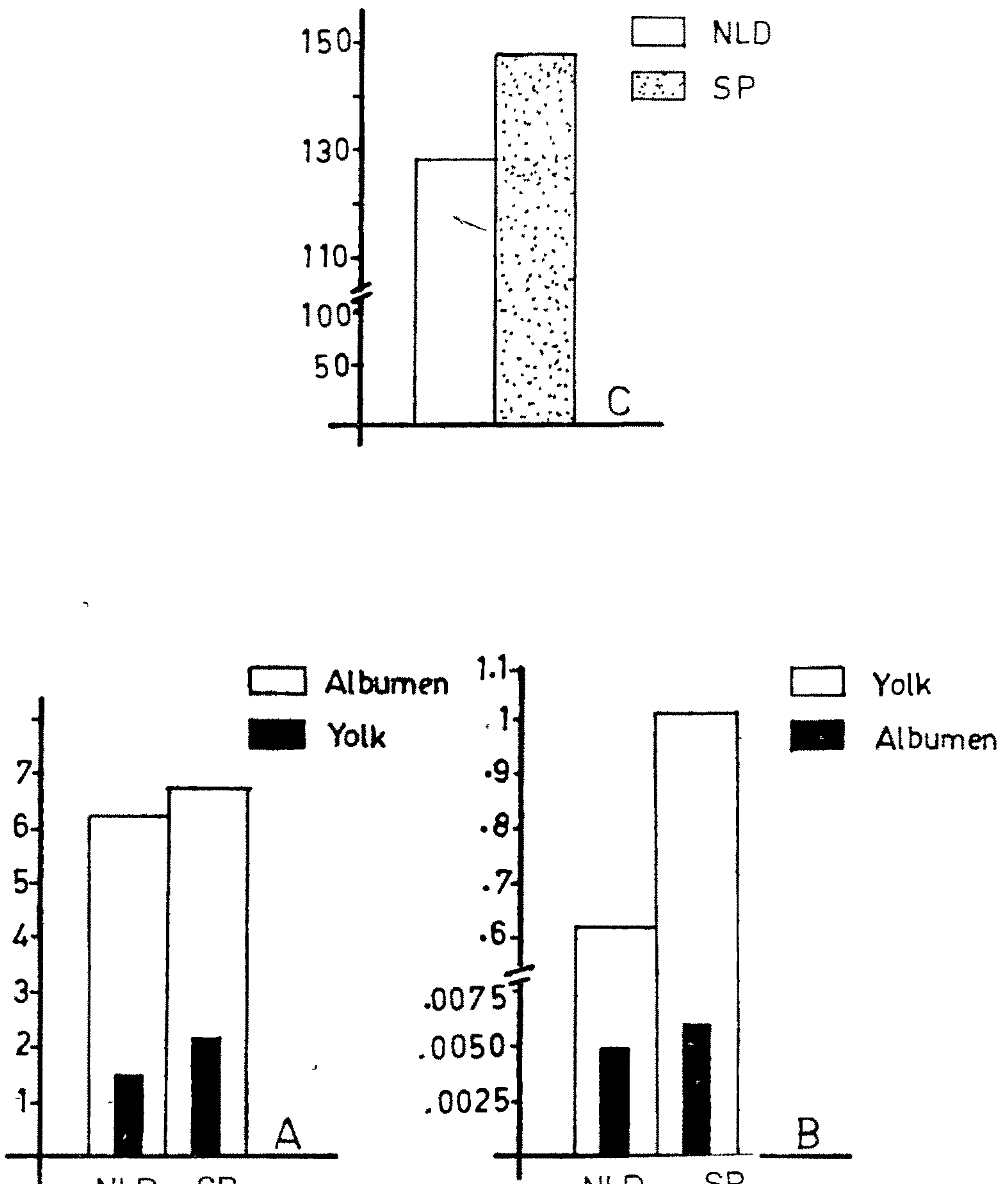

Fig. 4 A - C Figure showing Water Index (A), Lipid Index (B) and Calorific value/ 100gm egg(C).

Values : Mean, ±S.E, N= 12

DISCUSSION

The physical features and chemical composition of avian eggs vary significantly and, some of the documented differences have been related with the precocial versus altricial nature of the species (Ricklefs, 1977; Roca *et al.,* 1982, 1984). Amongst the precocial species, the domestic fowl, *Gallus domesticus*, has received greater attention due to its nutritional implications and dietary status in human beings. The structure and composition of the eggs of domestic fowl have been reported to differ in relation to many factors such as the species, the genetic breed, the diet, the age of birds and even the interval between successive ovulations (see Panda, 1995; Etches, 1996). Increased egg size and better shell quality have been realized by exposure of hens to ahemeral photic schedules (see Etches, 1996). However, no comprehensive studies have been carried out on the structure and composition of eggs laid by hens reared under different experimental photic schedules intended to improve their laying performance. The present study in this context provides compelling evidence for alteration in structure and composition of eggs when hens are reared under a step up photoperiod as against a continuous normal photoperiod.

In terms of physical measurements, the egg weight, egg width, shell thickness and yolk and albumen weights of SP eggs were significantly lesser by 9.6%, 11.6%, 18.9%, 12.6% and 8.5% respectively though, there were marginal but insignificant increase in the height of egg and shell weight (table 1). The decrease in the above parameters, in terms of mean of overall lay, is principally due to the effect of short photoperiod on the eggs laid in the initial phase. In general, all the physical features studied except shell weight showed a gradual temporal increase during lay under NLD schedule. The shell weight showed an opposite trend of decrement. The eggs of SP hens on the other hand, depicted a temporal increment in all physical measurements including shell weight. On a comparative basis, the temporal increment shown by the eggs of SP hens was significantly more than those of the NLD eggs. The most notable changes were with reference to egg weight (4.5% Vs 16.8%), egg volume (3.8% Vs 21%), Shell thickness (3.1% Vs 46%), yolk weight (12.9% Vs 46.6%) and albumen weight (6.6% Vs 16.4%). Whereas the shell weight of NLD eggs showed a maximum decrement by 14.8%, that of SP eggs showed a maximum increment by 20.1%. The mean overall yolk and albumen contents were 32.2% and 55.4% in the case of NLD eggs and 31% and 56.1% in SP eggs. Apparently, SP has no effect on the overall yolk and albumen contents. The presently observed percentage contents of yolk and albumen are within the range reported for poultry eggs: 31-35% for yolk and 52-60% for albumen (see Panda, 1995; Etches, 1996). Based on a study on six breeds of domestic fowl, Sainz *et al.* (1983) reported 30.3% yolk and 57.2% albumen in the eggs of RIR. Our evaluations on the Indian RIR breed, is in general agreement, with a slightly higher yolk content and lesser albumen content. Though the yolk and albumen weights as proportions of egg weight showed similarity between the eggs of NLD and SP hens, both these fractions showed significantly reduced absolute content in the SP eggs in the initial phase. The albumen content was less even in the late phase, however, in terms of percentage of egg weight, the albumen content in SP eggs was significantly greater in the initial phase which is reflected in the significantly lower yolk : albumen ratio of 0.46 as against 0.55 in the NLD eggs. Apparently, SP induces an increase in the percentage of albumen in the initial and mid phases and a decrease in the late phase with concomitant reverse set of changes in the percentage yolk content.

A comparison of the percentage content of water and solids in the yolk and albumen, shows that, while they remain invariantly identical in the albumen of the eggs of both NLD and SP hens, there is significant increment in the water content with a concomitant decrement in the total solid content in the yolk of SP eggs. These changes in the yolk of SP eggs are mainly due to the significant changes occurring in the initial and late phases of lay. The conservative and critical importance of water content for avian embryonic development and the relatively lesser content of water in the yolk due to increase lipid load have been well recognised (Roca *et al.,* 1984). Seen in this perspective, a short photoperiodic manipulation does not alter the percentage water and solid contents of albumen and yolk drastically. The overall protein content in yolk and albumen, was quite similar in the eggs of both NLD and SP hens, implying no significant influence of rearing photoperiod on the protein concentration of the eggs. The herein recorded protein contents are slightly higher than the range documented by Panda (1995) and Etches (1996) in their reviews. However, Sainz *et al.* (1983) and Roca *et al.* (1984) have reported similar protein content in the yolk of RIR hens. But the protein content in the albumen in the Indian RIR breed is slightly more than that reported by the above workers. Though, the overall yolk and albumen protein contents were similar in the eggs of NLD and SP birds, there was nevertheless significant difference in terms of temporal alterations during the laying period (tables 3 & 4; figs.1 A - D, 2 A & B, 3 A & B). Whereas the yolk protein content increased by 15% by mid phase and then decreased in the NLD eggs, the same remained steady from initial to mid phase and then increased by 24% in the late phase in the eggs of SP hens. Whereas a similar pattern of change was seen with respect to the albumen protein content as well , in the NLD eggs, the albumen protein content of SP eggs was significantly higher in the initial and late phases by 15% and 23% respectively and, lower in the mid phase by 22%. Apparently, exposure of chicks to SP during the rearing period has a consequential effect on the pattern of temporal alterations in the protein loading of eggs during the annual cycle of lay.

The general carbohydrate content of yolk and albumen which is a total of free and bound glucid contents, is reported to be in the range of 0.4 - 0.8% in the albumen and 0.6 - 0.7% in the yolk (Panda, 1995; Etches, 1996). Whereas, the free glucid content of yolk and albumen of NLD eggs decreased significantly by 80% and 86% respectively from the initial phase, it increased in the yolk and albumen of SP eggs by 77% and 550% respectively. Our evaluation which essentially represents the free glucid fraction is, on the whole, significantly lower in the Indian RIR breed and is only 0.086% and 0.015% in the yolk and albumen respectively of NLD eggs. This reveals that the glucid content of albumen is much lower (by 82%) than that in the yolk. Interestingly, the free glucid content in yolk and albumen of SP eggs was 42% less and 62% more respectively compared to those of NLD eggs. In the initial phase, the yolk and albumen of NLD eggs had higher glucid content by 83 and 80% respectively. The age dependent change in the course of lay, shows a clear difference between the eggs of NLD and SP hens. Overall, there is a differential alteration in the form of decreased yolk glucid content and increased albumen glucid content due to a step-up photoperiodic schedule.

The overall total lipid content in the yolk and albumen of NLD eggs in the present study is 20.14 and 0.29% respectively. The reported range of total lipids in the yolk and albumen in the domestic hen is 34% and trace (Broady, 1945; Romanoff and Romanoff, 1949), 35.2% and 0.42% (Roca, 1984), 32.2% in yolk (Hall and McKay, 1993) and 29 - 34% and trace to 0.05% (Panda, 1995; Etches, 1996). In comparison to these reported ranges of lipid content, the present evaluation on Indian RIR indicates a slightly lower content in the yolk and a significantly higher content in the albumen. The lipid content of both yolk and albumen was significantly increased by 26.6% and 34% respectively in the eggs of SP birds. Clearly, photoperiod has an apparent influence on the total lipid composition of both yolk and albumen. Consideration of the lipid content during the course of lay suggests decrement with age irrespective of photoperiod. However, the percentage decrement with age was relatively lesser in the eggs of SP birds with regard to both yolk lipid content (19.8% in NLD Vs 9.2% in SP) and albumen lipid content (72.6% in NLD Vs 69% in SP). The contents of water and lipids of eggs portrayed as ratios to the non-lipid dry material (water index and lipid index respectively) are expected to show correspondence with the water and lipid indices of newly hatched chicks due to the fact that the non-lipid dry component is the most conservative fraction of the egg, used primarily for synthesis and thereby assimilated by the embryo, while the water and lipid contents of the egg decrease during incubation owing to evaporation and metabolism during respiration respectively (Ricklefs, 1977). Both the water and lipid indices are higher in the eggs of SP hens primarily due to a decrease in the non-lipid dry matter (28%)(Tables 5). A scrutiny of the water and lipid indices of the constituent yolk and albumen fractions reveals similar indices for albumen between NLD and SP eggs, denoting the changes in the SP eggs to be essentially a reflection of changes in the indices of yolk. Interestingly, the non-lipid dry matter of the yolk was significantly less (by 36%). It is conceivable from these that the chicks hatching out from the SP eggs would have lesser weight due to the overall reduction in the assimilable material (table 5a & b; fig.4 A & B).

As reported in most of the studies cited above, even in the present study, cholesterol content is relatively more in yolk than in albumen in the eggs of both NLD and SP hens. However, the eggs of SP hens showed a significant increment in yolk cholesterol content and decrement in albumen cholesterol content. Further, in terms of age related changes, whereas the yolk cholesterol content tended to remain steady in the eggs of SP hens, the same showed a decrement in the eggs of NLD hens by 19% by the end of lay and a maximal decrement of 28.6% during the mid phase of lay. In contrast, the cholesterol content of albumen decreased by 94.8% in the NLD eggs and increased by 55.5% in the SP eggs. The decrement in the cholesterol content of yolk seen in the NLD eggs is substantiated by the report of a similar decrement during lay in the Hisex - Brown breed (Hall and McKay, 1993). However, the above workers reported a concomitant reciprocal increment in total lipid content of yolk, while in the present study, a parallel decrement in yolk lipid content is noted, suggesting a possible strain difference in this respect. In the above study on Hisex - Brown breed, Hall and McKay (1993) had inferred the occurrence of a higher yolk cholesterol content in the early eggs of hens commencing lay at an earlier age due to a high cholesterol laden plasma lipoprotein in the immature birds as against low cholesterol laden plasma lipoprotein in the mature birds. In this perspective, the presently recorded relatively higher yolk cholesterol content in the eggs of SP hens in the initial phase is self-explanatory as the SP hens started laying earlier at a comparatively immature age of 17 weeks as compared to NLD hens which started laying by 24 weeks. (Chapter 1). However, the persistently higher yolk cholesterol content throughout the lay as against a decrement in NLD eggs suggest a definite influence of short photoperiod in the early period in altering the lipoprotein metabolism of the hen. The noted difference in the albumen cholesterol content between SP and NLD eggs is also an indication of the induced alteration in the lipoprotein metabolism of the oviduct. The herein inferred permanent resetting of the lipoprotein metabolism due to SP, is further validated, when the proportion of cholesterol to total lipid content of the yolk during the three phases of lay in NLD eggs (ranging between 6.2 to 7.8%) is equated with the reported steady proportion of 7.4% cholesterol in the plasma lipoproteins of mature hens (Griffin *et al.*,1982). Further, the recorded steady higher content of cholesterol in the yolk SP eggs (10% to 12%) when equated with the reported proportion of 23% cholesterol to total lipid in plasma lipoprotein of immature hens (Griffin *et al.*, 1982), provides further validity. The variation in yolk cholesterol concentration with advancing age of the birds in the Hisex-Brown breed was suggested to be due to the differences in the proportion of cholesterol to other lipid components, rather than changes in the proportion of yolk protein or water (Hall and McKay, 1993). But the alteration in yolk cholesterol concentration in the Indian RIR breed is due to the increase in yolk protein and water in the NLD birds and due to yolk water alone in SP birds. Interestingly, the changes in the albumen cholesterol content with age is due to a difference in the proportion of cholesterol to other lipid fractions with a decreased ratio in NLD eggs and an increased ratio in the SP eggs.

In terms of nutritional value, the eggs of SP hens is superior as the energy content of 100 gms of edible egg was higher by 14% compared to that of NLD eggs (table 5b; fig.4C). Apparently, the reduction in egg size is adequately compensated by a higher energy content in the SP eggs.

The present results provide evidences for the first time, for an overall alteration in composition and energy content of egg due to exposure of immature chicks to SP during the rearing period.