CHAPTER 7

REARING PHOTOPERIOD : EFFECT OF LD 6:18 ON HISTOMORPHOLOGY AND HORMONES OF ADRENAL, THYROID AND OVARY AND GROWTH KINETICS OF LIVER AND LYMPHOID ORGANS IN RIR PULLETS.

General body and organ growth kinetics have been studied during post-hatch development, as well as, under thyroid or growth hormone excess or deficiency (Singh *et al.,* 1968; Bermudez *et al.,* 1983; Scanes *et al.*, 1984; Hayashi *et al.,* 1986; Yadav and Arneja, 1993). Many studies have also focused on the histomorphology of ovary and oviduct in the post-hatch phase of development, though most such studies are predominantly on adult laying hens (Williams and Sharp, 1978a; Etches *et al.,* 1983; Sharp *et al.,*1992). Similarly, except for a few studies on adrenal corticosteroids and thyroid hormones in the immature stages, most such studies on hormonal profile are in the adult birds in relation to ovulation and oviposition (Soliman and Huston, 1974; Beauving and Vonder, 1977; May, 1978; Sharp and Beauving, 1978; Etches, 1979; Wilson and Cunningham, 1980; Gibson *et al.*, 1986). A continuous evaluation of these parameters in the immature stages from the period of hatch till sexual maturity would be meaningful in understanding the temporal changes during post-hatch development and, may reveal, causal relations with initiation of egg laying as well as various features of egg laying. Moreover, the influence of rearing chicks on different photoperiodic conditions on these aspects has not been studied. It is likely that, the photoperiod induced alterations in attainment of sexual maturity and quantitative and qualitative aspects of egg laying, may be reflected on the changes induced by photoperiod in the immature stages and, might ultimately lead to the development of valid morpho-physiological correlates in relation to laying performance. In this respect, previous study had reported a favourable influence of, short photoperiod in the rearing stages amounting to a step-up photic schedule, on attainment of sexual maturity, egg yield and laying performance (Chapter 1,4). Hence, in the present study an attempt has been made to evaluate the changes in body and organ weights and histological features of the ovary, together with changes in T_3, T_4, progesterone and corticosterone during exposure to a short photoperiod (SP) and possibly correlate these changes with the previously observed effects on sexual maturity and laying performance.

RESULTS

Body and organ weights :

The body weight of SP pullets was significantly lower than that of the NLD pullets at 90 days, though at 30 and 60 days it was non-significantly greater. The growth rate showed a similar pattern. The weight of thyroid gland was significantly lower in the SP hens throughout with, significantly lesser growth rates at 30, 60 and 90 days. The weight of adrenal was also lower at 90 days in SP pullets. The adrenal of SP pullets however showed a significantly increased growth rate between 30 and 60 days and higher weight at 60 days. The absolute and relative weights of liver and lymphoid organs of SP chicks showed increment at 30 days .. However, at 90 days, the absolute and relative weights of liver showed a significant decrement at 90 days, whereas, the absolute weights of all the lymphoid organs showed similar weights as that of controls. The overall growth rate was significantly lower in SP pullets. The ovary of SP pullets was significantly heavier at 30, 60 and 90 days with significantly increased growth rate at 30 and 60 days . However, there was a significantly reduced growth rate between 60 and 90 days.

The organ growth index represented as a ratio of organ growth rate to body growth rate shows that both thyroid and adrenal have lower overall ratios in SP pullets. Whereas the reduced ratio for thyroid was due to a constantly lower ratio from day one to 90, that of adrenal was due to a lowered initial ratio between 0 to 30 days, despite the higher ratios between 30 and 60 days and 60 and 90 days. The growth index of ovary was consistently higher while, that of oviduct was significantly lower between 60 and 90 days resulting in lowered overall ratio. The data on body and organ weights and growth kinetics is shown in table1A,1B,2 &3.

Hormonal changes :

The serum corticosterone (CORT) level showed a similar pattern of decrease at 90 days from 30 days in both NLD and SP pullets. The CORT concentration in SP chicks at 30 days was significantly greater than that of NLD chicks. However, the CORT concentration at 60 and 90 days was significantly lower in SP chicks than the NLD chicks due to a significant fall at 60 days. Between 60 and 90 days both the groups of chicks showed a gradual decline.

The serum T_3 and T_4 levels were significantly lower in SP chicks at *all* the three age groups. Both T_3 and T_4 seem to show a significant decrease at 90 days in SP chicks with however an increased level at 60 days. But in the control chicks, whereas, the serum T_4 level tended to remain constant throughout, the T_3 levels seems to show a decrement.

Whereas the serum progesterone titre in SP pullets, showed a continuous significant reduction at 60 and 90 days,in the NLD pullets it showed a significant decrease at 60 days followed by a significant increase at 90 days, though much lower than the level at 30 days (Table-4).

Histological observations :

Thyroid :

The thyroid of NLD chicks showed medium sized follicles with cuboidal epithelium and varying contents of colloid at 30 days. At 60 days, the epithelial cell height was reduced and the follicles showed increased colloid content. By 90 days, the follicles were enlarged with rich colloid content and reduced cell height. The thyroid of SP chicks in contrast showed fully colloid filled follicles with flattened epithelium at 30 days. This condition was more or less seen even at 60 days, though some follicles depicted colloid depletion. At 90 days, the follicles were to medium to large sized with full colloid content and very flat epithelium (Plate 1).

Adrenal :

The adrenal of 30 day old NLD chicks, showed prominent active cortical cords with relatively less but active medullary cords. At 60 days, the cortical cords appeared very prominent but less active with condensed nucleus. There were signs of medullary activity. By 90 days, the cortical cords were well formed with active looking cells and depicting secretory exhaustion. The adrenal of SP chicks showed regressed less active cortical cords at 30 days and relatively less medullary cords. At 60 days, the medulla appeared well formed though the cortical cords remained reduced in size with less active cells. However, at 90 days the cortical cords were well formed with hypertrophied active cells showing extensive

PLATE I (figures 1-6)

Photomicrographs of sections of thyroid of pullets reared under NLD and SP for first 90 days of post-hatched development (320x).

Fig. 1 Thyroid of 30d NLD chick showing follicles with cuboidal epithelium and varying contents of colloid.

Fig. 2 Thyroid of 30d SP chick showing follicles with reduced cell height and few follicles showing colloid depletion.

Fig. 3 Thyroid of 60d NLD chick showing increased colloid content and reduced epithelial height.

Fig. 4 Thyroid of 60d SP chick showing colloid depletion in follicles.

Fig. 5 Thyroid of 90d NLD chick showing enlarged follicles with rich colloid content.

Fig. 6 Thyroid of 90d SP chick showing colloid filled follicles of medium to large size with flattened epithelium.

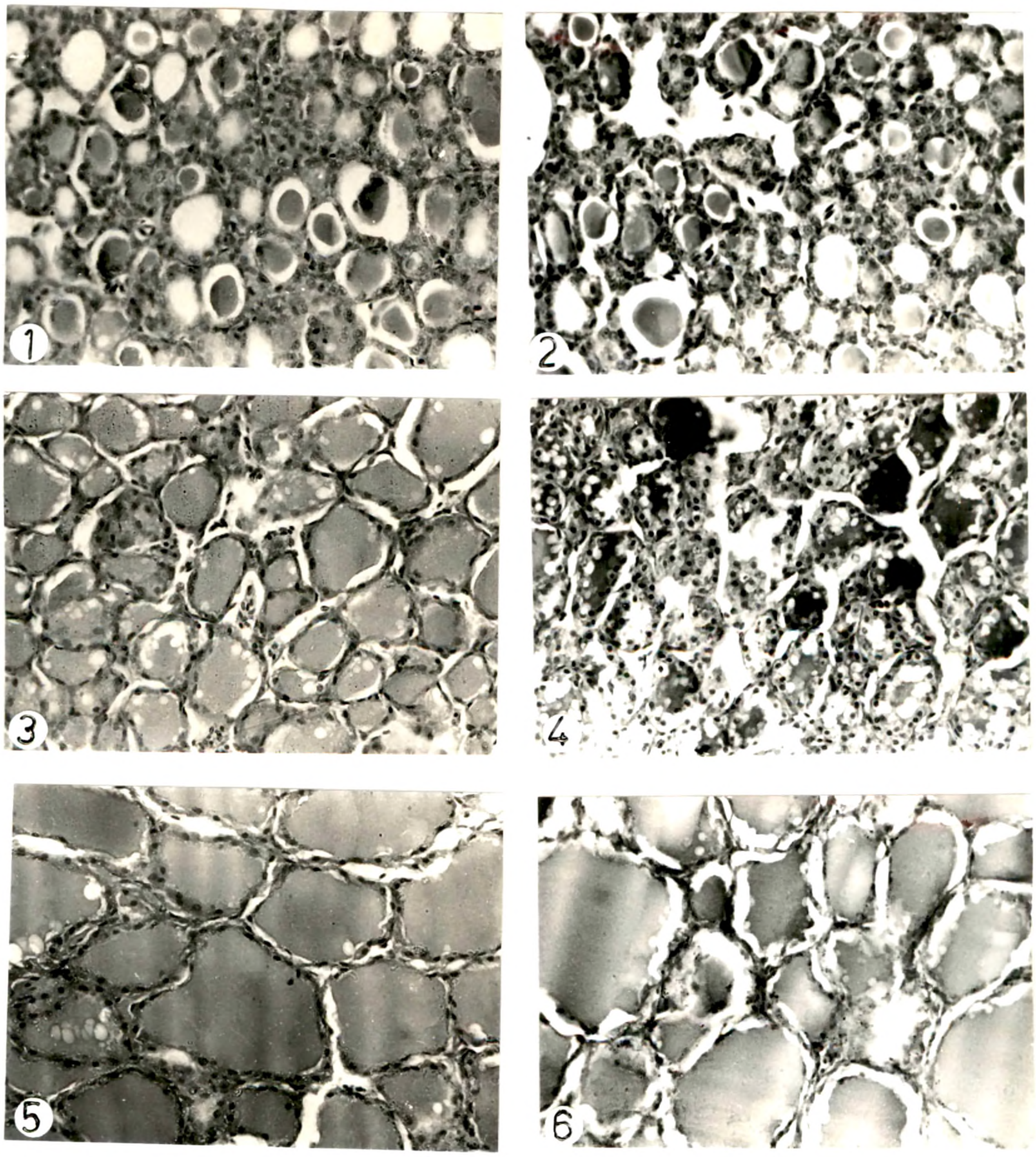
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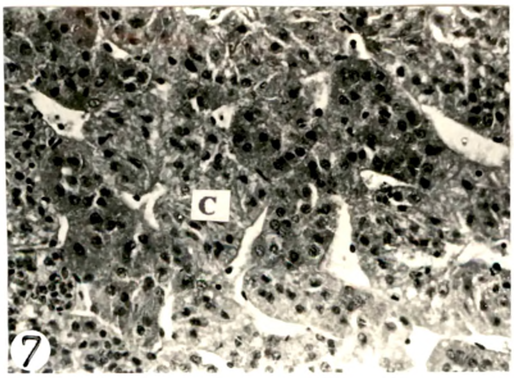
PLATE II (figs. 7-12)

Photomicrographs of sections of adrenal of pullets reared under NLD and SP for first 90 days of post-hatched development (320x).

Fig. 7	Adrenal of 30d NLD chick showing prominent active cortical cords (C), and less active medullary cords (M).
Fig. 8	Adrenal of 30d SP chick showing regressed cortical cords and less medullary cords.
Fig. 9	Adrenal of 60d NLD chick showing prominent but less active cortical cords with condensed nucleus.
Fig. 10	Adrenal of 60d SP chick showing well formed medullary cords.
Fig. 11	Adrenal of 90d NLD chick showing well formed cortical cords depicting secretory exhaustion.
Fig.12	Adrenal of 90d SP chick showing well formed cortical cords with hypertrophied active cells.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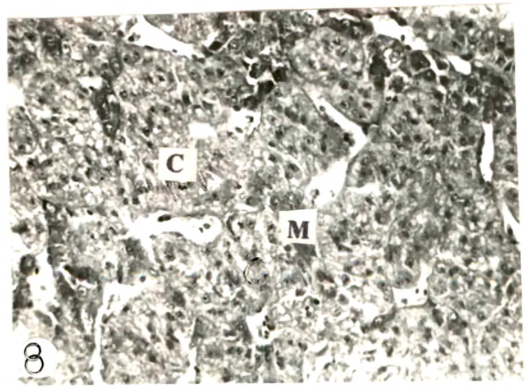
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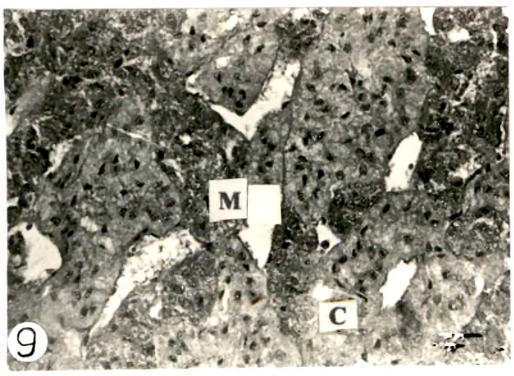
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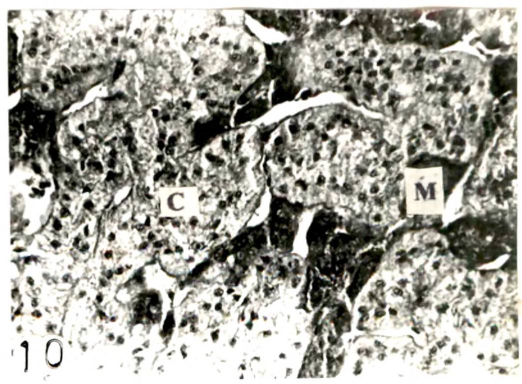
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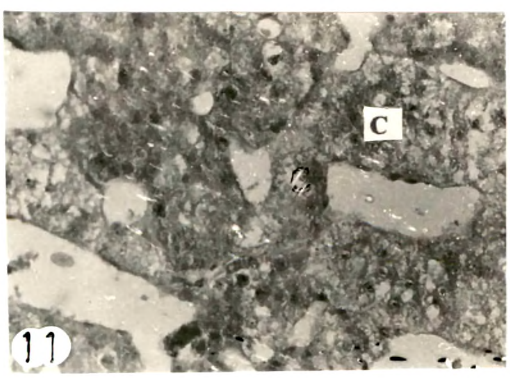
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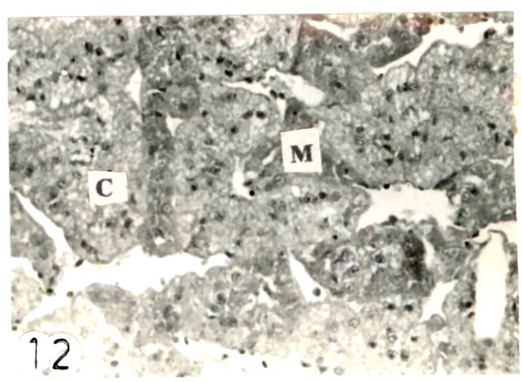
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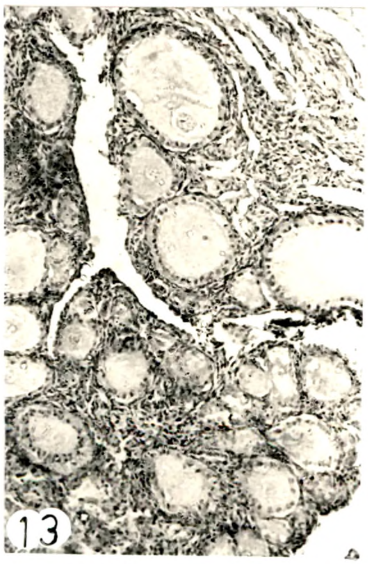
PLATE III (Figs. 13- 16)

Photomicrographs of sections of ovary of pullets reared under NLD and SP for the first 90 days of post-hatched development.

Fig 13 :	Ovary of 30 d NLD chick showing many primary and primordial follicles. (160 x)
Fig 14 :	Ovary of 30 d SP chick showing enlarged follicles. (160 x)
Fig 15 :	Enlarged version of ovary of 30 d NLD chick. Note the stromal (S.) compactness. (320 x)
Fig 16:	Enlarged version of two adjacent follicles showing prominent (T.) theca. (320 x)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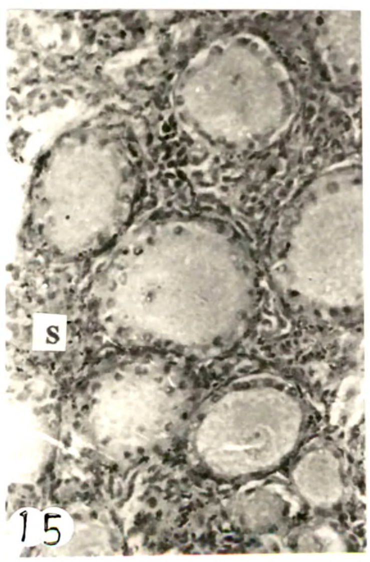
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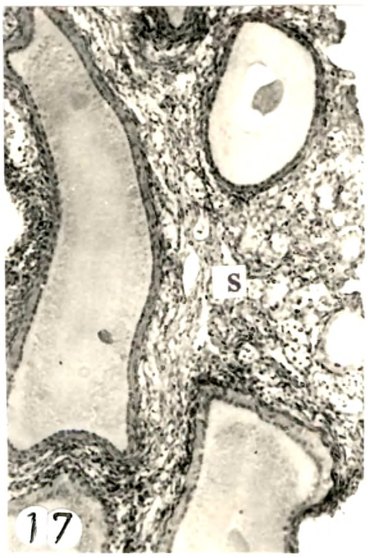
PLATE IV (Figs. 17- 20)

Photomicrographs of sections of ovary of pullets reared under NLD and SP for the first 90 days of post-hatched development.

Figs 17 & 18 : Section of ovary of 60 d NLD and SP chicks respectively showing increasing follicular size and prominent Stromal tissue. (160 x)

Figs 19 & 20 : Enlarged versions of the same. (320 x)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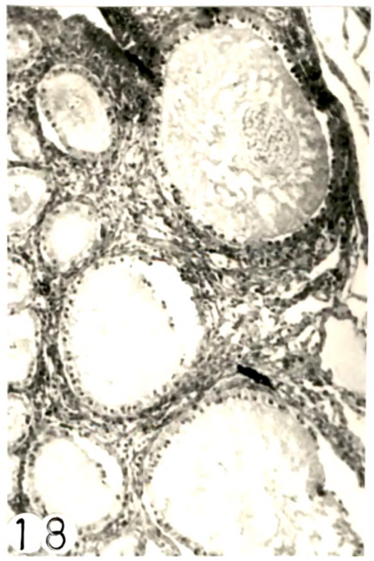
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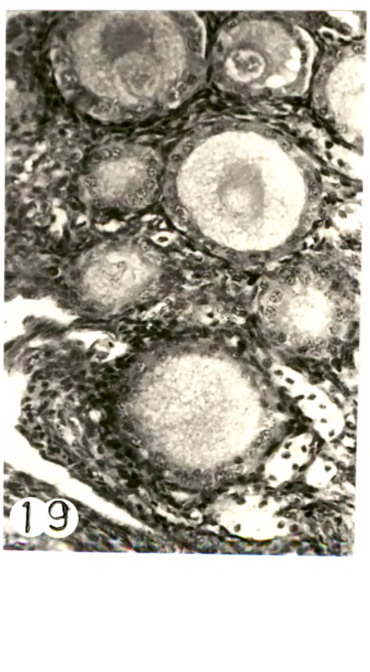
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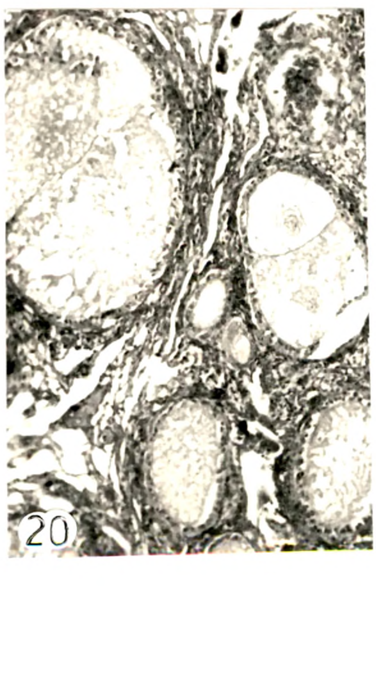
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PLATE V (Figs. 21- 24)

Photomicrographs of sections of ovary of pullets reared under NLD and SP for the first 90 days of post-hatched development.

Fig. 21: Section of ovary of 90 d NLD chick showing a large follicle with well developed granulosa and theca. (160 x)

Fig. 22: Section of ovary of 90 d SP chick showing the presence of many intermediary sized follicles and an atretic follicle (Ab) (160x)

Fig. 23: Section of ovary of 90 d NLD chick at a higher magnification showing large follicles showing well formed granulosa and theca. (320 x)

Fig. 24: Section of ovary of 90 d SP chicks showing growing and intermediary sized follicles. Note the prominent granulosa (G) and conspicuous thecal condensation(T)(320 x)


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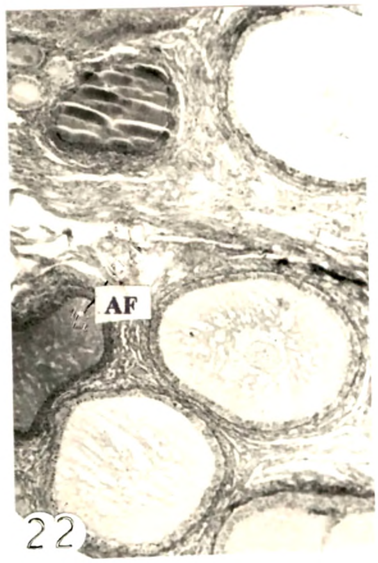
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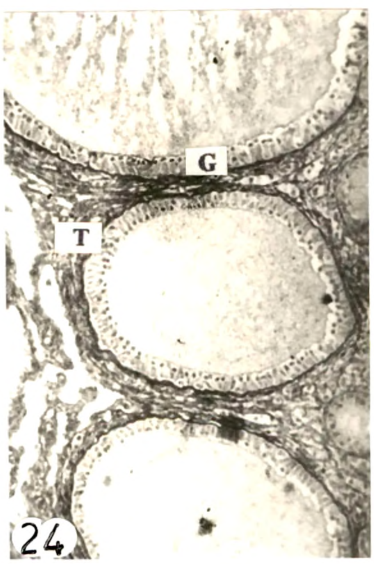
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Table 1A: Body weight and organ weight of NLD and SP birds.

		30 days		60 days		90 days	
Body weight gm	NLD	117.23 ±16.23		312.85 ±18.22		600.00 ±16.32	
	SP	122.50 ±19.25		322.00 ±13.03		533.33 ±15.87[a]	
Organ weight		**Abs. wt**	**Rel. wt**	**Abs. wt**	**Rel. wt**	**Abs. wt**	**Rel. wt**
Thyroid mg	NLD	12.00 ±0.81	10.23 ± 1.13	19.66 ±1.20	6.28 ± 1.55	33.00 ±1.80	5.5 ± 0.83
	SP	10.30 ±0 .86	8.57 ±0.607	15.50±1.44[a]	4.81 ± 0.75	23.03 ±1.47[c]	4.31± 0.49
Adrenal mg	NLD	21.50 ±1.64	18.33 ± 1.13	30.60 ±1.24	9.78 ± 0.80	68.00 ±2.44	11.33±0.87
	SP	17.00 ±0.80	13.87 ± 2.32	41.50±2.01[c]	12.88 ± 0.70[a]	48.00 ±1.47[c]	9.00 ± 1.09
Ovary mg	NLD	34.63 ±4.03	28.99 ± 1.58	65.20 ±2.93	20.84 ±1.96	116.33 ±9.31	19.38 ±1.59
	SP	45.33±5.63[c]	37.00±1.76[c]	134.66 ±8.61	41.81 ± 1.25[c]	150.00 ±4.61	28.12±1.09[c]
Oviduct mg	NLD	21.40 ±2.52	18.24 ± 1.52	57.33 ±3.19	18.32 ± 1.08	112.30 ±1.88	18.72±0.83
	SP	21.33 ±3.79	17.41 ± 1.04	53.00 ±2.93	16.45 ± 0.73	64.00 ±1.54	12.00 ± 0.79

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

Abs. wt : Absolute weight; Rel. wt : Relative weight; NLD: LD 12:12; SP: LD 6:18

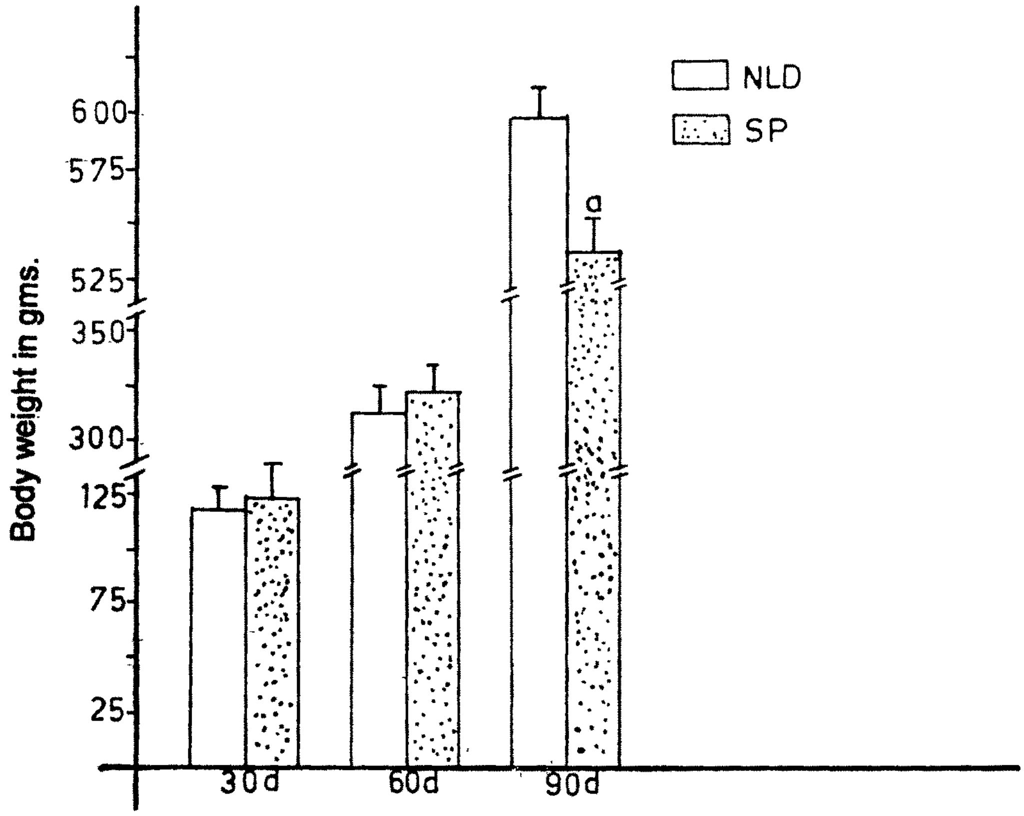

Fig.1 Body weight gain in NLD and SP pullets.
Values : Mean, ±S.E, N= 12 $^{a}P < .05$.
NLD - LD 12:12 ; SP - LD 6:18

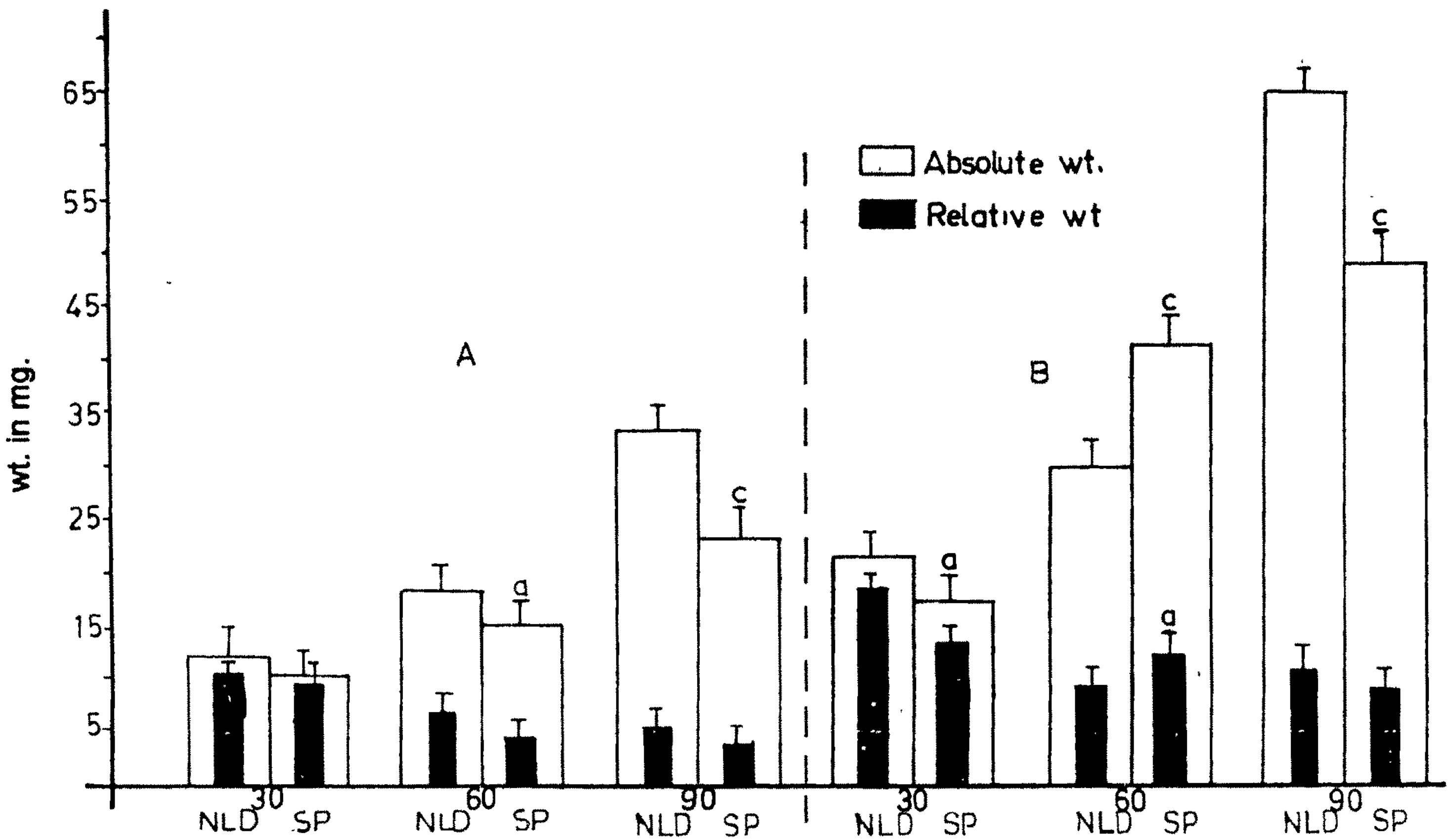

Fig. 2(A-B). Figure showing absolute and relative weights of Thyroid (A) and Adrenal (B) in NLD and SP pullets.

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

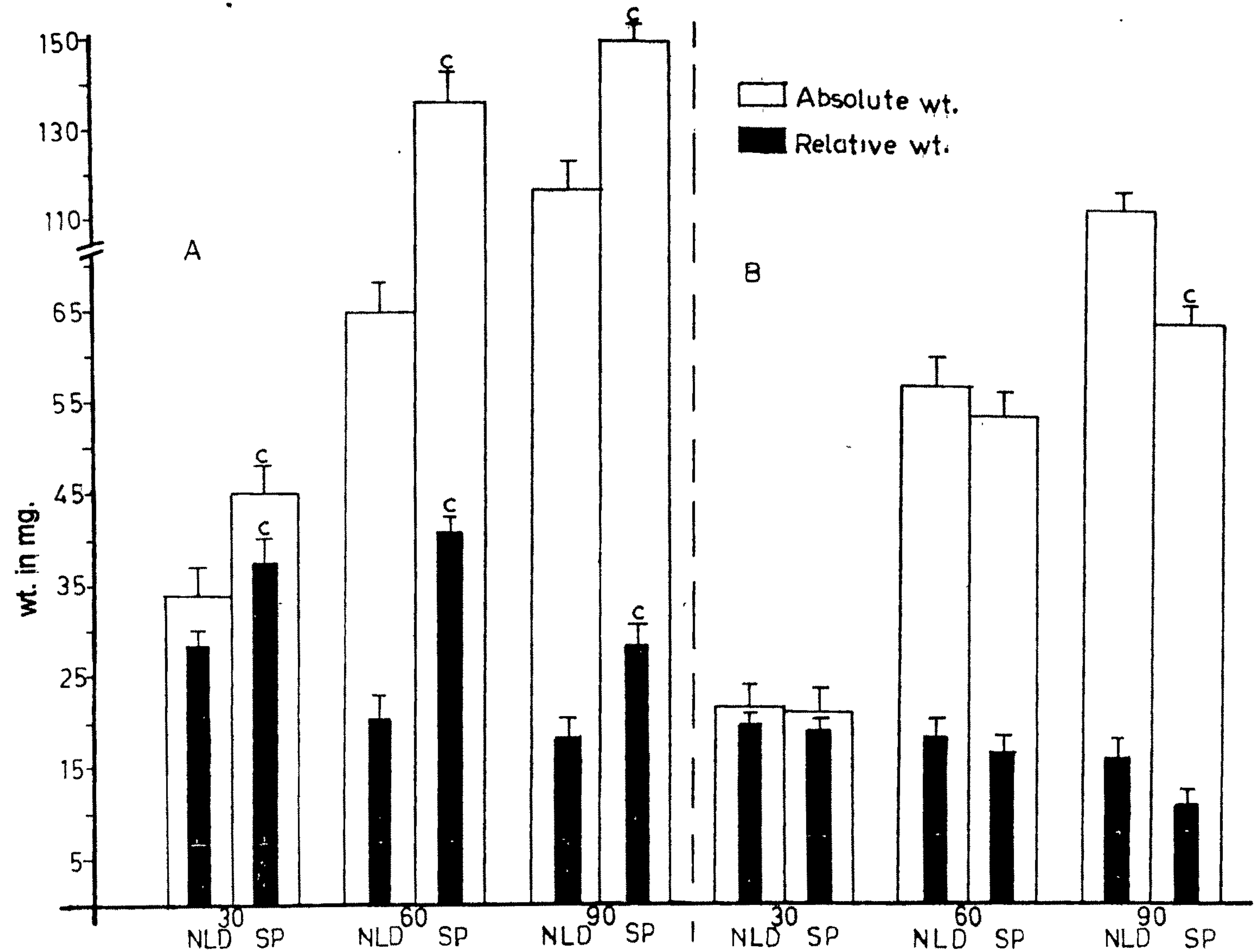

Fig. 3(A-B). Figure showing absolute and relative weights of Ovary (A) and Oviduct (B) in NLD and SP pullets.

Values : Mean, ±S.E, N= 12 ^{c}**P < .0005.**

Table 1B: Table showing absolute and relative weights of lymphoid organs.

		30 days		60 days		90 days	
Lymphoid Organs		**Abs. wt**	**Rel. wt**	**Abs. wt**	**Rel. wt**	**Abs. wt**	**Rel. wt**
Liver gm	**NLD**	3.48 ±0.15	2.970 ±0.30	6.44 ±0.199	2.06 ±0.43	11.41 ±0.218	1.902 ±0.17
	SP	4.86 ±0.31^{c}	3.973 ±0.24^{c}	6.23 ±0.263	1.93 ±0.23^{b}	9.42 ±0.138^{c}	1.766±0.68^{a}
Thymus gm	**NLD**	0.392 ±0.036	0.248 ±0.02	1.282 ±0.012	0.409 ±0.008	2.12 ±0.218	0.354±0.019
	SP	0.46 ±0.02^{a}	0.381±0.303^{c}	1.100±0.19	0.341±0.108^{c}	2.20 ±0.201	0.412±0.022^{c}
Bursa gm	**NLD**	0.148 ±0.007	0.126 ±0.01	0.450 ±0.010	0.143±0.026	1.56 ±0.289	0.261±0.028
	SP	0.170 ±0.01^{a}	0.138±0.01^{c}	0.670±0.014^{c}	0.208±0.014^{c}	1.37 ±0.138	0.257±0.013
Spleen gm	**NLD**	0.137 ±0.019	0.116 ±0.01	0.528 ±0.005	0.168 ±0.01	0.720 ±0.021	0.120±0.025
	SP	0.175 ±0.021	0.142±0.018^{c}	0.359±0.008^{c}	0.11 ±0.013^{c}	0.728 ±0.037	0.136±0.019^{c}

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

Abs. wt : Absolute weight; Rel. wt : Relative weight; NLD: LD 12:12; SP: LD 6:18

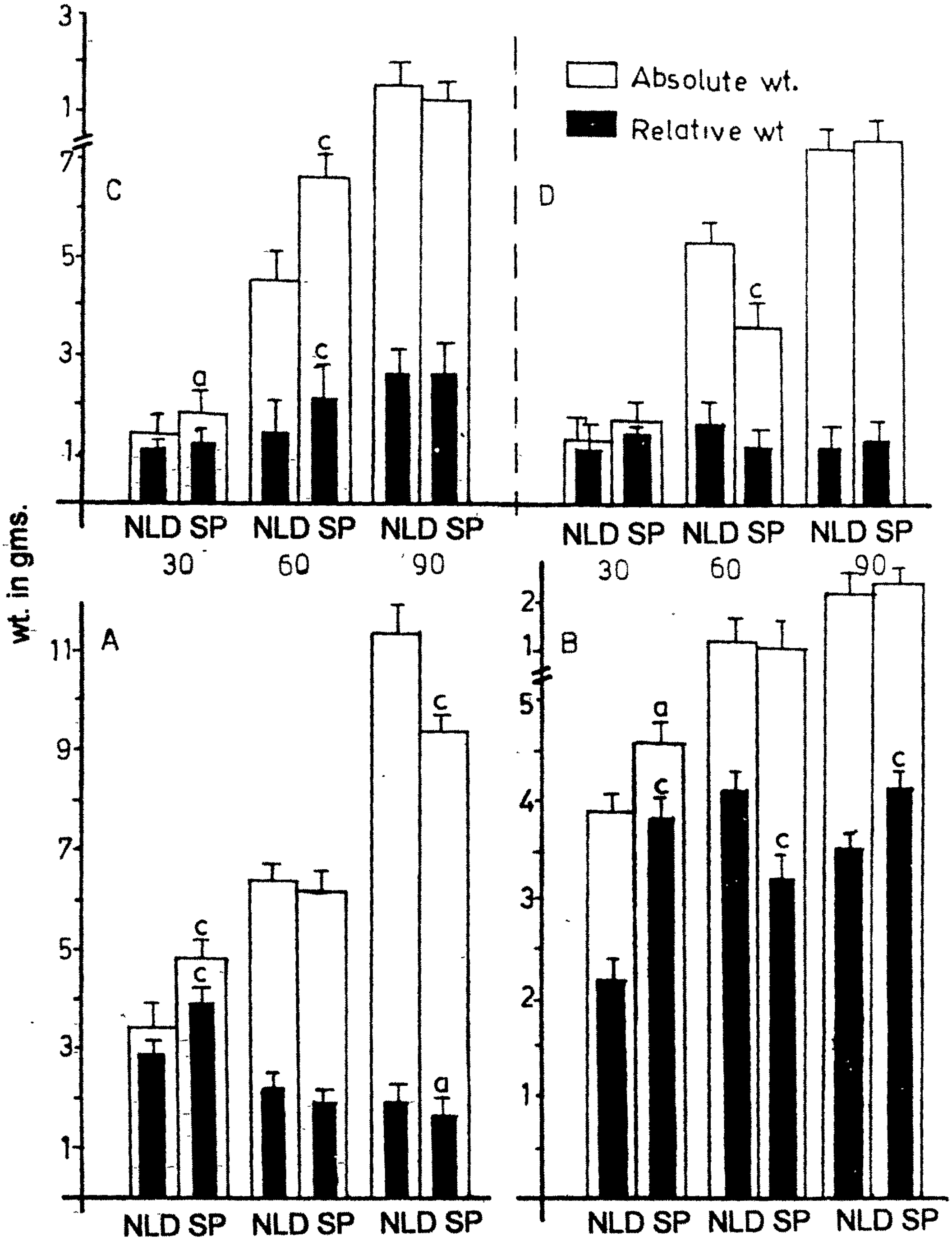

Fig. 4(A-D). Figure showing absolute and relative weights of Liver (A), Thymus (B), Bursa (C) and Spleen (D) in NLD and SP pullets. Values : Mean, ±S.E, N= 12 [a]P < .05, [c]P < .0005.

Table 2: Per day growth rate in NLD and SP pullets.

		0-30	30-60	60-90	Overall
Body weight	*NLD*	3.02	6.51	9.57	6.37
	SP	3.19	6.65	7.04	5.62
Thyroid	*NLD*	0.255	0.255	0.444	0.318
	SP	0.205	0.166	0.251	0.207
Adrenal	*NLD*	0.291	0.303	1.24	0.613
	SP	0.141	0.816	0.216	0.391
Ovary	*NLD*	0.399	1.01	1.70	1.04
	SP	0.755	2.97	0.511	1.41
Oviduct	*NLD*	0.588	1.19	1.83	1.20
	SP	0.586	1.05	0.366	0.669
Liver	*NLD*	0.086	0.098	0.165	0.116
	SP	0.132	0.048	0.106	0.103
Thymus	*NLD*	0.0033	0.033	0.027	0.021
	SP	0.0091	0.021	0.036	0.022
Bursa	*NLD*	0.0021	0.010	0.037	0.016
	SP	0.0029	0.016	0.023	0.014
Spleen	*NLD*	-0.00043	0.013	0.0064	0.0063
	SP	0.0008	0.0061	0.0123	0.0064

Values : Mean

Table :3 Growth Index in NLD and SP pullets

		0-30	30-60	60-90	Overall
Thyroid	***NLD***	0.084	0.039	0.046	0.049
	SP	0.064	0.024	0.035	0.036
Adrenal	**NLD**	0.096	0.046	0.129	0.096
	SP	0.044	0.122	0.030	0.069
Ovary	**NLD**	0.132	0.155	0.177	0.163
	SP	0.236	0.446	0.072	0.250
Oviduct	**NLD**	0.194	0.182	0.191	0.188
	SP	0.183	0.157	0051	0.199
Liver	**NLD**	0.028	0.015	0.017	0.018
	SP	0.041	0.007	0.015	0.018
Thymus	**NLD**	0.001	0.005	0.002	0.003
	SP	0.002	0.003	0.005	0.004
Bursa	**NLD**	0.0006	0.001	0.003	0.002
	SP	0.0009	0.002	0.003	0.0025
Spleen	**NLD**	0.0001	0.001	0.0006	0.0009
	SP	0.0002	0.0009	0.001	0.001

Values : Mean

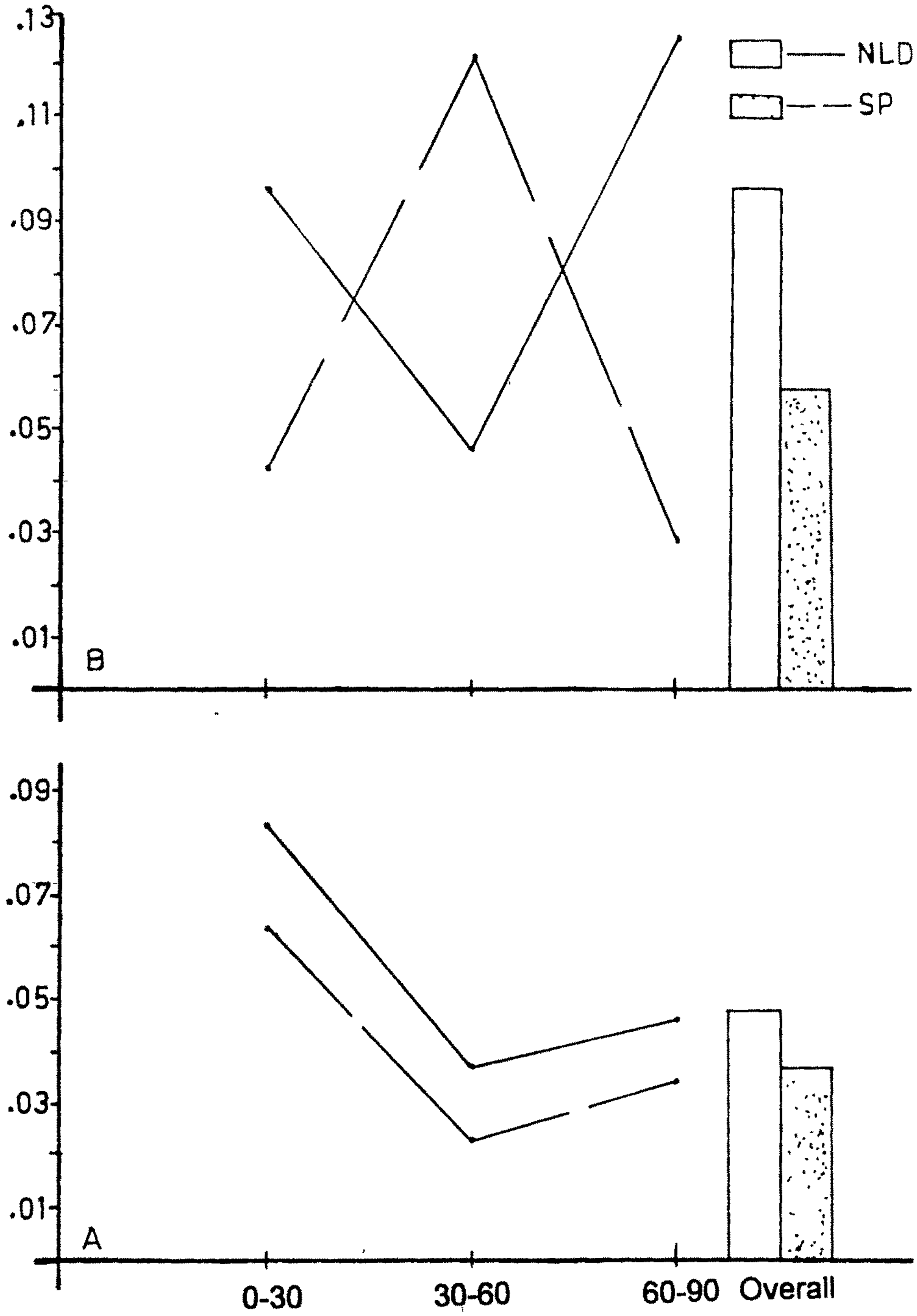

Fig. 5 (A-B). Figure showing growth index of Thyroid (A) and Adrenal (B) in NLD and SP pullets.
Values : Mean N= 12

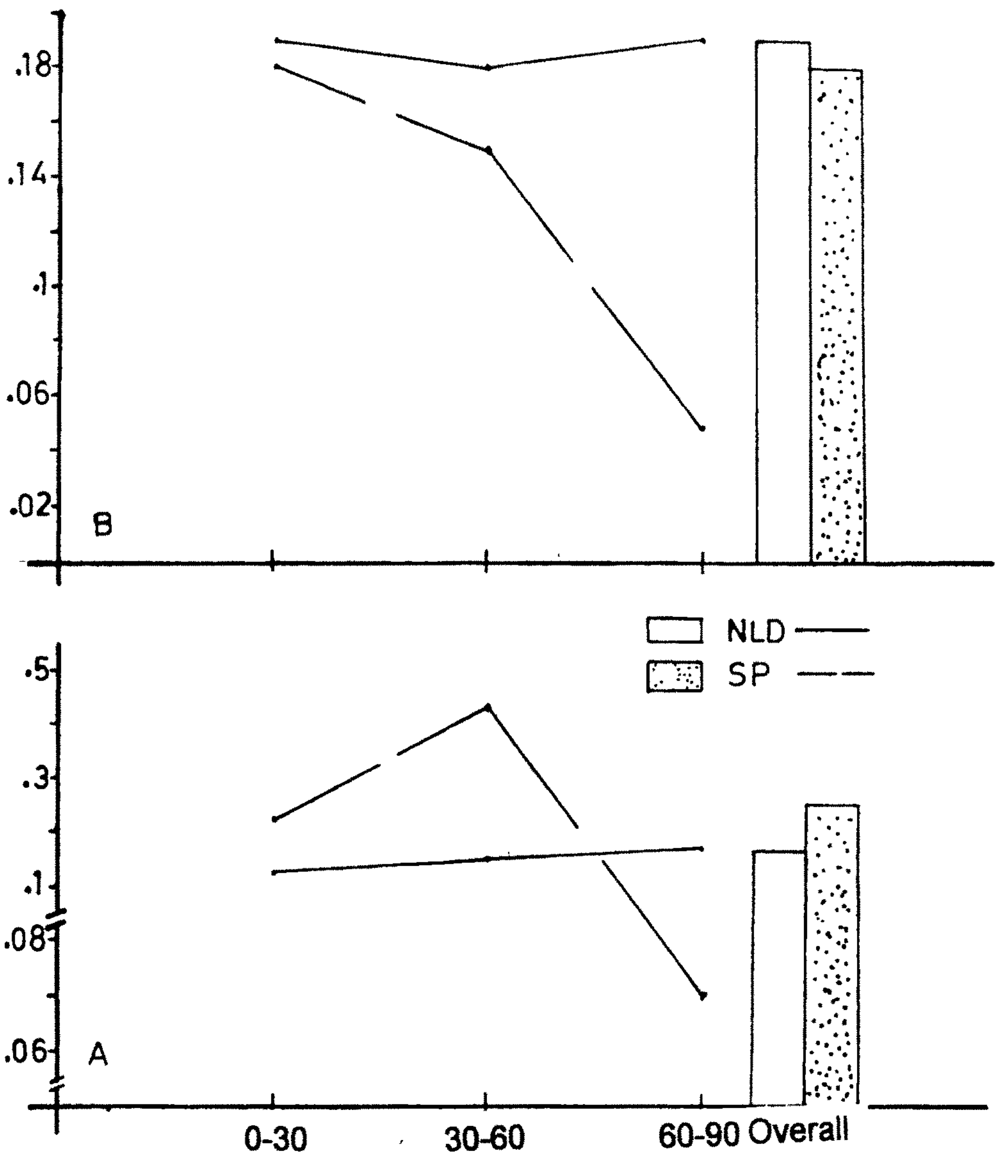

Fig. 6 (A-B). Figure showing growth index of Ovary (A) and oviduct (B) in NLD and SP pullets.
Values : Mean, N= 12

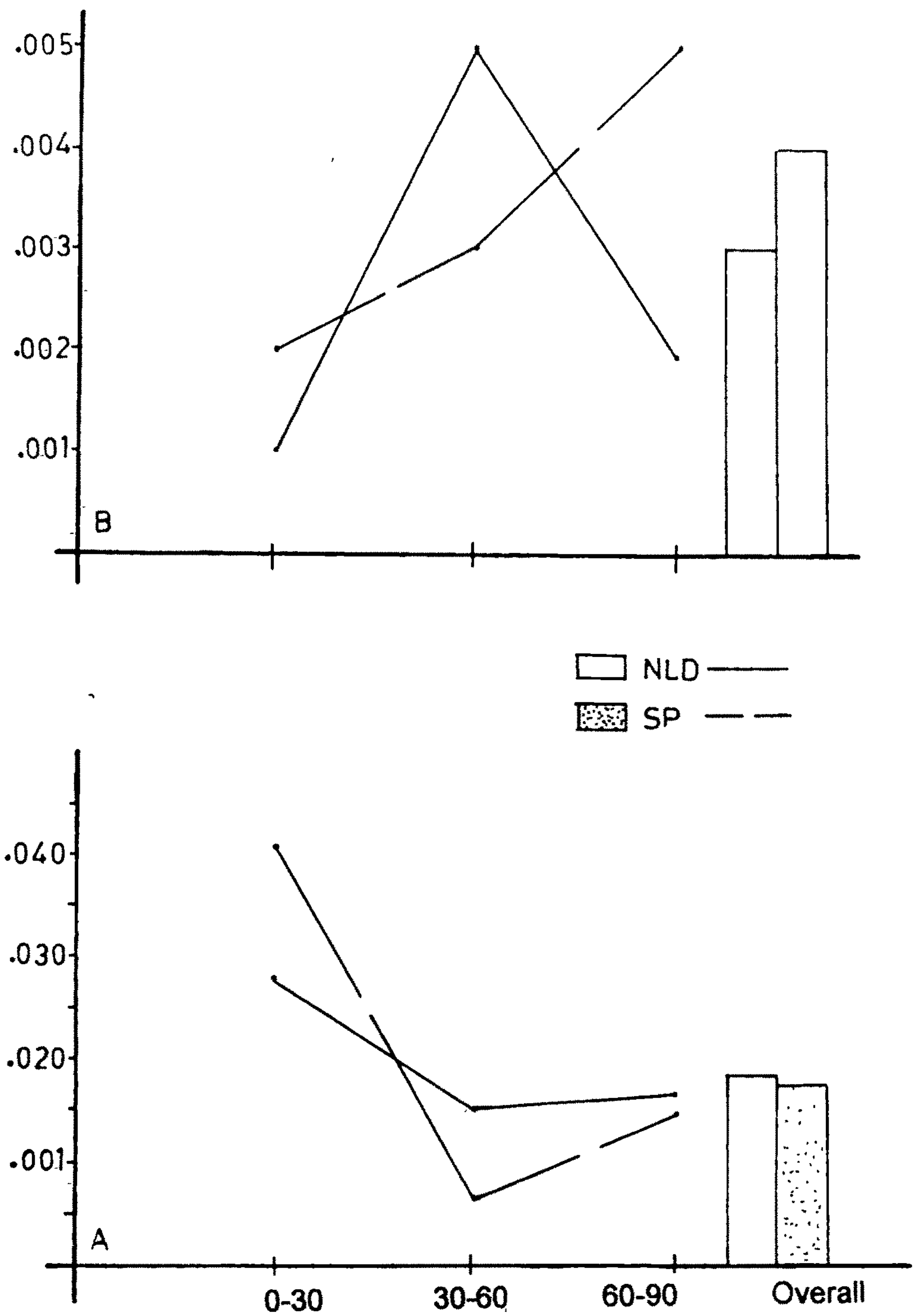

Fig. 7 (A-B). Figure showing growth index of Liver (A) and Thymus (B) in NLD and SP pullets.
Values : Mean. N= 12

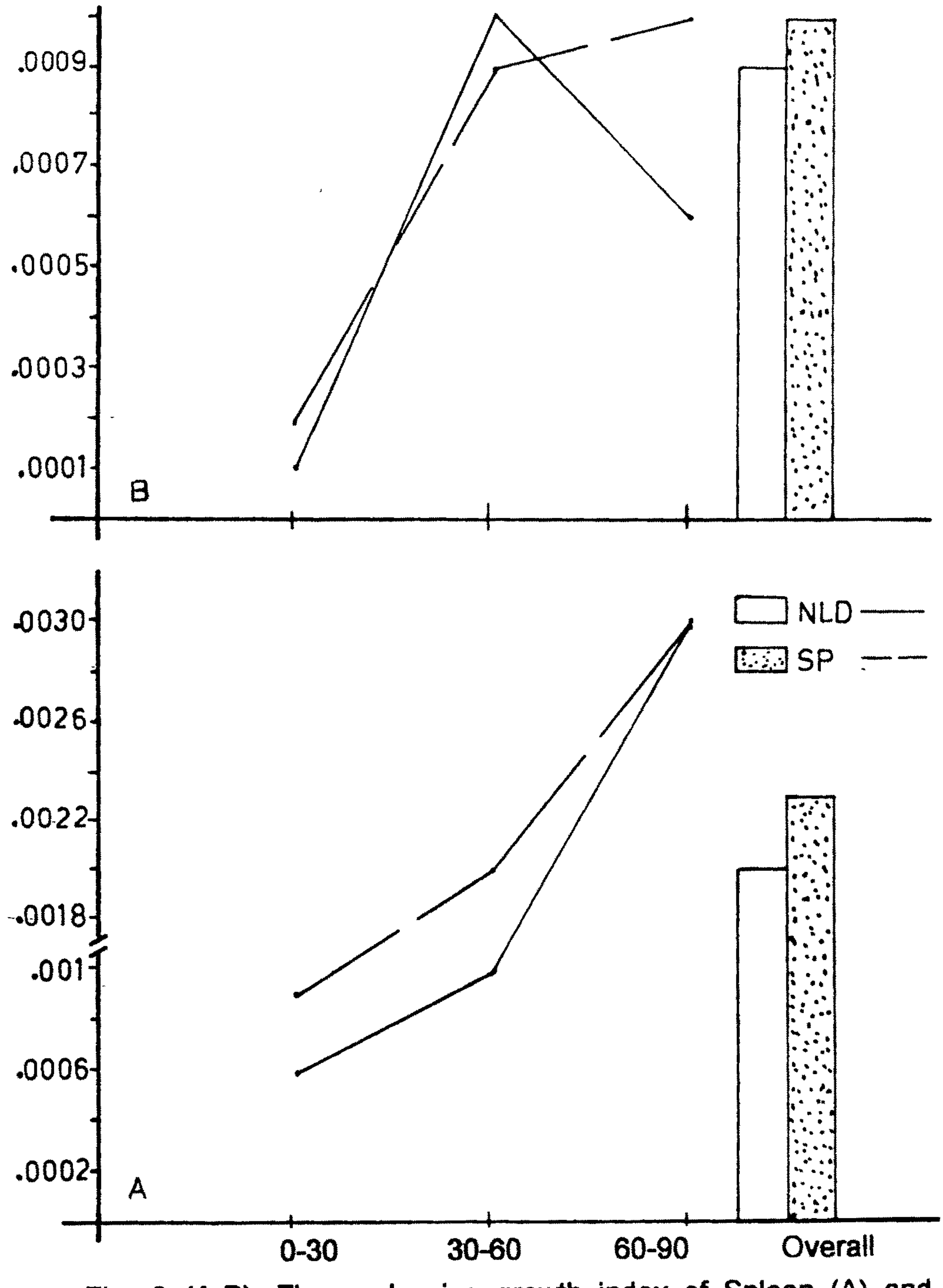

Fig. 8 (A-B). Figure showing growth index of Spleen (A) and Bursa (B) in NLD and SP pullets.
Values : Mean. N= 12

Table : 4 Serum hormone levels of NLD and SP pullets

		30 days	60 days	90 days
Corticosterone (ng/ml)	NLD	2.48 ±0.037	2.23±0.20	2.02 ±0.42
	SP	3.78 ±0.340[C]	1.57±0.09[b]	1.36 ±0.94[a]
T_3 (ng/ml)	NLD	0.690 ±0.073	0.528 ±0.029	0.593±0.089
	SP	0.389 ±0.062[b]	0.428±0.022[b]	0.305±0.017[b]
T_4 (µg/dl)	NLD	3.016 ±0.237	3.03 ±0.183	3.18 ±0.154
	SP	2.59 ±0.39	2.90 ±0.32	1.37 ±0.06[C]
Progesterone (ng/ml)	NLD	0.511 ±0.013	0.120 ±0.013	0.266 ±0.006
	SP	0.573 ±0.029[a]	0.180±0.031[a]	0.070 ±0.008[C]

Values : Mean, ±S.E, N- 12. **$^aP < .05$, $^bP < .005$, $^cP < .0005$**

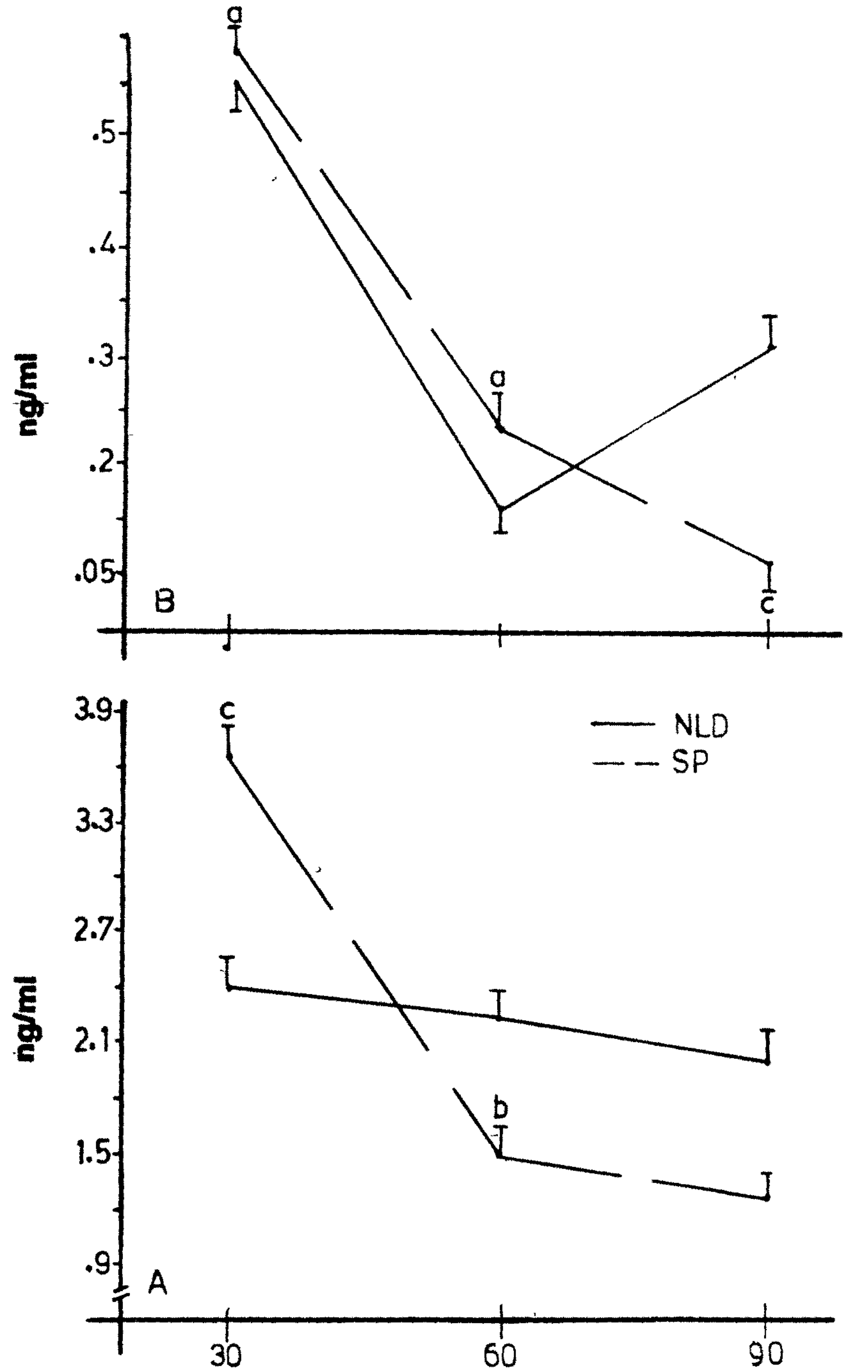

Fig. 9 (A-B). Serum hormone levels of corticosterone (A) and Progesterone (B) in NLD and SP pullets.
Values : Mean, ±S.E, N= 12 **[a]P < .05, [b]P < .005, [c]P < .0005.**

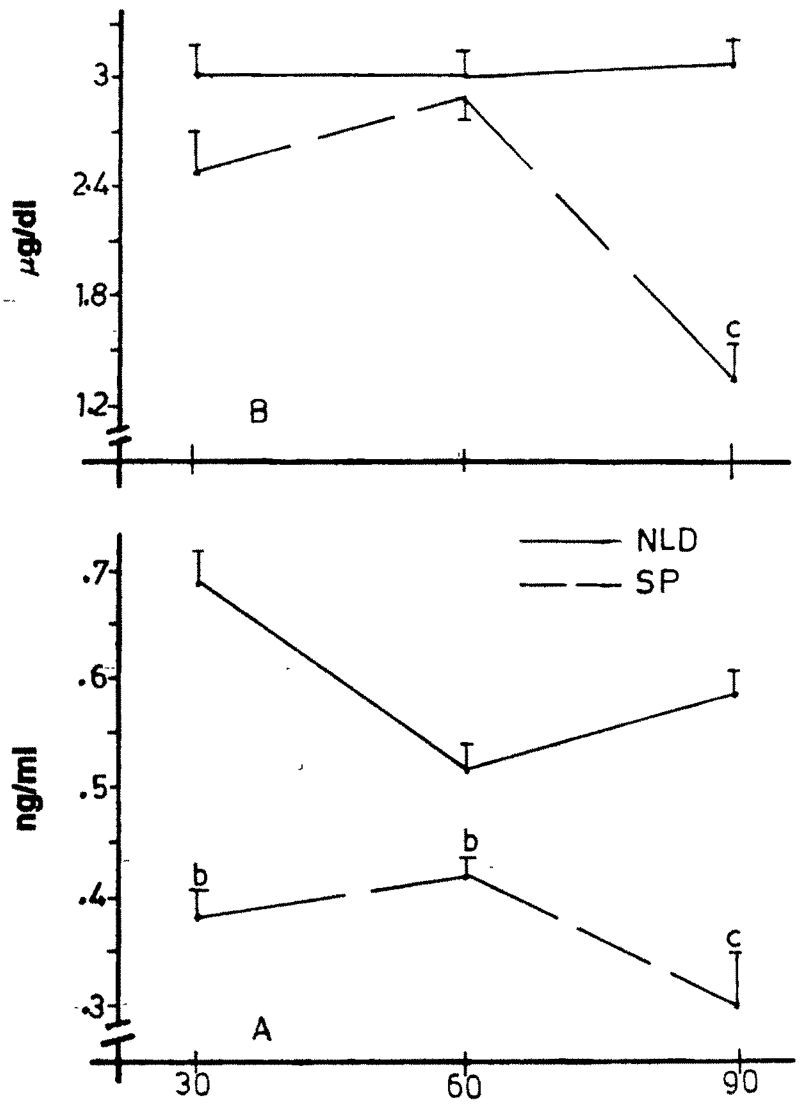

Fig. 10(A-B). Serum hormone levels of T_3 (A) andT_4 (B) in NLD and SP pullets.
Values : Mean, ±S.E, N= 12 **$^{b}P < .005$, $^{c}P < .0005$.**

Table : 5 Table showing ratios of various hormones with respect to other hormones, body weight and respective organ weight.

		30 days	***60 days***	***90 days***
T_3 : T_4	**NLD**	0.228	0.174	0.186
	SP	0.150	0.147	0.222
T_3 : Corticosterone	**NLD**	0.278	0.236	0.286
	SP	0.102	0.272	0.224
T_3 : Body wt.	**NLD**	0.0058	0.0016	0.0009
	SP	0.003	0.001	0.0005
T_3 :Thyroid wt.	**NLD**	0.057	0.020	0.0179
	SP	0.037	0.0276	0.0132
T_4 : Corticosterone	**NLD**	1.216	1.351	1.530
	SP	0.685	1.84	1.007
T_4 : Body wt.	**NLD**	0.025	0.0092	0.0053
	SP	0.021	0.009	0.002
T_4 :Thyroid wt.	**NLD**	0.251	0.154	0.0963
	SP	0.246	0.187	0.059
Corticosterone :Body wt.	**NLD**	0.021	0.0071	0.0034
	SP	0.030	0.0042	0.0022
Corticosterone:Adrenal wt.	**NLD**	0.115	0.0720	0.0301
	SP	0.222	0.037	0.028

Values : Mean

Table : 6 Table showing histometric data of ovary of NLD and SP pullets.

			Small 1 <30µm	Small2 31-90µm	Small3 91-120µm	Big1 21-240µm	Big2 241-440µm	Small 6-200µm	Big 200-300µm	Large >300µm	Total
30days	NLD	*Total*	23 (38%)	29(48%)	3 (5%)	5 (8%)	---	58	2	---	60
		A.F	2 (8%)	---	---	---	---				2(3%)
	SP	*Total*	22 (27%)	42(52%)	12 (15 %)	4 (5 %)	-	80	---	--	80
		A.F	4 (18%)	17(40%)	2(16 %)	1(25 %)	---				24(30%)
60days	NLD	*Total*	21(29 %)	35(48%)	7(8 %)	6(8 %)	3(4 %)	66	6	---	72
		A.F	8(38 %)	3(%)*	1(14 %)	1(%)*	---				12(%)
	SP	*Total*	28(35 %)	40(51%)	4(6 %)	5(6 %)	2(2 %)	77	2	---	79
		A.F	4(14 %)	5(12 %)	2(50 %)	---	---				11(13 %)
90days	NLD	*Total*	---	25(47%)	5(9 %)	17(32 %)	6(11 %)	35	14	4	55
		A.F	---	11(44%)	2(40 %)	3(18 %)	---				16(31 %)
	SP	*Total*	18(20 %)	31(35%)	12(13 %)	20(22 %)	7(8 %)	65	18	5	88
		A.F	1(5 %)	4(13 %)	5(41 %)	4(20 %)	---				14(15 %)

NLD: LD 12:12; SP: LD 6:18; *A.F* : Atretic follicles;

T able 6. Table showing percentage rate of transition from small (0-120μ) to big (121-240μ) and big to large(>300μ) follicular hirearchy in NLD and SP pullėts.

	30d		60d		90d	
	$S \Rightarrow B$	$B \Rightarrow L$	$S \Rightarrow B$	$B \Rightarrow L$	$S \Rightarrow B$	$B \Rightarrow L$
NLD	33%	---	9.8%	---	26.4%	7.5%
SP	0.00	---	2.5%	---	20.4%	5.7%

Values: Mean, N=12

signs of secretion exhaustion in the form of vacuoliasation (Plate 2).

Ovary :

The 30 day old ovary of both NLD and SP chicks was characterised by the presence of many primordial and primary follicles; however the granulosa of the follicles of SP chicks was quite prominent with visible signs of thecal condensation and prominent germinal vesicle. By 60 days, the follicles of both NLD and SP chicks were enlarged and few follicles depicted atretic changes. The stroma was, in general, well developed with visible signs of interstitial gland differentiation in the SP ovary. At 90 days, follicles were further enlarged with signs of yolk deposition in the oocyte. Thecal differentiation was well evident with active granulosa. Overall, the ovary of SP chicks showed lesser number of atretic follicles (Plate 3,4, and 5).

The approximate follicular count as represented in table-6, reveals a temporal progression from 6-30 µm diameter follicles to 240-440 µm diameter follicles from 30 days to 90 days in the ovary of both NLD and SP chicks. However, the total number of follicles and the relative number of follicles of various sizes were comparatively more in the ovary of SP chicks. There was also lesser number of atretic follicles. At 90 days, whereas the ovary of NLD birds showed no follicles of 6-30 µm range, the SP ovary showed the presence of such follicles in almost the same number as seen in the 30 and 60 days old ovary. The rate of transition in terms of percentage follicles entering into higher size hierarchy (table-7) revealed a slower rate in SP chicks with the presence of a higher percentage of follicles of less than 200 µm size at all periods.

DISCUSSION

The body and organ weights and the growth kinetics indicate an overall reduced weight and growth kinetics ratios in SP pullets. This decrement was essentially due to the significantly reduced weights and kinetics during the third month, while the same in the first two months were greater than the NLD pullets. Apparently, there is some growth retardatory influence in the third month. Though adrenal, thyroid and oviduct showed significantly reduced weights and growth indices in SP chicks, the ovary showed significantly higher weights and growth indices throughout. Though, rearing of chicks of domestic fowl under different photoperiodic conditions has been attempted by many workers, mainly to evaluate the effect of same on attainment of sexual maturity and egg laying, none of these studies has reported the effect of photoperiod on organ weights and growth kinetics. It is clear from the present study that SP has a favourable influence on a short term basis (60 days) but has a definite retardatory influence on growth and growth kinetics on prolonged long term exposure (beyond 60 days). Favourable influence of SP on organ growth is clearly manifested in the case of ovary (throughout) and also in the case of liver (first two months). However, the growth of adrenal, thyroid and oviduct has shown a negative correlation with SP throughout.

In general, the serum levels of T_3, T_4, CORT and Progesterone show a decrement with age in both the groups of chicks. The relative levels of all the hormones were lower in SP chicks at all the ages, except for CORT level at 30 day and the Progesterone levels at 30 and 60 days, which were higher. The higher level of CORT in the first month in SP chicks is well correlated with the recorded high relative weights of liver, thymus, bursa and spleen (Garren and Barber, 1955; Garren, 1957; Garren *et al.,*1966; Davison *et al.,* 1985). Apparently, CORT has a favourable influence on the growth of liver and lymphoid organs during the first 30 days. This correlation is validated by the few previous reports showing increased weights of liver and lymphoid organs during the first month (Garren *et* *al.,*1961; Davison *et al.,* 1979 Siegel *et al.,* 1979; Davison *et al.,* 1985). The higher serum level of CORT at 30 days is not supported by the weight and histological feature of adrenal. In this context, it may be speculated that, the metabolic clearance rate of CORT is significantly reduced under SP during the first month leading to a higher serum CORT level which results in favourable growth of CORT responsive organs. Despite the increased weights of liver and lymphoid organs in the first month in SP chicks, the weights of these organs levelled off at 90 days indicating a gradual nullification of initial growth burst. This is well corroborated by the significantly reduced CORT level during the second and third months. Though both T_3 and T_4 levels showed age dependent decrease in both the groups of chicks, the relative levels of both T_3 and T_4 were lower in SP chicks, more pronouncedly with respect to T_3 (approximately 40%). However, the serum T_4 level was significantly lower in the third month. There have been no studies regarding the measurement of hormone levels during the period of photoperiodic manipulations in rearing chicks, except for an isolated report of Renden *et al.* (1994) showing no alteration or slight reduction in adrenal and thyroid hormone levels at different ages during photoperiodic manipulations. The above study had however used shifting combinations of photoperiods which do not conform to an experimental design involving a fixed photoschedule as employed in the present study. The present report is therefore the first one, which projects reduced serum CORT, T_3 and T_4 profile due to exposure to SP. The significantly reduced growth rates of body, liver, ovary and oviduct between the 2nd and 3rd months and, the consequent effect on the weights of these organs at 90 days in the SP pullets, seem to be mainly due to lower levels of all the three hormones i.e T_3, T_4 and CORT. The T_3 : CORT ratio and T_4 : CORT ratios were also lower during the 3rd month (Table-5). However, the body weight and the weights of these organs were identical or even more than those of NLD chicks, with better growth rates. These observations tend to imply that the serum titres of T_3 and T_4 in the SP chicks during the first two months are within the optimum threshold level with no effect on Growth Hormone (GH) secretion/action. However, between 2nd and 3rd month the levels of T_3 and T_4 are below the optimum threshold level which may result in dampened GH secretion, as, correlation between GH secretion and thyroid hormone secretion has been revealed in both birds and mammals (Harvey *et al.,* 1978; Scanes *et al.,* 1981; Harvey *et al.,* 1983.; Kameda *et al.,* 1984; Huybrechts *et al.,* 1985; Thedaropoulos, 1985; Kuhn *et al.,* 1986; Lam *et al.,* 1986; Decuypere and Kuhn, 1988). The highly retarded growth of body and organs during the 3rd month, could be related to the reduced levels of growth promoting hormones like T_3, T_4, GH and Corticosterone. The consistently lower weights and growth rates of adrenal and thyroid in SP chicks seem to indicate SP induced slow maturation/activation of hypothalamo-hypophysial-thyroid and hypothalamo-hypophysial-gonadal axes. This is confirmed by the significantly lower hormone to body weight ratios with reference to thyroid and adrenal hormones.

The hypothalamo-hypophysial-gonadal axis however seems to be potentiated under exposure to SP from hatch, as marked by the significantly increased weight and histological picture of the ovary. The greater follicular pool and the presence of greater number of follicles in the size range of 31 - 90 µm and 91 - 120 µm in the ovary of SP chicks attest to the presumed activation of HHG axis. As an alternative to the potentiation of HHG axis, increased responsiveness/sensitivity of the ovarian tissue could also be considered feasible. The total follicular pool was significantly greater during the three months of study in the ovary of

SP pullets. There was a progressive transition from small to big and big to large category of follicles during the 2nd and 3rd months respectively, in the ovaries of both NLD and SP pullets. However, the relative number of such follicles was always lesser in the SP condition. The histometric data clearly reveals that the relative hierarchial progression of follicles in terms of size, is slower in the SP pullets compared to NLD. A comparison of the rate of transition shows that, while 3.3% of the follicles progress from small to big in the 1st month and 9.8% in the 2nd month in NLD chicks, in the SP chicks, it was nil in the 1st month and 2.5% in the 2nd month. Similarly in the 3rd month, whereas 26.4% of the follicles progressed from small to big and 7.5% from big to large in NLD pullets, only 20.4% progressed from small to big and 5.7% from big to large in SP pullets. Obviously, the pace of follicular progression is slowed down due to a exposure to a short photoperiod. Another aspect of clear distinction, is the degree of follicular atresia which decreased from a maximum 30% in the 1st month to a minimum of 5% in the 3rd month in SP chicks while, it increased from a minimum of 3% in the 1st month to a maximum of 31% in the 3rd month in NLD chicks. A related consequence of these changes is the presence of higher number of follicles of less than 200µm size at any time in the ovary of SP chicks and, more clearly, the continued presence of follicles of 0 - 30um size in the ovary of SP chicks while, there was a total absence of follicles of this size range in the ovary of NLD chicks in the 3rd month. The higher follicular pool and the persistent presence of follicles of smaller size range tend to suggest augmented oogonial proliferation coupled with lesser degeneration of germ cells, so that more germ cells are available for recruitment into follicles. The reduced rate of atresia seems to extend even to the follicles during folliculogenesis, as noted by the decreasing follicular atresia under SP condition. From extensive studies on mammals, androgens have been implicated as one of the factors involved in follicular atresia (see Knobil, 1990) and in this respect it can be speculated that there is reduced androgen production in the ovary of SP pullets which finds corroboration in the herein observed relatively higher levels of serum progesterone in the SP chicks in the 1st and 2nd months. The significantly reduced degree of follicular atresia and serum progesterone level in the 3rd month in SP chicks, suggest increased oestrogen production. The slower rate of follicular growth transition in SP chicks might provide them with more time for maturational changes and consequently an augmented stimulatory response to the increased hypothalamo-hypophysial output in response to a step-up photoperiod after 90 days (Sharp, 1993; see Etches, 1996), resulting in faster progression through white and yellow yolky follicular hierarchy, as characteristic of hens closer to sexual maturity and oviposition (see Etches, 1996). In this respect, our previous study had reported early attainment of sexual maturity and commencement of egg laying (by 53 days) in pullets exposed to SP to a step-up photoperiod (Chapter 1).

Overall, our present observations extend, the already established potential of a stepup photic schedule during rearing period to increase the stimulatory component of the HHG axis at the time of switch from short to long photoperiod (Sharp, 1993; see Etches, 1996), by providing evidence for favourable intraovarian changes during the period of exposure to SP and, consequent competence of the ovary in a quantitative and qualitative sense to respond to the increased hypothalamo-hypophysial output. The early initiation of egg laying and, relatively higher egg yield from these pullets as reported previously (Chapter 1), could be related to the present observations during the period of exposure to SP.