CHAPTER 1

CHANGING PHOTOPERIOD AND FIRST AND SECOND LAY PERFORMANCE IN RIR BREED; FAVOURABLE INFLUENCE OF SHORT PHOTOPERIOD (LD 6:18) IN PULLETS BUT NOT IN ADULT HENS.

Poultry farming is an economically vibrant industry developed primarily to satisfy human dietary requirements in terms of egg and meat. Over the years, extensive breeding and selection techniques have succeeded in raising genetically superior breeds of poultry birds all over the world. However, the productivity of such birds is still vulnerable to environmental factors as, multitudes of factors like nutrition, management techniques, humidity, light and temperature have all been recognised to have an impact on the growth and maturation of the birds as well as on the overall productivity. The growth of pullets, the age at which egg laying is initiated, the attainment of sexual maturity, the size of eggs at initiation of lay, weight and total number of eggs laid and the total duration of lay period are all variables dependent on environmental conditions. Feed management and nutritional manipulations have been shown to influence the productivity in poultry birds (Dunn *et al.*, 1990; Sandoval and Gernat, 1996). The major environmental factor that has been manipulated to help improve various features of poultry productivity is, photoperiod.

Absolute photoperiod is inconsequential in the domestic hen as, regardless of duration of photoperiod, they undergo ovarian development and, become sexually mature at about 5-6 months under widely different lighting regimens (Lewis *et al.,* 1994). A shortened photoperiod has been shown to reduce the rate of egg production in laying hens (Sykes, 1956; Hutchinson *et al.*, 1957; Morris *et al.,* 1964). Birds maintained on 6h or 18h photoperiod from day 1 become sexually mature later than birds kept on 10h photoperiod (Morris, 1968) and, 12h increase in photoperiod from 8 to 20h did not affect ovarian growth (Dunn *et al.,* 1990). The sexual response of the domestic hen to changes in photoperiod is age dependent and, Morris (1968) showed that they become more responsive to photic changes closer to sexual maturity. A delay in the onset of sexual maturity was revealed in pullets reared under normal or long days versus short (8h) days (Payne, 1975; Proudfoot, 1980; Renden and Oates, 1989). Age at first egg is shown to be advanced when growing pullets are exposed to an increased photoperiod, and delayed when exposed to decreased photoperiod (Morris,1968). The degree of advancement or delay was shown to be dependent on the size and timing of change in photoperiod (Morris, 1963; Lewis *et al.,* 1992). The above studies also revealed that the hen's sensitivity to a change in photoperiod is not uniform in terms of photoperiod or age as changes made outside the range from 8 to 16h proved to be less potent than changes made within that range, and increase in photoperiod made closer to sexual maturity was less effective than when given at younger ages.

Though studies involving photoperiodic manipulations have been extensively carried out on breeds of temperate countries, such studies have not been extended to the breeds of tropical countries. The Indian RIR breed is a hybrid produced by further cross between the original RIR breed

(USA) and the Kalinga (Orissa, India) for better temperature resistance. It is this stock which has been perpetuated over the years (as per Govt. of India Poultry record).

The aim of the present study is to evaluate the effect of rearing pullets of RIR breed (dual purpose breed for egg and meat) on a short photoperiod of LD6:18 from day 1 till 90 days of age and then shifting them to natural photoperiod on, growth and various parameters of egg productivity as compared to pullets reared continuously under natural photoperiod. The second objective was to evaluate the impact of a similar photic manipulation on adult hens of 72 weeks age (in the last week of first lay) till 76 weeks of age on, the performance of second lay as there are very few experimental studies regarding second lay, bar, the management practice of induced moulting by starvation (Clarke *et al.,* 1992).

RESULTS

Set-up I :

Body weight and duration of egg laying :

The changes in body weight as represented in table 1; fig.1 show identical weights of pullets during the first 60 days irrespective of the photoperiod. However, between 60 and 90 days, the pullets reared under SP showed a significant decrement in body weight. This difference in body weight persisted thereafter and the SP reared pullets tended to have a slightly reduced body weight even in the adult condition. The NLD hens initiated egg laying by 178.27days (approximately 6 months) while the hens which were previously exposed to SP initiated egg laying by 120.42 days (approximately 4 months). The termination of egg laying occurred at

530.63 days and 476.68 days in the two groups with an effective period of lay of 352.36 and 356.25 days respectively (table 2; fig.2A - C).

Number & weight of eggs and rate of lay :

The NLD hens laid a total of 168.47 eggs/hen, while the SP hens laid 193.68 eggs/hen. The average number of small eggs (<40 gm) laid by NLD hens was 16.25 eggs/hen and the same by SP hens was 23.43 eggs/hen. The effective lay represented by the average sized eggs (40 gm and above) obtained by subtracting the number of small eggs from the total number was 152.22 and 170.25 eggs/hen respectively. The average rate of lay in NLD hens was 0.47 eggs/hen/day with a duration of 50 h between eggs. In contrast, the SP hens laid 0.54 eggs/hen/day with a duration of only 44 h between eggs. The average weight of eggs laid by NLD hens was 46.59 gms and that by SP hens was 44.68 gms (tables 3 & 4; fig. 3A-C).

Monthly variations in the first lay :

The average monthly yield of eggs was significantly higher at 2 and 4 months in both NLD and SP hens. As seen from table 5; fig. 4, the number of eggs yielded by SP hens was greater than NLD hens during the first 7 months, with the greatest difference being manifested in the first four months. The average monthly clutch size (table 5; Fig.5A & B) also shows that the largest clutch size of 3.7/hen/month in SP hens occurred in the second and fourth months while, it was 3.0/hen /month in the second month in NLD birds. The number of clutches of various sizes (table 6) shows that, in NLD hens, the largest clutch size was of 5 eggs laid during the second month. Clutches of 4 and 3 eggs were laid till 6th and 9th months respectively, while clutches of 2 and 1 eggs were laid throughout the egg laying period. In comparison, the SP hens laid the largest clutch of 6 eggs in the first month and clutches of 5 and 4 were laid till 4th and 6th months respectively, while clutches of 1-3 eggs were common throughout. A comparative account of the monthly rate of lay (table 7) shows that a maximum rate of 0.66 and 0.61 eggs/hen/day at an egg interval of 36 h and 39 h respectively during the 2nd and 4th months in NLD hens and a rate of 0.77 and 0.75 eggs/hen/day with an egg interval of 31 h during the2nd, 4th and 1st months respectively in SP hens. The minimal rate of lay with the largest egg interval was 0.32 and 0.31 eggs with an egg interval of 73 and 77 h in the NLD and SP hens respectively. The average weight of eggs laid by the NLD birds was 46.59 gms while that by the SP hens was only 44.68 gms. This overall decrement in egg weight in SP birds was due to the very low egg weights during the first two months, though the egg weight from the 5th month onward was significantly higher than the NLD birds (table 4). The data of 12th month is not taken into consideration as it was a period of residual egg lay at the fag end of first lay, and the rate and interval are not representative of normal lay.

Set-up II :

The performance during the second lay of hens of 72 weeks of age maintained under LD 12:12 or L:D 6:18 for one month and then shifted to normal ambient photoperiodic conditions is shown in table 8. The NLD hens laid an average of 96.47 eggs/hen with an average egg weight of 48.79 gms during 11 months at an average rate of 8.7 eggs/month. However, the effective period of lay was only 9 months with an average rate of lay of 10.2 eggs/month during the first 9 months and a trailing lay rate of 0.1 and 0.03 eggs during the 10th and 11th months (table 9). The SP hens remained intransigent and failed to lay any egg during the four month period and hence were taken out of the study (table 9)..

Table: 1 Body weight gain upto 180 days in NLD and SP pullets.

	30 d	60 d	90 d	120 d	150 d	180 d
NLD	117.2 ± 16.33	312.85 ± 18.22	600.00 ± 16.32	852.80 ± 20.05	1020.8 ± 23.65	1140.20 ±25.43
SP	122.50 ±19.25	322.00 ± 13.03	533.33[a] ± 15.87	840.75 ± 23.54	1013.33 ± 22.11	1108.64 ± 23.42

Values: Mean, ± S.E, n= 12, [a] $P<.05$. NLD : LD 12:12, SP : LD 6:18.

Table: 2 Age at which initiation and termination and of egg laying occurred in NLD & SP birds.

	Initiation (days)	Termination (days)	Effective days of lay
NLD	178.34 ± 4.32	530.65 ± 5.76	352.36 ± 4.53
SP	120.74[c] ± 3.45	476.45[b] ± 4.65	356.25 ± 3.43

Values: Mean, ± S.E, n= 12, [b]$P < .005$, [c]$P < .0005$. NLD = LD 12:12, SP = LD 6:18.

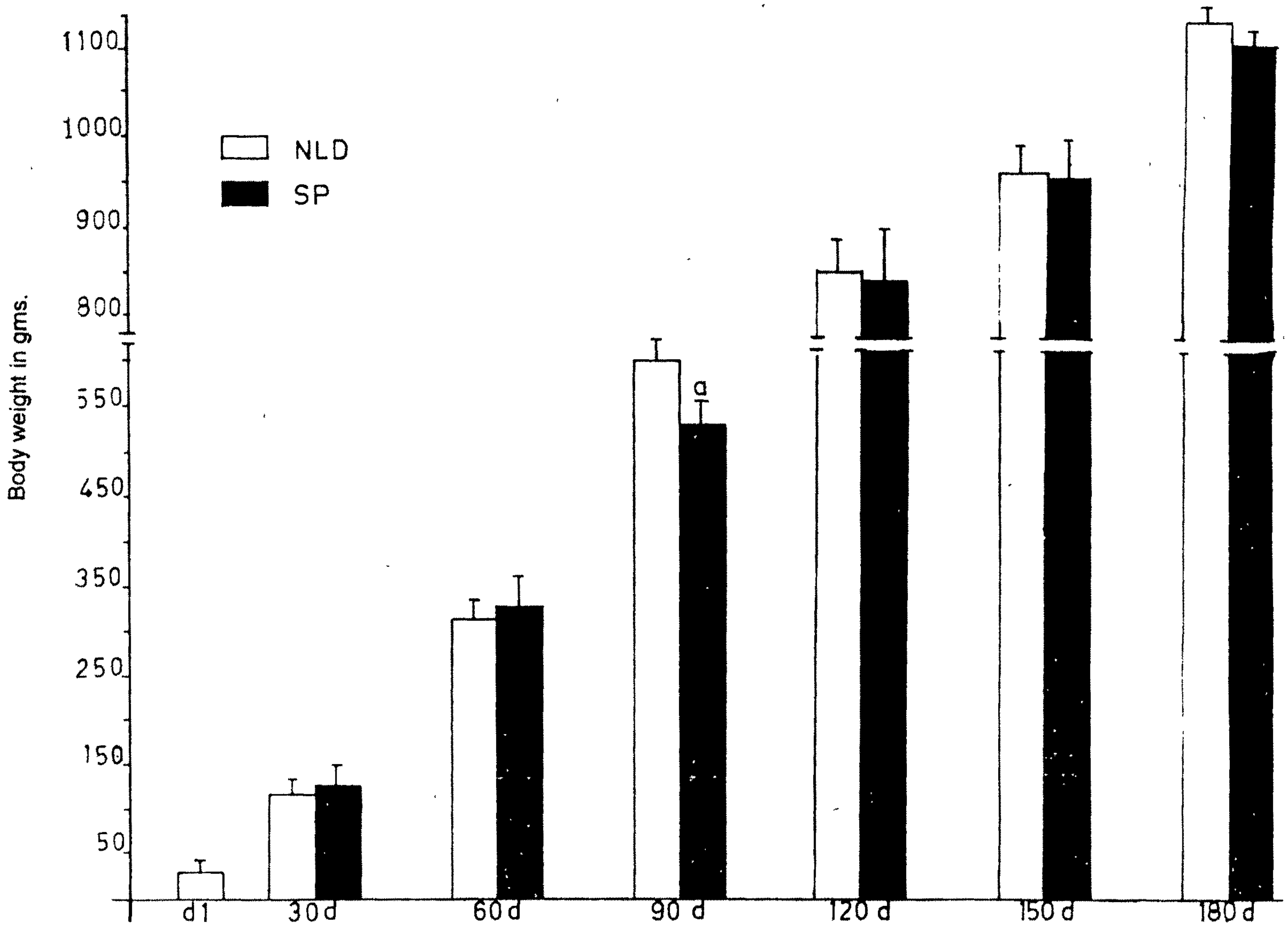

Fig.1 Body weight gain from day 1 upto day 180 in NLD and SP pullets.
Values : Mean, ±S.E, N= 12 **[a]P < .05.** NLD - LD 12:12 ; SP - LD 6:18

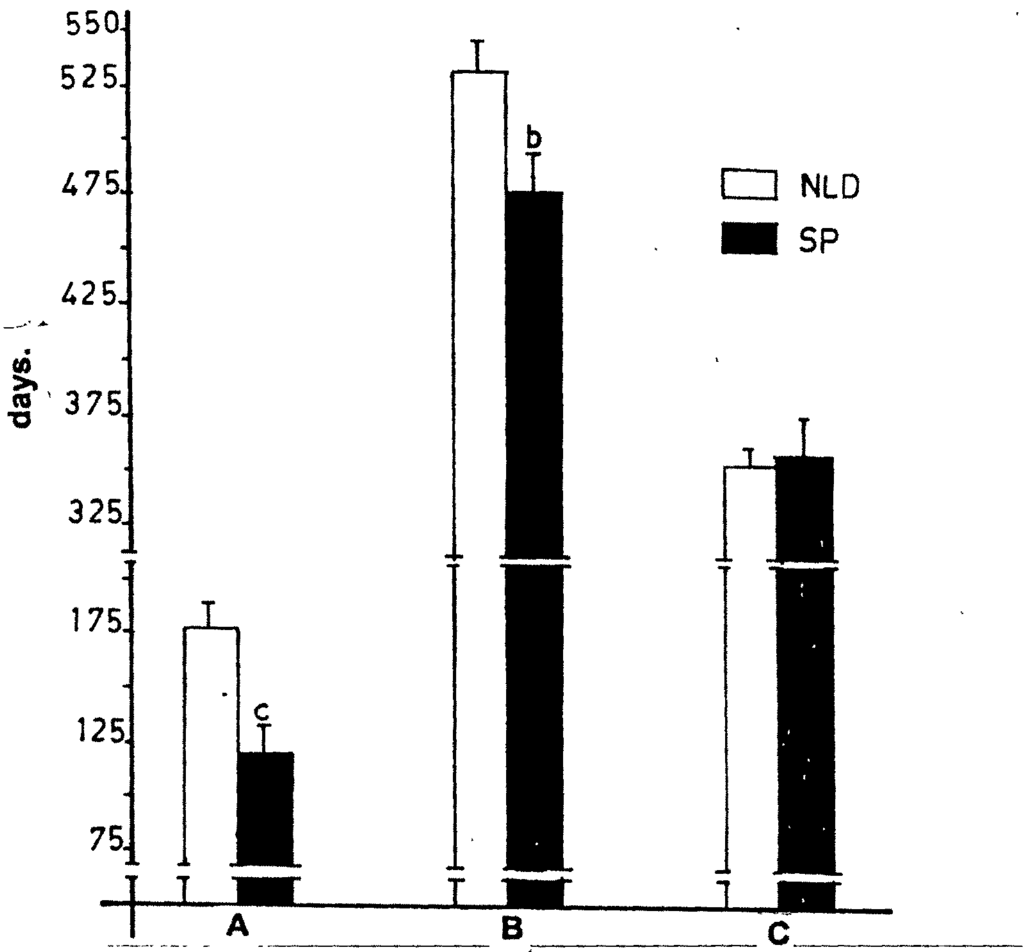

Fig 2 Figure showing age at initiation (A), termination (B), and, (C) effective number of days of lay of NLD and SP hens.
Values : Mean. ±S.E. N= 12 **[b]P < .005, [c]P < .0005.**
NLD - LD 12:12 ; SP - LD 6:18

Table:3 Laying performance of first lay in NLD and SP birds.

	Total no. of Eggs /hen.	Total no. of small eggs /hen.		Total no. of effective eggs/hen	rate of lay	
					egg/d	oviposition interval
NLD	168.47 ±3.76	16.25 ±2.43	9.5 %	152.22 ±2.86	0.47	50hrs
SP	193.68^{b} ±4.26	23.43^{b} ±2.64	11.9 %	170.25^{c} ±3.54	0.54	44hrs

Values: Mean, ± S.E , n= 12, $^{b}P < .005$., $^{c}P < .0005$. NLD = LD 12:12, SP = LD 6:18.

Table: 4 Mean monthly egg weight in NLD and SP birds.

months	*NLD*	*SP*
1.	42.20 ± 3.37	33.46 $\pm 4.37^{c}$
2.	44.46 ± 5.41	36.19 $\pm 6.32^{c}$
3.	44.92 ± 3.41	43.81 ± 4.18
4.	44.08 ± 3.84	43.71 ± 3.09
5.	44.16 ± 4.42	49.43 $\pm 4.13^{b}$
6.	46.18 ± 7.69	47.39 ± 3.69
7.	45.48 ± 3.90	47.58 ± 4.29
8.	45.90 ± 3.96	47.13 ± 4.11
9.	45.28 ± 5.28	46.11 ± 2.37
10.	45.90 ± 2.53	47.73 ± 3.91
11.	45.66 ± 2.54	47.69 ± 2.76
12.	48.06 ± 2.65	49.67 ± 3.02
Overall egg weight.	46.59 ± 5.11	44.68 $\pm 6.11^{c}$

Values : Mean, ± S.E, $^{b}P < .005$, $^{c}P < .0005$.
NLD = LD 12:12, SP = LD 6:18.

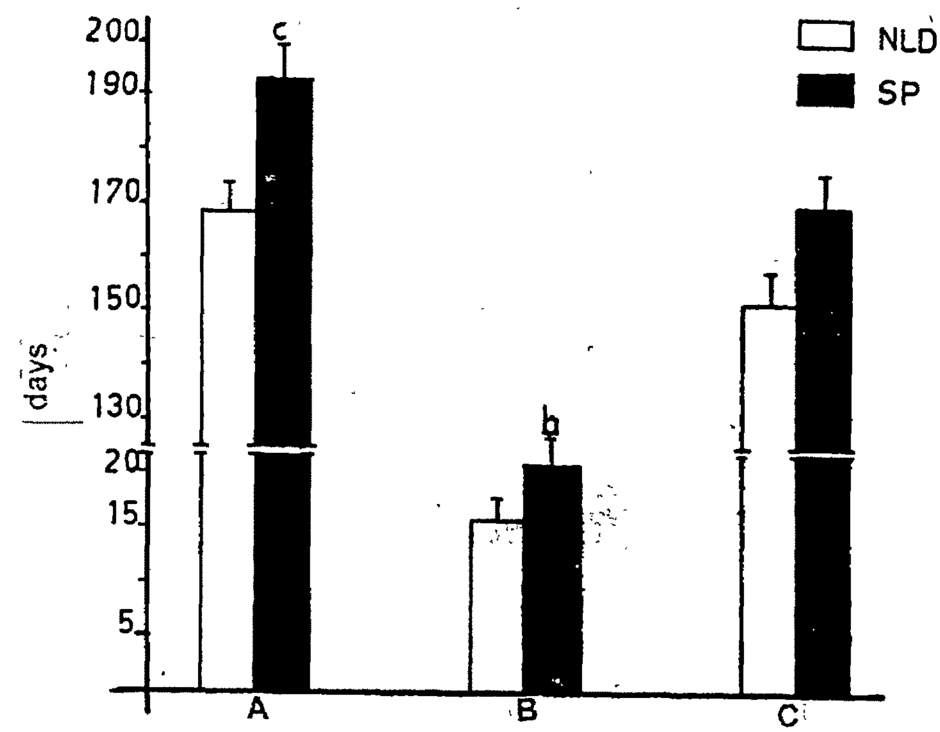

Fig. 3 Figure showing egg laying performance of NLD and SP hens. **A)** Total no. of eggs per hen (hen day production), **B)** Total no. of small eggs and **C)** Total no. of effective eggs.

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

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

Table: 5 Showing number of eggs/month, numberof clutches/month and average monthly clutch size of NLD & SP pullets.

	No of eggs per month		***No. of clutches per month***		***Average monthly clutch size***	
M	***NLD***	***SP***	***NLD***	***SP***	***NLD***	***SP***
1	15.5 ±1.29	22.66[c] ±0.52	8.00 ±0.42	7.66 ±0.54	1.93 ±0.16	3.00 ±0.36
2	20.00 ±0.81	23.33[a] ±0.68	6.50 ±0.57	6.33 ±0.57	3.07 ±0.34	3.69 ±0.23
3	14.75 ±0.35	21.00[c] ±1.00	6.75 ±0.50	8.66 ±0.57	2.18 ±0.21	2.42 ±0.08
4	18.25 ±1.70	23.34[c] ±0.72	7.00 ±0.21	6.33 ±0.58	2.60 ±0.24	3.70 ±0.37
5	16.00 ±0.83	19.01[a] ±1.02	6.75 ±0.50	8.33 ±0.54	2.37 ±0.10	2.29 ±0.43
6	13.25 ±1.25	17.70[c] ±2.30	7.25 ±0.50	8.66 ±0.57	1.80 ±0.24	2.04 ±0.38
7	13.75 ±0.95	15.33[b] ±2.50	10.00 ±0.81	9.33 ±1.15	1.36 ±0.04	1.68 ±0.50
8	15.20 ±2.06	14.33 ±0.57	11.00 ±0.81	10.33 ±0.59	1.39 ±0.27	1.39 ±0.11
9	14.00 ±1.41	14.00 ±1.00	9.25 ±0.95	10.33 ±0.57	1.52 ±0.24	1.35 ±0.12
10	12.5 ±0.57	10.33 ±0.57	8.00 ±0.81	8.00 ±0.06	1.56 ±0.12	1.29 ±0.12
11	9.57 ±0.50	9.33 ±1.52	8.75 ±0.95	7.00 ±0.03	1.11 ±0.13	1.33 ±0.21
12	3.25 ±0.53	4.00 ±0.04	3.25 ±0.50	3.33 ±0.57	1.00 ±0.02	1.22 ±0.19

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

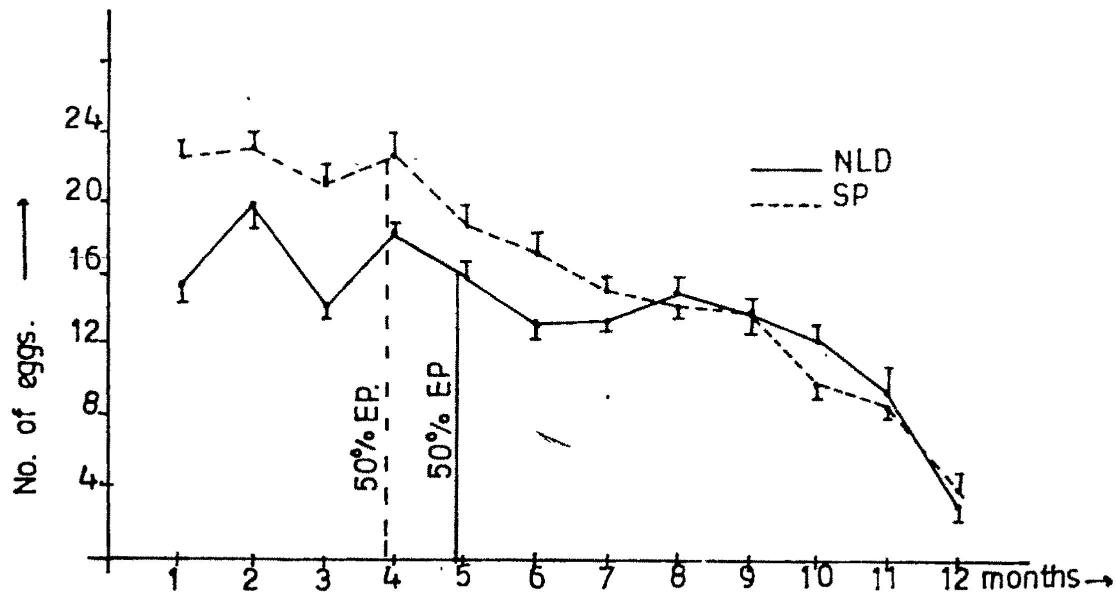

Fig.1 Figure showing average monthly egg production in NLD & SP birds.
Values: Mean, ±S.D. n=12. EP-Egg Production.

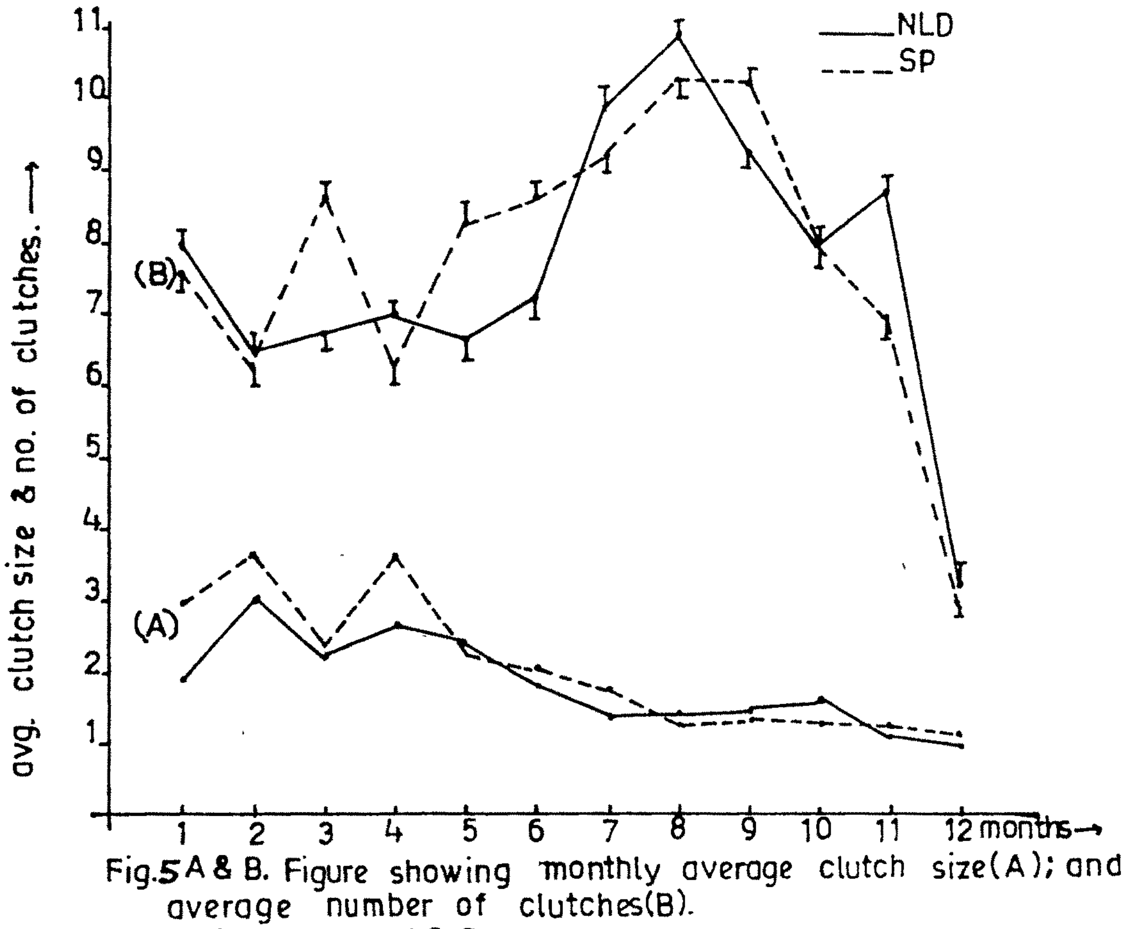

Fig.5 A & B. Figure showing monthly average clutch size(A); and average number of clutches(B).
Values: Mean, ±S.D n=12

Table: 6 Monthly variation in the average number of clutches of various sizes laid by in NLD and SP birds.

No of Months.		Clutches of various sizes.					
		1	2	3	4	5	6
1	NLD	3.5 ±1.29	1.75 ±0.5	2.0 ±.81	0.5 +.18	-----	----
	SP	1.00±.2 [b]	1.0 ±.25	3.0 ±1.0	1.66±.57 [a]	.66 ±.19	.33 ±.09
2	NLD	1.25 ±.95	1.0 ±.21	1.75 ±.75	2.25 ±.5	1.25 ±.22	----
	SP	----	1.0 ± .09	2.0 ±.12	1.33 ±.57	1.66 ±.57	----
3	NLD	1.75 ±.50	1.78 ±.50	1.83 ±.80	1.00 ±.09	----	----
	SP	.66 ±.21 [b]	1.66 ±.09	1.66 ±.13	1.33 ±.28	1.33 ±.31	----
4	NLD	.25 ±.05	3.75 ±.5	2.25 ±.78	.50 ±.13	----	----
	SP	---	.33 ±.06 [c]	2.66 ±.56	1.66 ±.5 [a]	1.66 ±.53	---
5	NLD	.50 ±.01	3.5 ±1.29	2.16 ±1.5	.50 ±.08	----	----
	SP	2.66 ±.5 [b]	3.0 ±.08	2.0 ±.69	1.0 ±.17	----	----
6	NLD	3.0 ±1.82	2.25 ±1.2	1.25 ±.30	.50 ±.11	----	----
	SP	1.33 ±.5 [a]	5.3±1.5 [a]	1.66 ±.52	.33 ±.06	----	----
7	NLD	6.5 ±1.29	2.75 ±.5	.50 ±.05	----	----	----
	SP	4.33 ±.98	4.0 ±1.73	1.0 ±.08	----	----	----
8	NLD	6.5 ±2.38	3.75 ±1.5	.25 ±.01	----	----	----
	SP	6.6 ±1.15	3.33 ±.57	3.3±.06 [b]	----	----	----
9	NLD	4.2 ±2.21	4.75 ±1.2	.25 ±.01	----	----	----
	SP	6.3 ±1.0 [a]	4.0 ±1.73	----	----	----	----
10	NLD	4.0 ±1.15	4.25±.5	----	----	----	----
	SP	6.0 ±1.2 [a]	1.66 ±.57	.33 ±.06	----	----	----
11	NLD	8.25 ±1.5	.75 ± .15	----	----	----	----
	SP	5.3 ±1.1 [a]	1.33 ±.5 [a]	.33 +.08	----	----	----
12	NLD	3.0 ±.81	----	----	----	----	----
	SP	2.33 ±.52	1.07 ±.23	----	----	----	----

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

Table: 7 Mean monthly rate of lay in NLD and SP birds.

	Rate of lay. *NLD*	*SP*	Eggs /Day.	
Months.	**Hours.**	**Hours.**	**NLD**	**SP**
1.	46	31	.516	.755
2.	36	31	.660	.777
3.	49	34	.491	.700
4.	39	31	.608	.777
5.	44	37	.533	.633
6.	54	40	.441	.580
7.	52	47	.458	.511
8.	47	50	.508	.477
9.	51	51	.466	.466
10.	57	69	.416	.344
11.	73	77	.325	.311
12.	221	180	.108	133.

Values : Mean

Table: 8 Second cycle laying performance in NLD and SP hens.

	Total no. of eggs in 11 months.	**Average egg weight (gms).**	**Rate of lay.**
NLD	96.20 ± 3.57	48.79 ± 3.87	8.9 eggs/months
SP	----	----	----

Values : Mean, ± S.E, n=9.

Table: 9 Table showing rate of lay during the course of second cycle of lay in NLD and SP hens.

	monthly rate of lay (eggs/month)	trailing rate of lay		
		9 months	10 months	11 months
NLD	10.2 (upto 9 m)	-----	0.1	0.03
SP	---	---	---	---

Table :10 Comparative projection of total amount of feed consumed/bird till the end of lay and feed/dozen eggs.

	Govt. Poultry.	Present experimental regimen.	
		NLD	SP
Total no. of days.	530	530	476
Total feed/bird in Kg.	63.500	51.180	46.400
Difference			
Govt. Vs NLD	------	-12.32 (19.4%)	------
Govt. Vs SP	------	------	- 17.10 (26.92%)
NLD Vs SP	------	------	- 4.78 (9.33%)
Feed/dozen eggs.	4.23 Kg.	3.65 Kg.	2.96 Kg.

DISCUSSION

The general poultry practice in India is to rear the chicks from the day of hatch till 8 weeks on continuous lighting and then strictly under natural light during the growing period. This is followed by shifting the birds to laying house maintained under 16 h of light from 20 weeks onwards, with a further increase of one hour after 6 months of lay. No studies involving photoperiodic manipulations have ever been carried out to assesses the egg laying performance under Indian conditions. The present study in this context has revealed that the two photoperiodic schedules employed have differential effects on the laying performance.

Set-up I :

A comparison of data under the two lighting schedules, shows that, IL occurs 58 days earlier in birds shifted from a 6 h photoperiod (*i.e* SP) to normal day length as compared to birds shifted from 12 h of light. However, the total lay period was identical in the two groups as termination of egg laying occurred 54 days earlier in SP birds. The advancement in IL by 58 days obtained in the present study is a greater response compared to an advancement by only 18 days achieved in ISA Brown and Shaver 288 breeds when the photoperiod was changed from 8 h to 13 h at 84 days (Lewis *et al.,* 1996a). In these breeds, the maximum advancement in IL (AFE in the above author's terminology) was only by 33 days when the photoperiod was changed from 8 to 13 h at 63 days and, by a minimum of 6 days when the shift was done at 119 days (Lewis *et al.,* 1996a). This difference in the degree of response could be accredited to either breed difference (ISA Brown and Shaver 288 v/s RIR) or conditions (temperate v/s tropical) or even the light intensity (10 lux v/s 250 lux). The total output during the first year of lay in terms of eggs/hen was better in SP birds by

25.21 eggs/hen. In these birds there was an average improvement by 15% in egg output, as well as in terms of per day rate of lay, and egg interval. The number of small eggs was marginally higher in the SP birds; however, the number of effective eggs was higher by 12% on a hen/year basis.

The data on body weight (table 1) shows that at the time of photoperiodic switch (90 d), the SP birds weighed 11% lesser than the NLD birds. The critical period during the trimester of rear in 6 h of photoperiod appears to be the last month as the per day growth rate was significantly lesser compared to, identical or even marginally better rate in the first two months. The body weight at IL was significantly different as, the SP birds weighed almost 300 gms lesser than the NLD birds. Apparently IL seems to have no relation with body weight and is more related to maturation of the reproductive system. It is obvious that, there is no positive correlation between body weight and reproductive maturity but, photoperiod has a definite influence on growth and maturation of the reproductive system as, rearing of pullets under differential temporally regulated optimized photoperiodic conditions can hasten reproductive maturity and IL irrespective of body weight. Somewhat similar observations have been made recently with reference to even other breeds of domestic fowl under temperate conditions (Lewis *et al.,* 1996 a,b). The weight of the first egg at IL was significantly less in SP (36 g in NLD v/s 26 g in SP). Nevertheless, a comparison of the total number of small eggs laid by the two groups of birds shows that, while 9.5% of the total eggs laid were small under NLD, the same was 11.9% under SP, a difference which is not very incriminatory when considered as a whole.

The laying performance over the year, analysed on a monthly basis, reveals that the SP birds attained 50% egg production at an earlier age *i.e*

72 days ahead or, two weeks earlier. Though the annual mean egg weight was less in SP birds, a cursory glance on the monthly performance shows that the egg weight was lower in SP birds only during the first two months while it was similar during the 3rd month and heavier from the 5th month onwards. The difference in egg weight during the first two months was about 8 gms amounting to about 20% and 18% reduction in egg weight respectively. The maximal egg lay in terms of mean monthly yield (20 eggs or above per month) was only during the 2nd month in the case of NLD birds while it was persistent during the first 4 months in SP birds. Both the groups revealed an age dependent monthly decline in egg production. A reciprocal relationship is evident between average clutch size and number of clutches throughout in both groups, with a greater average clutch size being recorded by SP birds during the first 4 months. A comparison of the monthly distribution of clutches of various sizes indicates a maximum clutch size of 5 in NLD birds only during the second month and of 6 in SP birds only during first month. There is evidently a gradual decline in the clutches of larger sizes in both the groups with the SP birds showing a better performance over the year throughout (Table 6). In SP birds, the average per day egg production was greater, with lesser mean oviposition interval. On a monthly basis, this trend was very clearly manifested for the first seven months of egg laying.

The present results also show 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 (table 10). In fact, appropriate photoperiodic manipulation with rationed diet can increase egg production at lower food intake as, the SP birds showed a productivity of 12 eggs/bird for every 2.96 kg feed consumed compared to 3.65 kg feed consumed by NLD birds. Even the NLD birds consumed less feed per dozen eggs/bird compared to the birds at the Government Poultry (3.65kg Vs. 4.23kg) with identical egg output (table 9). Studies on different schedules of feed restriction have yielded different results, as, Tucker and Charles (1993) obtained higher egg production by rationed diet during rearing and Sandoval and Gernat (1996) obtained no difference in laying performance but only a slight delay in attainment of sexual maturity.

Set- up II

In normal poultry practice, it is only the layer breeds of hens which are maintained for a second cycle of lay and, meat type and dual purpose breeds are usually disposed off at the end of the first cycle of lay as their second cycle productivity is very low. Any photoperiodic manipulation which could raise the second year productivity in such breeds would be a positive endeavour of practical significance in poultry economy. However, a step-up photoperiodic manipulation (one month exposure to SP followed by natural photoperiod) given at the fag end of the first cycle of lay proved to be adverse as such birds laid no eggs during the four months of observation though they underwent a moult at 15-19 days after exposure to SP. The poor second cycle performance of Indian RIR breeds is clearly evident from the presently observed yield of meagre 96 eggs/hen though the average egg weight was greater than the first cycle. The average monthly lay in the second cycle of 10 months was 9.6 as against 15.27 during the first cycle of 11 months. This amounted to a 43% lesser yield and not only that, the maximum clutch size never exceeded two and the oviposition interval was protracted and irregular. The present observations clearly suggest the ineffectiveness of photoperiodic manipulation in adult RIR birds at the end of their first lay in improving the performance during second lay. The exposure to a short photoperiod infact has a potent inhibitory effect as there was a total cessation of lay. It would be interesting to see what such photoperiodic manipulation given a second time would have on birds subjected to manipulation for the first lay.

It can be concluded from the present study that a step-up photoperiod at the interphase between brooding and growing periods (58-60 days) can greatly enhance the productivity during first lay in RIR birds under tropical conditions despite a restricted rationed diet.