CHAPTER: 3

Effect of transient hypothyroidism on egg lay and egg composition of hens maintained under a step-up photoperiod.

Observations of stimulated egg production by exposure of hens to artificial lighting have helped recognize photoperiod as an important environmental variable for poultry productivity (Callenbach *et al.,* 1943; Morris, 1968; Dunn and Sharp, 1992; Shanawany *et al.,* 1993a; Tucher and charles, 1993). It was also shown that changes in the length of photoperiod during the rearing period have more consequential influence on the age at sexual maturity, egg weight and egg production (Eilan and Soller, 1991). The influence of light on reproductive potential of the domestic hen was deciphered to be an effect of change in day length and not related to absolute day length. The observation that hens mature sexually under widely different lighting regimes helped establish the relative unimportance of absolute day length (Lewis *et al.,* 1994). Both sensitivity to change in photoperiod as well as the age of optimal sensitivity was found to be not uniform as photoperiod of duration 8 to 16 hours proved to be more effective, and further, changes made at younger ages much earlier than the age of sexual maturity was more meaningful (Morris, 1963; Lewis *et al.,* 1992). Possibility of genetic differences also influencing photoperiodic responses was suspected (Shanawany *et al.,* 1993b). In this context, a previous study from this laboratory had recorded significantly earlier induction of egg lay by a step-up photoperiod from 6 hours to 12 hours given at the end of 90 days to the Rhode Island Red pullets (Dandekar, 1998). This advancement in initiation of egg lay was more significant in terms of days than the one noted by Lewis *et al.* (1996a) in ISA Brown and Shawer 288 breeds by a step up photoperiod from 8 to 13 hours given at the end of 84 days. A step up photoperiod during the rearing period of RIR pullets has therefore a favourable influence on reproductive potential and egg productivity.

Apart from the classical gonadotropins, the regulatory hormones of reproductive functions, even the modulatory influence of non classical hormones of adreno-cortical and thyroid origin are also increasingly realized in mammals. (Kalland *et al.,* 1978; Panka bostri *et al.,* 1982; Palmero *et al.,*1989; Francevilla *et al.,* 1991; Joyce *et al.,* 1993; 1992;1993; Dekrester *et al.,* 1995).

Differential interrelationship between adrenal and gonad has also been inferred in aves (Thapliyal and Pandha, 1967a, b; Jallageas and Assenmacher, 1973; 1974; Oshi and Konishi, 1978; Patel *et al.,* 1986; Ramachandran *et al.,* 1987; Dandekar, 1998).

Since the above studies were mostly conducted with adult birds, studies on immature birds were lacking and to that end a previous study made an attempt to evaluate the effects of hyper or hypo corticalism in growing pullets up to 90 days of age on various aspects of egg laying performance. Their studies suggested subtle favourable influences of both hyper and hypocorticalism on the overall egg laying performance of RIR birds (Dandekar, 1998). In the course of the present study, both a step-up photoperiod given at 90 days as well as timed induction of hypothyroidism between day 1 and 90 have shown favourable influences on attainment of sexual maturity and initiation of egg lay (chapters 1 and 2). In the present study, the combined effect of timed transient hypothyroidism and step-up photoperiod given at 90 days has been tested for attainment of sexual maturity, initiation of egg lay and egg composition.

Results:

Age at first egg and total number of eggs laid in the first month:

Whereas the control hens subjected to a step up photoperiod of 90 days laid the first egg at an average age of 116 days, the experimental groups of hens rendered hyperthyroidic prior to step up photoperiod laid the first egg at 144, 126,123 and 111 days respectively. This has resulted in a delay 28, 10, and 7 days respectively for hypothyroidic groups 1-3 and an enhancement by 5 days in group IV hypothyroid hens. The hens of group I and II laid significantly lower number of 14 and 7 eggs respectively during the first month as against 24 eggs by control hens and 33 and 30 respectively by the hens of group III and IV. (Table: 3.1, Fig: 3.1, 3.2)

Egg weight:

The weights of the first egg laid by hens of different groups were 23.0 gms (control), 29.3 gms (group I), 22.1 gms (group II), 28.1 gms (group III), 23.7 gms (group IV). There was an increase in egg weight from first laid egg to the 30th day egg in all the groups, the percentage increment was 33% (control), 26% (group I), 67% (group II), 17% (group III) and 42% (group IV). (See table: 3.2).

Physical parameters of eggs:

Eggs in the first week of the month

Except for group I, whose first day egg weight was higher than the control egg, the first day egg weight of all other groups was not significantly different. The egg weight was not significantly different in any other groups compared to controls. The shell weight was greater in all the experimental groups with the greatest in group II and least in group IV. Shell thickness was lesser in all the groups compared to control with maximum decrease in group I and almost identical in group III and group IV. Egg width was greater in all experimental groups except for group III. Shell height was slightly higher in group I and group II and lower in group III and group IV. The yolk and albumen weights were lower in all experimental groups. (Table: 3.3)

Eggs in the last week of the month:

Except for group III which showed lower egg weight and volume, all other groups showed no difference compared to controls. Shell weight and thickness were similar in all experimental groups as in the controls. Shell width and height were same in all experimental and control groups. Yolk and albumen weights were significantly lesser in all experimental groups compared to controls. (Table: 3.4)

Biochemical composition of eggs:

Metabolite content:

Whereas the first day eggs showed in general increased yolk protein content and decreased albumen protein content in the eggs of all the experimental groups compared to controls, the 30th day eggs showed decreased protein content in both yolk and albumen. The total lipid content of first day egg was significantly high in all the experimental groups relative to controls. However the albumen lipid content showed increased lipid content in group I and II birds and decreased in group III and IV birds. The 30th day eggs of all groups showed decreased yolk lipid content and increased albumen lipid content. Both the yolk and albumen cholesterol contents were lesser in the first day eggs of all groups. However in the 30th day egg, both the yolk and albumen content were higher in all experimental groups compared to controls. (Table: 3.5, 3.6; Fig: 3.3 to 3.13)

Percentage water and dry content

The first day eggs of all experimental groups showed in general decreased water content and increased dry content in both yolk and albumen, but in the 30th day eggs, whereas the percentage water content increased and percentage dry content decreased in the yolk, there was a reverse change of decreased water content and increased dry content in the albumen. (Table: 3.6; Fig: 3.14, 3.15)

Water and lipid indices and calorific value:

Whereas the yolk lipid index of the first day egg of all experimental groups was significantly higher compared to control, the same in the 30th day eggs was lower in the first group, higher in fourth group and similar in second and third groups compared to control. Relative to controls, the albumen lipid index was lesser in group II, higher in group III and similar in groups I and IV of first day eggs. However, the albumen lipid index of all groups was significantly lower with reference to the 30th day egg. Though there was no significant difference in the yolk water index of both first day and 30th day eggs relative to controls, the albumen- water index tended to be lower in the first day eggs and higher in the 30^{th} day eggs.

The whole egg calorific value of first day eggs of all experimental groups was significantly higher, while that of 30^{th} day eggs was significantly lower except for II and IV groups compared to the values of the control eggs. (Table: 3.8, 3.5, 3.6; Fig: 3.8)

Table3.1: Age at first egg and total no. of eggs in a month after initiation of lay under the effect of Hypothyroidism (HPOT) and step-up photoperiod in combination.

Experiment Groups	Age at first egg	Total no. of eggs/month
Control (SuP)	116.481 ±4.842	24.66 ±2.403
Group-I	144[b] ±3.0	14.50[a] ±1.864
Group-II	126 ±1.154	17.50 ±2.500
Group-III	123.5 ±0.50	33.50 ±3.5
Group-IV	111.66 ±2.962	30.66 ±2.185

Group-I: 15-45 day HPOT, Group-II: 30-60 day HPOT; Group-III: 45-75 day HPOT; Group-IV: 60- 90 days HPOT

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

Table 3.2: Average egg weight (gm) under the effect of Hypothyroidism (HPOT) and step-up photoperiod

Days after initiation of lay	Experiment Groups				
	Control (SuP)	Group-I	Group-II	Group-III	Group-IV
1	23.04 ±1.142	29.33[a] ±0.981	22.12 ±0.161	27.18 ±2.22	23.72 ±1.075
5	24.83 ±1.620	33.15[b] ±0.395	29.74 ±1.118	27.44 ±0.125	25.45 ±1.61
10	28.43 ±1.96	33.705 ±0.310	30.57 ±1.11	28 12 ±1.539	26 69 ±0.46
15	30.16 ±0.138	34.09 ±0.83	32.73 ±1.26	29.64 ±2.05	29.59 ±0.690
20	33.51 ±0.138	34.26 ±1.110	33.48 ±1.103	30.39 ±1.37	32.42 ±0.47
25	33.89 ±1.16	34.88 ±0.36	34.91 ±1.81	31.65 ±1.65	33.53 ±1.53
30	34.83 ±1.28	37.1 ±0.58	36.88 ±0.93	32.96 ±1.80	33.63 ±1.02
Over all Egg wt	**29.81 ±1.75**	33.78 ±0.88	31.49 ±1.81	29.62 ±0.82	29.29 ±1.53

Group-I: 15-45 day HPOT, Group-II: 30-60 day HPOT; Group-III: 45-75 day HPOT; Group-IV: 60- 90 days HPOT

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

Table3.3: Physical Parameters of Egg under the effect of hypothyroidism (HPOT) and step-up photoperiod in combination during first week of initiation of lay

Parameters	Experiment Groups				
	Control (SuP)	Group-I	Group-II	Group-III	Group-IV
Weight (gm)	22.41 ±3.246	28.006 ±0.667	23.46 ±0.905	22 778 ±1.951	24.825 ±1.795
Volume (CC)	19.53 ±5.783	22.633 ±0.835	19.58 ±1.317	16.41 ±2.601	14.50 ±1.530
Shell Weight (gm)	1.92 ±0.404	2.456 ±0.199	2.994 ±0.256	2.387 ±0.040	2.115 ±0.013
Shell Thickness (cm)	0.035 ±0.002	0.026 ±0.0005	0.029 ±0.003	0.032 ±0.0025	0.031 ±0.0028
Width (cm)	3.18 ±0.117	3.404 ±0.136	3.592 ±0.036	3.247 ±0.076	3.533 ±0.188
Height (cm)	4.21 ±0.391	4.403 ±0.069	4.462 ±0.103	4.011 ±0.171	4.069 ±0.088
Yolk Weight (gm)	5.9 ±0.877	6.478 ±0.520	5.20 ±0.964	5.046 ±0.136	5.538 ±0.248
Albumen Weight (gm)	14.2 ±2.800	18.94 ±1.151	15.32 ±0.254	14.7 ±0.577	16.877 ±1.96
Yolk: Albumen ratio	0.41	0.34	0.33	0.34	0.32

Group-I: 15-45 day HPOT, Group-II: 30-60 day HPOT; Group-III: 45-75 day HPOT; Group-IV: 60- 90 days HPOT

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

Table3.4: Physical Parameters of Egg under the effect of Hypothyroidism and step-up photoperiod in combination during the last week of first month of lay.

Parameters	Experiment Groups				
	Control (SuP)	Group-I	Group-II	Group-III	Group-IV
Weight (gm)	33.65 ±0.124	32.8 ±1.510	37.4 ±3.218	26.95 ±2.423	31.95 ±1.460
Volume (CC)	29.61 ±0.348	29.9 ±0.081	35.77 ±1.153	23.5 ±2.466	29.07 ±0.809
Shell Weight (gm)	2.94 ±1.050	2.608 ±0.035	3.397 ±0.118	2.547 ±0.110	2.992 ±0.230
Shell Thickness (cm)	0.028 ±0.001	0.024 ±0.002	0.030 ±0.0003	0.029 ±0.001	0.027 ±0.001
Width (cm)	3.76 ±0.450	3.557 ±0.057	3.688 ±0.045	3.391 ±0.092	3.561 ±0.024
Height (cm)	5.42 ±0.386	4.757 ±0.073	4.805 ±0.037	4.461 ±0.120	4.654 ±0.131
Yolk Weight (gm)	8.89 ±0.461	10.28 ±0.481	9.71 ±0.180	8.82 ±0.310	5.91 ±0.461
Albumen Weight (gm)	20.26 ±2.024	19.02 ±0.912	23.466 ±0.808	15.54 ±1.45	22.98 ±3.024
Yolk: Albumen ratio	0.48	0.54	0.405	0.56	0.257

Group-I: 15-45 day HPOT, Group-II: 30-60 day HPOT; Group-III: 45-75 day HPOT; Group-IV: 60- 90 days HPOT

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

Table3.5: Egg composition mg/100mg yolk or albumen under the effect of Hypothyroidism and step-up photoperiod in combination during the first week of initiation of lay.

Experiment Groups	Total protein		Total lipid		Total cholesterol		Calorific value (calories)
	Yolk	Albumen	Yolk	Albumen	Yolk	Albumen	
Control (SuP)	19.675 ±2.181	15.996 ±2.219	18.437 ±1.984	0.037 ±0.005	1.0839 ±0.259	0.004 ±0.0009	69.88
Group-I	22.73 ±3.35	26.456^{c} ±2.63	49.80^{c} ±4.18	0.0429 ±0.0034	0.807^{c} ±0.050	0.008^{c} ±0.0002	181.69
Group-II	20.93 ±1.23	24.772^{b} ±1.62	22.126 ±2.45	0.021 ±0.001	0.703^{c} ±0.29	0.0016^{a} ±0.0003	90.89
Group-III	23.851 ±1.77	30.848^{c} ±1.31	49.517^{c} ±7.15	0.093^{c} ±0.005	0.526^{c} ±0.058	0.0011 ±0.0003	170.33
Group-IV	20.79 ±2.28	23.172^{b} ±0.69	25.485^{a} ±1.57	0.048 ±0.002	0.526^{c} ±0.035	0.0010 ±0.0001	101.83

Group-I· 15-45 day HPOT, Group-II: 30-60 day HPOT; Group-III: 45-75 day HPOT; Group-IV: 60- 90 days HPOT

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

Table3.6: Egg composition mg/100mg yolk or albumen under the effect of Hypothyroidism and step-up photoperiod in combination during the last week of first month of lay.

Experiment Groups	Total protein		Total lipid		Total cholesterol		Calorific value (calories)
	Yolk	Albumen	Yolk	Albumen	Yolk	Albumen	
Control (SuP)	23.562 ±2.322	24.329 ±3.640	30.052 ±2.835	0.0142 ±0.0003	1.138 ±0.226	0.0006 ±0.0001	155.87
Group-I	19.457 ±2.027	18.007 ±0.625	20.596 ±0.403	0.0497 ±0.008	1.812 ±0.1486	0.0012 ±0.0006	111.38
Group-II	20.906 ±3.672	19.868 ±1.066	30.009 ±1.291	0.043 ±0.0075	2.2841 ±0.320	0.00086 ±0.0003	161.95
Group-III	20.360 ±0.592	22.574 ±3.467	33.053 ±3.2016	0.0671 ±0.0075	1.2665 ±0.466	0.0012 ±0.0002	128.06
Group-IV	20.621 ±1.267	16.318 ±1.222	42.327 ±4.763	0.0842 ±0.005	2.9258 ±0.418	0.00016 ±0.00005	171 30

Group-I: 15-45 day HPOT, Group-II: 30-60 day HPOT; Group-III: 45-75 day HPOT; Group-IV: 60- 90 days HPOT

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

Table3.7: Effect of HPOT and step-up photoperiod on % water content and % dry content /100gm of egg's yolk and albumen.

Treatment	During the first week of initiation of lay				During the last week of initiation of lay			
	Yolk		Albumen		Yolk		Albumen	
	% water content	% dry content	% water content	% dry content	% water content	% dry content	% water content	% dry content
Control (SuP)	52.04 ±2.368	48.48 ±2.389	85.54 ±2.54	14.45 ±1.53	51.668 ±2.477	48.330 ±1.477	81.404 ±1.54	18.595 ±0.549
Group I	42.63 ±2.38	57.36 ±3.18	81.321 ±3.48	18.67 ±3.48	48.89 ±1.12	51.607 ±1.62	87.757 ±1.50	12.242 ±0.057
Group II	50.129 ±2.21	49.87 ±2.2	86.343 ±2.1	13.656 ±1.40	54.281 ±1.823	45.714 ±1.8	84.858 ±1.8	15.143 ±0.89
Group III	51.952 ±1.42	48.04 ±1.41	81.625 ±3.48	18.36 ±3.40	50.00 ±1.283	49 99 ±1.236	83.057 ±1.501	16.941 ±0.503
Group IV	45.227 ±1.14	54.68 ±2.83	82.64 ±2.3	17.65 ±2.031	49.29 ±1.74	50.06 ±1.63	86.336 ±1.713	13.655 ±0.721

Group-I: 15-45 day HPOT, Group-II: 30-60 day HPOT; Group-III: 45-75 day HPOT;
Group-IV: 60- 90 days HPOT
Values expressed as Mean ± S.E, n=6; a: $p \leq 0.05$, b: $p \leq 0.02$, c: $p \leq 0.001$

Table3.8: Effect of HPOT and step-up photoperiod on water index and lipid index

Treatment	During the first week of initiation of lay				During the last week of initiation of lay			
	Water index		Lipid index		Water index		Lipid index	
	Yolk	Albumen	Yolk	Albumen	Yolk	Albumen	Yolk	Albumen
Control (SuP)	1.673	5.91	0.38	0.002	1.06	4.37	0.621	0.0007
Group I	0.743	4.37	0.90	0.008	0.92	4.19	0.631	0.0004
Group II	1.00	5.32	0.44	0.001	1.18	5.60	0.65	0 0004
Group III	1.08	4.44	1.03	0.007	1.00	4.90	0.66	0.0003
Group IV	0.82	4.68	0.46	0.002	0.98	6.32	0.84	0.006

Group-I: 15-45 day HPOT, Group-II: 30-60 day HPOT; Group-III: 45-75 day HPOT; Group-IV: 60- 90 days HPOT

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

Fig.3.1:Age at first egg under the effect of HPOT and Step-Up photoperiod in different groups of RIR hens

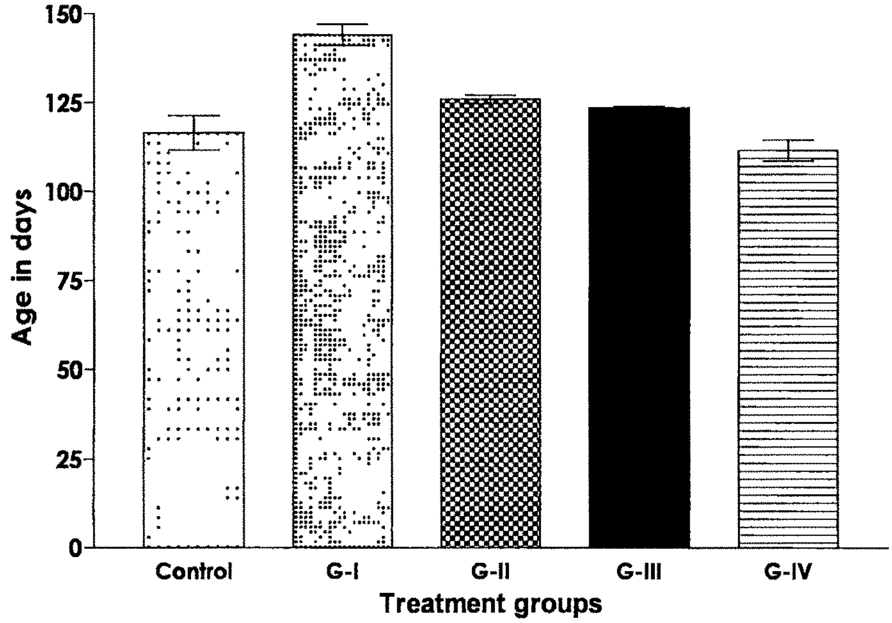
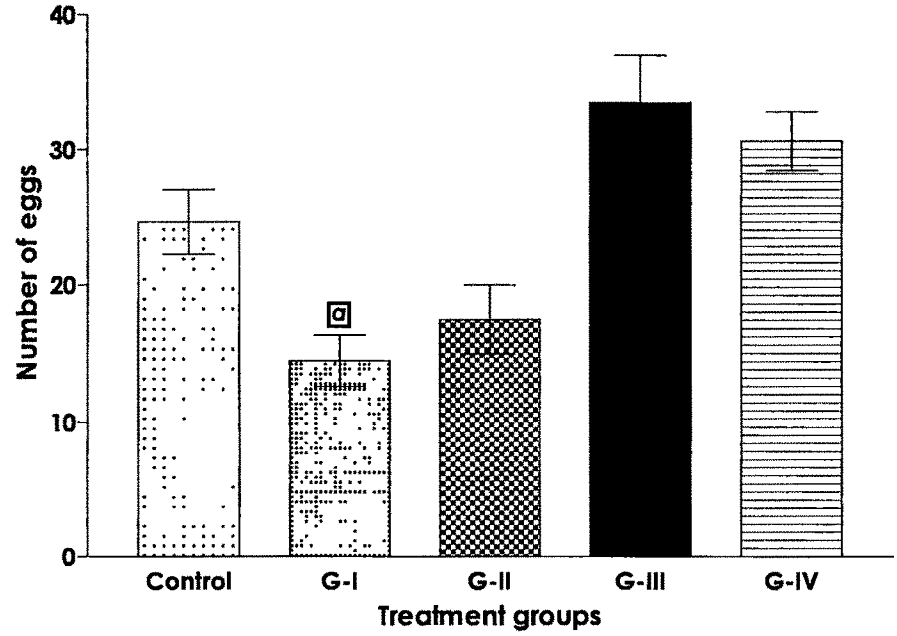


Fig.3.2: Number of eggs laid under the effect of HPOT and Step-Up photoperiod by different groups of RIR hens



Control: SuP, Gr-I: 15-45day HPOT, Gr-II. 30-60day HPOT, Gr-III: 45-75day HPOT, Gr-IV: 60-90day HPOT, a: $p \leq 0.05$, b: $p \leq 0.02$, c: $p \leq 0.001$ of 6 animals

Fig.3.3: Proptein (mg/100mg) yolk or albumen in HPOT hen's eggs at Step up photoschedule on First week of initiation of lay.

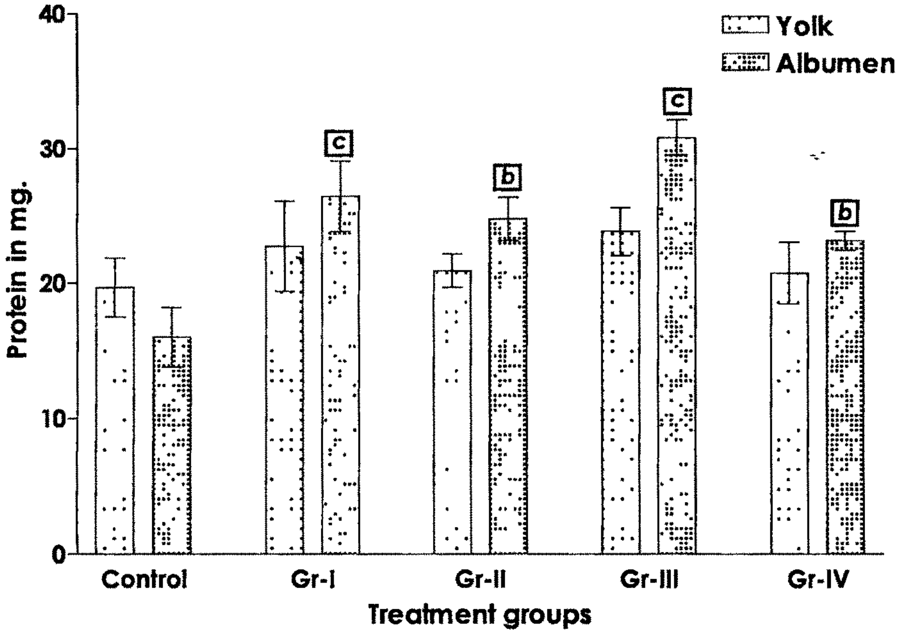
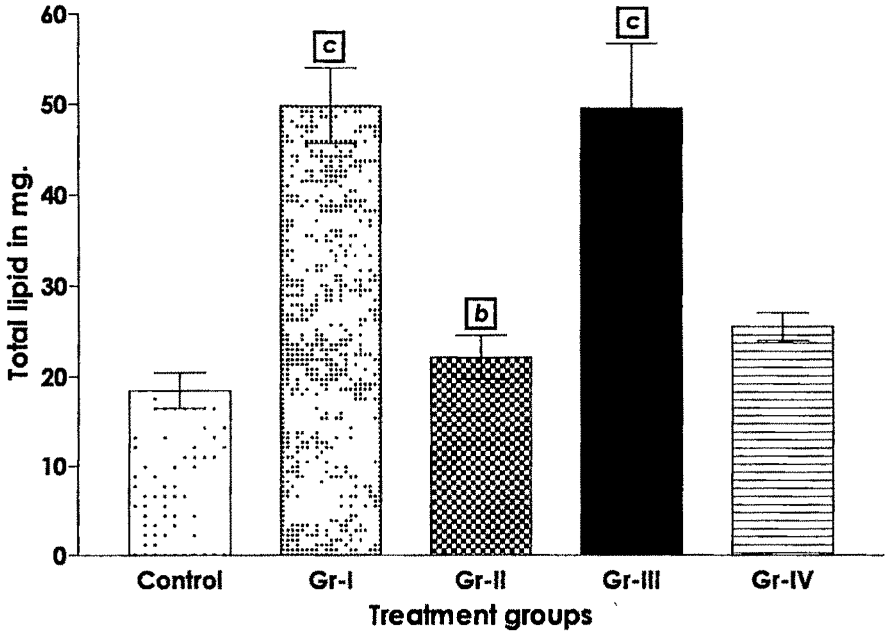


Fig.3.4: Total lipid(mg/100mg yolk) in HPOT hen's eggs at Step-Up photoperiod on first week of initiation of lay.



Control: SuP, Gr-I: 15-45day HPOT, Gr-II: 30-60day HPOT, Gr-III: 45-75day HPOT, Gr-IV: 60-90day HPOT, a: $p \leq 0.05$, b: $p \leq 0.02$, c: $p \leq 0.001$ of 6 animals

Fig.3.5: Total lipid(mg/100mg) albumen in HPOT hen's eggs at Step-Up photoperiod on first week of initiation of lay.

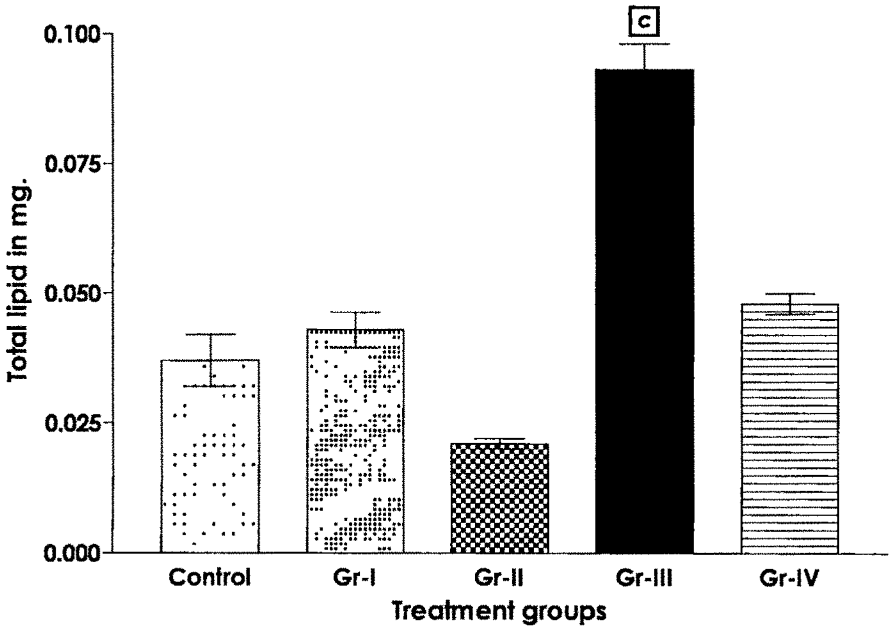
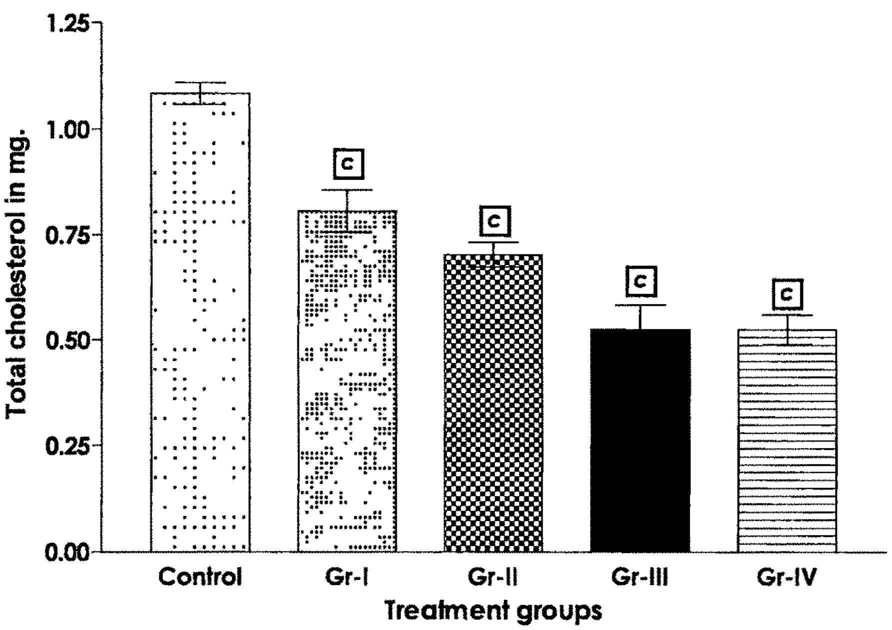


Fig.3.6: Total cholesterol(mg/100mg) yolk in HPOT hen's eggs at Step-Up photoperiod on first week of initiation of lay.



Control: SuP, Gr-I: 15-45day HPOT, Gr-II: 30-60day HPOT, Gr-III: 45-75day HPOT, Gr-IV: 60-90day HPOT, a: $p \leq 0.05$, b: $p \leq 0.02$, c: $p \leq 0.001$ of 6 animals

Fig.3.7: Total cholesterol (mg/100mg) albumen in HPOT hen's eggs at Step-Up photoperiod on first week of initiation of lay.

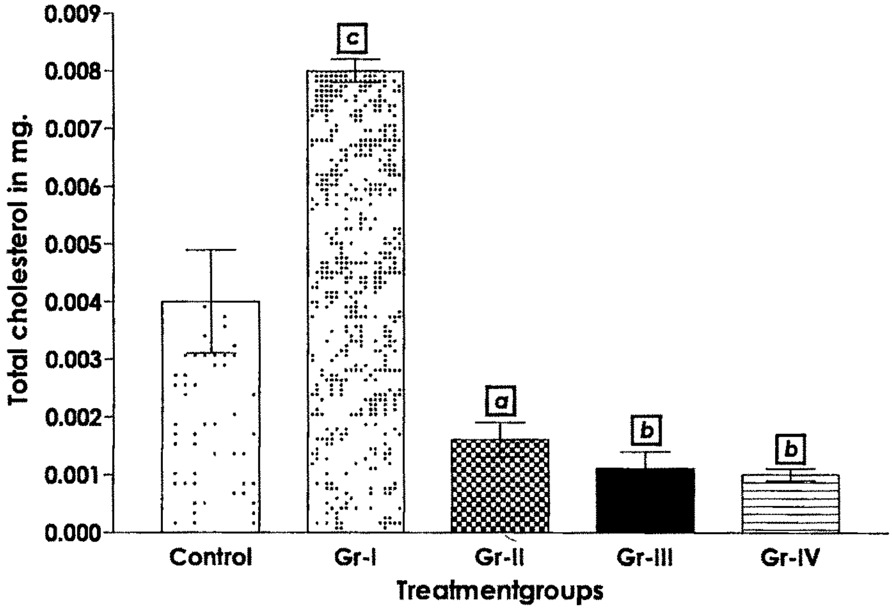
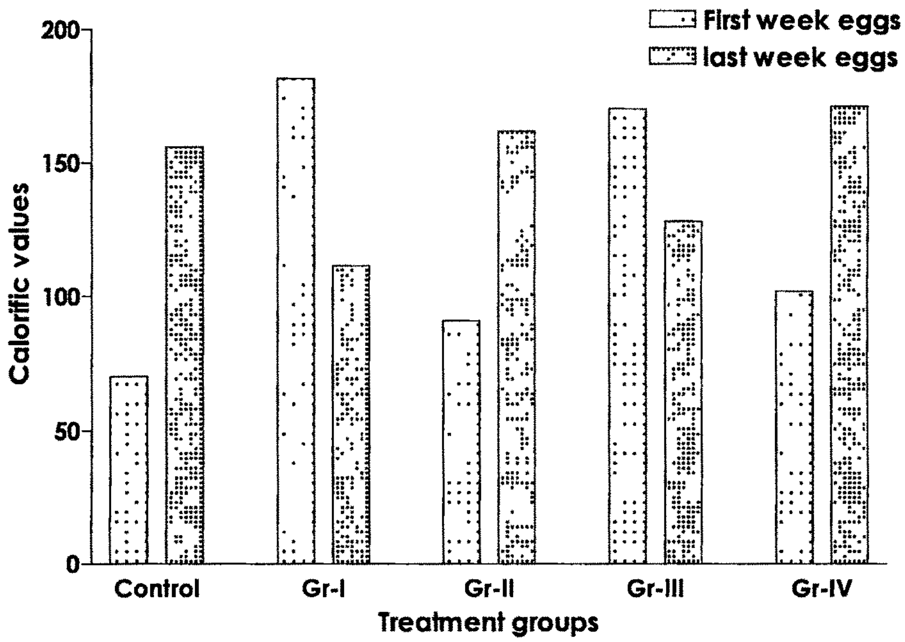


Fig.3.8: Calorific values of HPOT hen's at Step-Up photoperiod.



Control: SuP, Gr-I: 15-45day HPOT, Gr-II: 30-60day HPOT, Gr-III: 45-75day HPOT, Gr-IV: 60-90day HPOT, a: $p \leq 0.05$, b: $p \leq 0.02$, c: $p \leq 0.001$ of 6 animals

Fig.3.9: Total protein(mg/100mg)yolk or albumen in HPOT hen's eggs at Step-Up photoperiod on first week of initiation of lay.

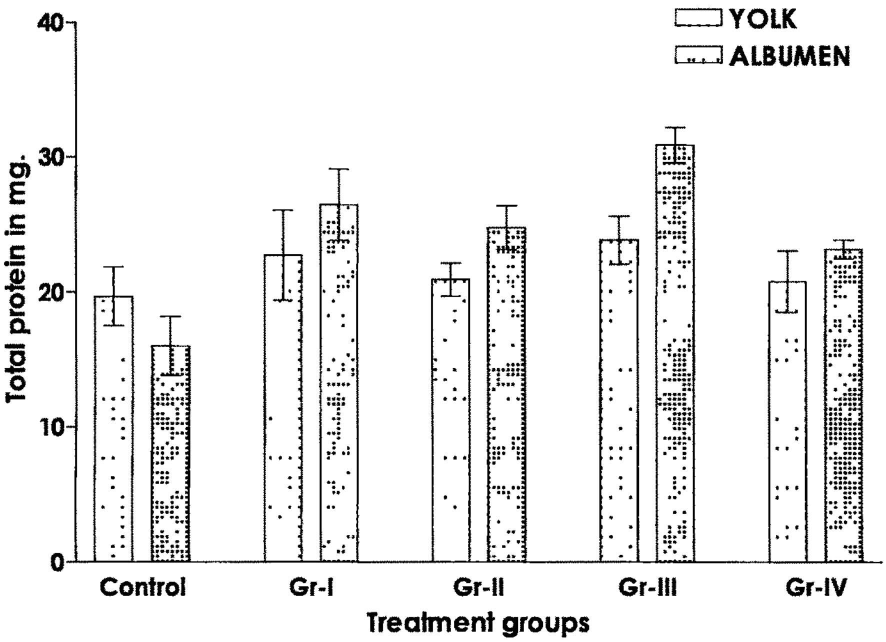
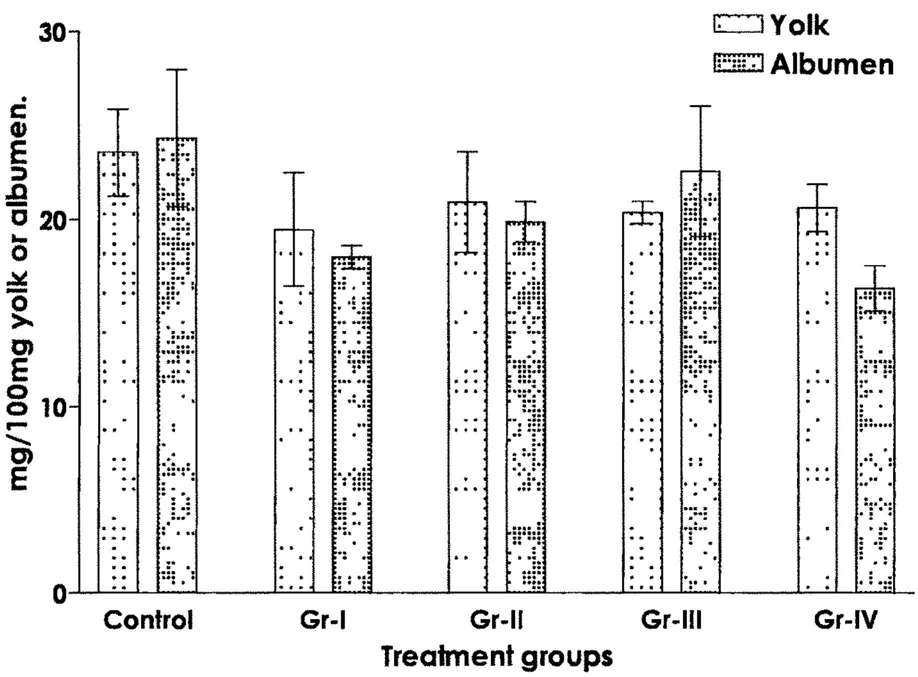


Fig.3.10: Total protein in yolk or albumen of HPOT eggs at Step-Up photoperiod during last week of first month of lay.



Control: SuP, Gr-I: 15-45day HPOT, Gr-II: 30-60day HPOT, Gr-III: 45-75day HPOT, Gr-IV: 60-90day HPOT, a: $p \leq 0.05$, b: $p \leq 0.02$, c: $p \leq 0.001$ of 6 animals

Fig.3.11: Total lipid in yolk of HPOT eggs at Step-Up photoperiod on last week of first month of lay.

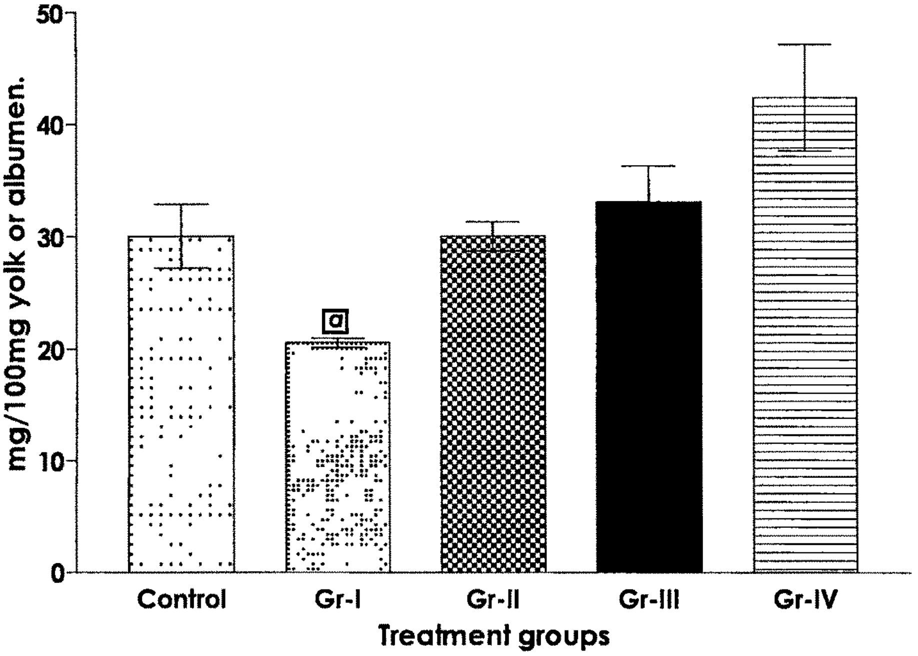
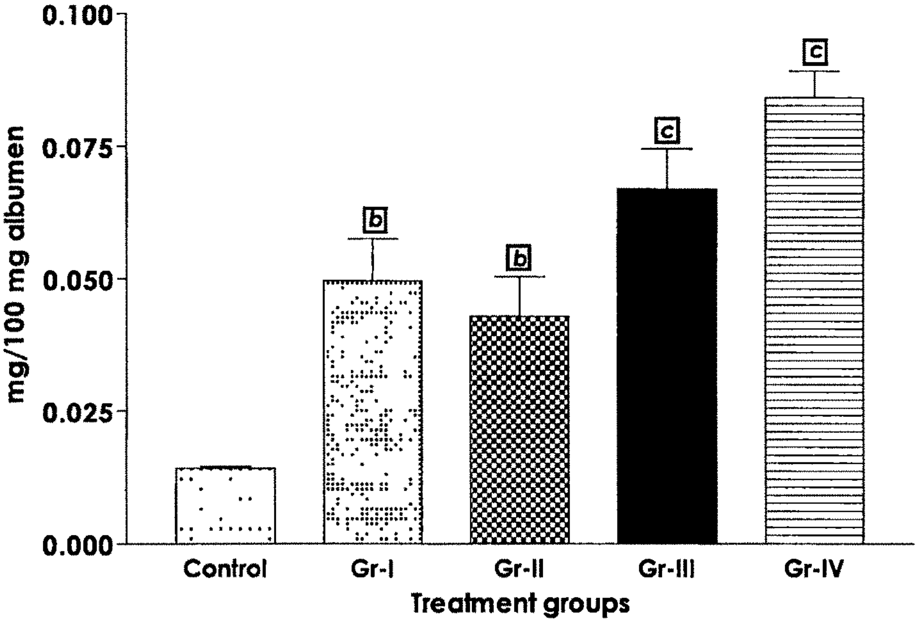


Fig. 3.12: Total lipid inalbumen of HPOT eggs at Step-Up photoperiod on last week of first month of lay.



Control: SuP, Gr-I: 15-45day HPOT, Gr-II: 30-60day HPOT, Gr-III: 45-75day HPOT, Gr-IV: 60-90day HPOT, a: $p \leq 0.05$, b: $p \leq 0.02$, c: $p \leq 0.001$ of 6 animals

Fig.3.13: Total cholesterol of HPOT eggs at Step-Up photoperiod on last week of first month of lay.

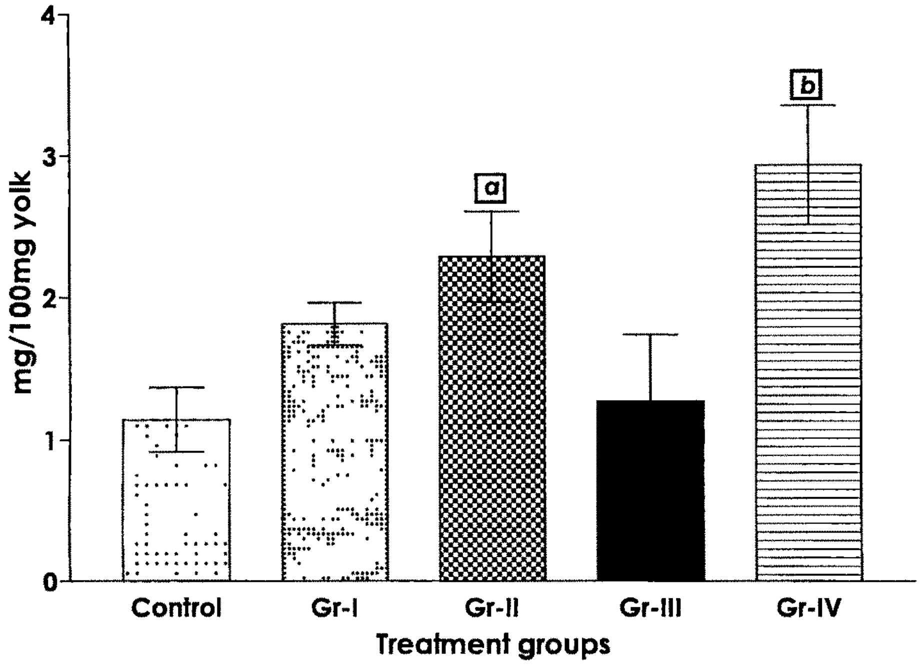
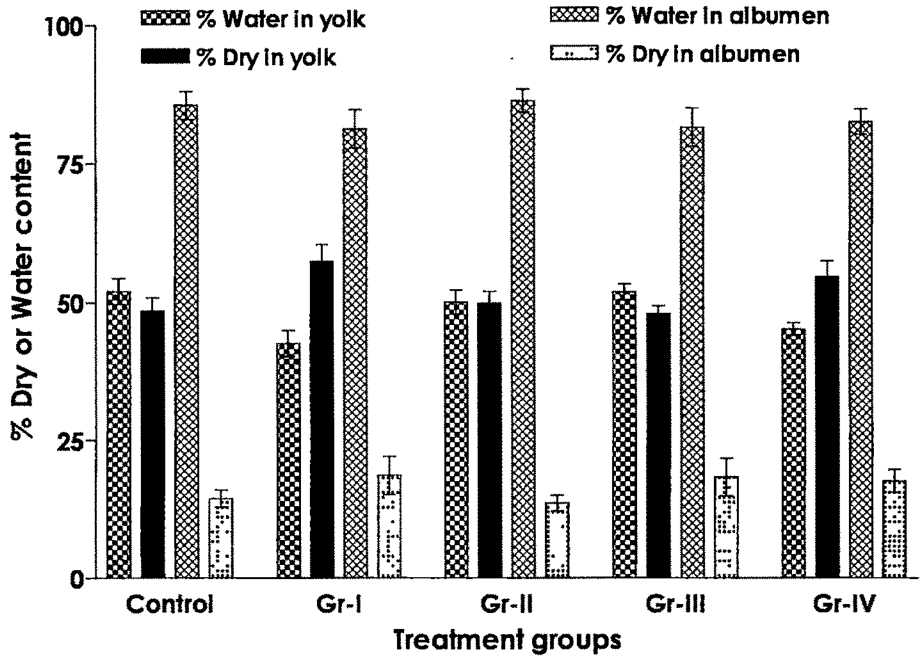
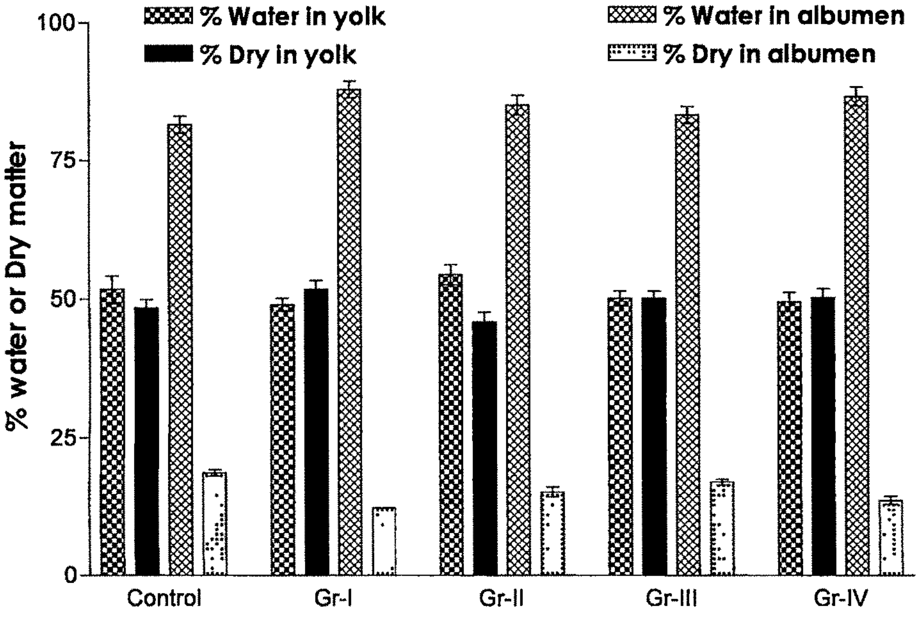


Fig.3.14: % Water or Dry matter in HPOT treated hen's eggs at Step-Up photoperiod on first week of initiation of lay.



Control: SuP, Gr-I: 15-45day HPOT, Gr-II: 30-60day HPOT, Gr-III: 45-75day HPOT, Gr-IV: 60-90day HPOT, a: $p \leq 0.05$, b $p \leq 0.02$, c: $p \leq 0.001$ of 6 animals

Fig.3.15: % Water or Dry matter in HPOT treated hen's eggs at Step-Up photoperiod on last week of first month of lay.



Control: SuP, Gr-I: 15-45day HPOT, Gr-II: 30-60day HPOT, Gr-III: 45-75day HPOT, Gr-IV: 60-90day HPOT, a: $p \leq 0.05$, b: $p \leq 0.02$, c: $p \leq 0.001$ of 6 animals

Discussion:

A previous study on timed transient induction of hypothyroidism for 30 day starting from 15, 30, 45 or 60 days has shown a gradual advancement in initiation of egg lay with a maximum advancement of 39 days in 60 to 90 days hypothyroid hens and a minimum of 13 days in the 15 to 45 days hypothyroid hens. Another study in which pullets have been subjected to a step – up photoperiod from 90 to 180 days of age had shown a significant advancement by 42 days as in the present control group. However, in the present study in which hypothyroidism has been combined with a step – up photoperiod, has shown a nullifying influence of hypothyroidism on the favourable influence of step – up photoperiod. Apparently, previous hypothyroidic history seems to have a dominant influence over the later step – up photoperiodic influence. In this context, the only group which has shown a favourable influence of a sequential combination of hypothyroidism followed by step – up photoperiod is the one rendered hypothyroidic between 60 and 90 days as these hens showed an advancement in age at 1st egg by 5 days compared to hypothyroidism alone and an advancement by 8 days compared to step – up photoperiod alone. When considered along with the total number of eggs laid in the 1st month, the 60 to 90 and 45 to 75 days HPOT + SuP groups seems to have the best results as the number of eggs laid is more by 6 and 9 respectively compared to SuP alone hens and 9 and 11 eggs more respectively compared to corresponding HPOT alone hens. Inferably, hypothyroidism induced during 45 to 75 or 60 to 90 days first, prior to shifting to a step – up photoperiod, is more favourable in terms of age at 1st egg and total egg lay. Though the influence of hypothyroidism has a dominant influence on step – up photoperiod, it is also clear that a step – up photoperiod improves the number of eggs laid in early age hypothyroid group, where hypothyroidism alone had a significant negative effect on the number of eggs laid(chapter 2). How a transient hypothyroidic state first, prior to changing the photoperiod to a step-up schedule translates itself into a favourable influence on initiation and total egg lay is a matter of conjecture. It is likely that hypothyroidism prior to application of a step-up photoperiod, has a permissible influence on pre-mature activation of the hypothalamo-hypophyseal-gonadal axis. In fact, a favorable influence of hypothyroidism in early attainment of sexual maturity and higher egg yield was shown by Singh and Parshad (1978) in white leghorn chicks. Since it is reported that PTU treated hypothyroid pullets respond by hyper secretion of thyroid hormones in the post PTU treatment periods, as it is also likely that increased thyroid hormone levels at the critical period of step-up photoperiod. Induction of maturation of the hypothalamo-hypophyseal axis potentiates the response.

Whatever be the mechanism, the present study clearly shows critically timed hypothyroidism prior to a step – up photo stimulation has an additive favourable influence on age at first egg as well as total egg lay in the initial phase of oviposition. The average egg weight for the first month of lay shows no significant difference between various hypothyroid groups subjected to a Step - up Photoperiod compared to SuP alone group. However, there is a tendency for earlier hypothyroid groups (group I and group II) to have heavier eggs. But in comparison to the corresponding HPOT alone hens studied previously, the HPOT + SuP eggs are lighter (Chapter 2). There are a few studies available on hypothyroidism induced effects on age at first egg, egg weight and the number of eggs laid in white leghorn pullets (Singh and Parshad, 1978; Peebles *et al.*, 1994; 1997) and these have been reviewed in relation to timed hypothyroidism in the Rhode island Red breed of pullets (Chapter 2). Since, there are no study on the effect of a combination of hypothyroidism and step - up photoschedule, much less in a sequential schedule, it is difficult to discuss the present observations more objectively.

The 9-13 and 6-11 HPOT + SuP groups showed significantly lower egg volume during the initial lay, while in the last week of lay, the egg volume was lower only in the 6-11 HPOT + SuP group. The eggs of almost all groups of hens have shown a near 50% increment in egg volume except for the 2 – 6 and 6 – 11 weeks

HPOT + SuP groups. Apparently a sequential combination of HPOT + SuP adequately compensates for the decrease in egg weight and volume caused due to early initiation of lay due to HPOT alone (Chapter 2). The shell weight of 1st day egg is higher in all hypothyroid groups (highest in 4 – 9 week and lowest in 9 – 30 week HPOT + SuP) and shell weight of 30th day egg is similar to controls in 2 – 6 and 9 – 13 weeks of HPOT + SuP hens and significantly higher in 4 – 9 weeks HPOT + SuP and significantly lower in 6 – 11 weeks HPOT + SuP groups. Decreased shell thickness was seen in hypothyroid egg (Chapter 2) and similar observation was made by Singh and Parshad (1978) in white leghorn hens. An effect of altered thyroid activity on egg shell formation has been suggested earlier (Wentworth and Ringer, 1986). In this connection, Asmundson and Pinsky (1935) had observed increased shell weight in birds fed with desiccated thyroid during lay and further, Peebles *et al.* (1992) have recorded decreased shell weight per unit area in white leghorn chicks fed 0.1 % dietary thiouracil. Though Peebles *et al.* (1994) could not record any change in egg quality in their white leghorn chicks rendered hypothyroidic from 0-6 or 6-16 weeks of rearing, in RIR chicks decreased shell thickness due to hypothyroidism has been recorded (chapter -2). However hypothyroidism coupled with Step - up photoperiod seems to nullify the effect of hypothyroidism on shell thickness. Interestingly the difference observed in shell weight in the present study is essentially due to an increase in shell width in the 1st day eggs and due to decreased shell height in the 30 day eggs of HPOT + SuP hens.

In terms of yolk and albumen contents, the 1st day eggs of HPOT + SuP birds do not show any significant difference compared to SuP controls, though there is a tendency for slight increase in albumen content in the 2-6 and 6-11 weeks HPOT + SuP birds. Neither is there any significant difference in the contents of 30th day eggs except for a decrease yolk content in the 9-13 week HPOT + SuP and decreased albumen content in the 6-11 week HPOT + SuP eggs. The above observed decrease in yolk and albumen contents is essentially due to unchanged content in the 9-13 and 6-11 HPOT + SuP eggs respectively relative to 1st day eggs. In all other cases there is a comparable proportionate increase in yolk and albumen contents from 1st day to 30th day egg.

Even in terms of percentage of water and solid contents in yolk and albumen of 1st day eggs or 30th day eggs, there is no great difference between the various groups. The only noticeable effect is decreased water content with increased dry content in the yolk of 1st day egg of 2 – 6 and 9 – 13 week HPOT + SuP eggs and a generalized tendency for increased water content with decreased dry content in the albumin of 30th day eggs of all

HPOT + SuP bird. In a previous study, hypothyroidism alone given at different periods between 2 and 13 weeks of rearing age was seen to have some effects on percentage dry content of the late hypothyroid groups (Chapter 2). The conservative and critical importance of water content for avian embryonic development and the relatively lesser content of water in the yolk due to increased lipid load have been well recognized (Roca *et al.*, 1984). Accordingly, hypothyroidism between 9 – 13 weeks was suggested to favour developmental activities due to the increased solid content in both yolk and albumen (Chapter 2). The presently observed changes indicate that SuP given subsequent to HPOT nullifies the above changes in the water and solid content of yolk and albumen caused due to hypothyroidism alone.

There are some interesting alterations with reference the metabolite contents of yolk and albumen from the 1st day to 30th day eggs when compared with control SuP and experimental HPOT + SuP eggs. Whereas the protein content of yolk and albumen and the lipid content of yolk tended to show increase from the 1st day to 30th day eggs in the SuP birds, there is significantly increased yolk and albumen protein contents and yolk lipid content of the1st day egg of HPOT + SuP hen, which remains either constant or if at all a slight decrease by the 30th day. Similarly, the albumen lipid content and the albumen cholesterol content of the HPOT + SuP eggs are higher right from the 1st day comparable to the 30th day contents of SuP eggs only. The yolk cholesterol content shows gradual increase from 1st day to 30th day of HPOT + SuP birds which results in a higher content in the 30th day.

A temporal increase in yolk lipid content from 1st to 60th day of lay has also been reported in the Ostrich (Superchi *et al.*, 2002). Lipids usually constitute about 30 % or yolk and they are the primary nutrient source to the developing embryo (Speak *et al.*, 1998). Lipids also provide a range of essential components for tissue development and functionality (Noble *et al.*, 1996a) and also Supply over 90 % of energetic needs. The β - oxidation of fatty acids is the predominant pathway of energy provision in this system (Freeman and Vince, 1974) and approximately 50 % of the initial fatty acid content of the yolk is recovered in the tissue lipids of the chick (Nobel and Coechi, 1990; Lin *et al.*, 1991) while, the remaining part is used for energy production.

Interestingly, Hall and McKay (1993) had inferred the occurrence of higher yolk cholesterol content in the early eggs of Hisex – Brown breed of hens commencing lay at an earlier age to be due to a high cholesterol laden plasma lipo-protein in the immature birds as against low cholesterol laden plasma lipo-protein in the mature ovary. However, in the present study though the 1st laid eggs had higher yolk and lipid content and higher water and lipid indices, by the 30th day egg, these parameters had decreased below the SuP (control) levels. Similarly, the cholesterol content which was lower in the 1st day eggs increase to higher level in the 30th day eggs. These changes suggest an altered lipid metabolism in the oviduct as well as altered lipo-protein metabolism due to HPOT and SuP. In terms of nutritional value, the eggs of HPOT + SuP birds have a higher calorific value especially in the 1st laid eggs. However, this gets reversed to lower calorific value by the 30th day. Apparently, the experimental paradigm of HPOT + SuP may be useful in generating a low calorie eggs, and which suggests an alteration in overall physiology of hens.

Overall, the present study has shown dominating influence of HPOT over Step – up photoperiod, and a combination of HPOT + SuP could affect the biochemical composition of eggs and lead to the yield of low calorie eggs. However, the present study has not tried to evaluate the biochemical composition and nutritive values of eggs laid during the later stage of oviposition.

Summary:

In the present study the combined effect of timed transient hypothyroidism and step-up photoperiod given at 90 days has been tested for attainment of sexual maturity, initiation of egg lay and egg composition. Pullets fed with MMI at different age groups where subjected to a step-up photic schedule. The

results obtained were, early initiation of lay shown by group IV hypothyroid hens with higher umber of egg lay compared to control hens. The total lipid content of first day egg was significantly high in all the experimental groups relative to controls. Overall, the present study has shown dominating influence of HPOT over Step – up photoperiod, and that a combination of HPOT + SuP could affect the biochemical composition of eggs and lead to the yield of low calorie eggs.