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EFFECT OF SEASONAL AVERAGE TEMPERATURE ON SOME PHYSIOLOGICAL ACTIVITIES IN THE ROCK PIGEON (*COLUMBA LIVIA*) IN A TROPICAL AREA

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ABSTRACT:

The aim of the study was to understand the effect of 'temperature' on different physiological activities such as thermoregulation, energy deposition, gonadal activity, breeding and moulting in the Rock Pigeon. Study conducted in an urban area that falls in semi-arid zone. The climate of study area was periodic and seasonal. It was found that initial stage of chicks remained poikilothermic and the age of 29 days, chicks maintained their body temperature at 41oC. Effect of seasonal average ambient air temperature does not play any significant role on body weight, Gonado-somatic index (GSI), number of clutches laid by bird, average egg weight in a clutch, incubation period, nesting success and growth rate. However, there was significant relation between average air temperature on lipid and water index and moult rate. All above activities may be influence to each other by external stimuli as well as energy demanded overlapping activities.

KEY WORD: *Ambient air temperature, Energy deposition, Thermoregulation, Lipid Index, Water Index, Gonado-Somatic Index, Clutch, Incubation period, Growth rate, Nesting success, Moult rate.*

INTRODUCTION:

The Rock Pigeon (*Columba livia*) is a common resident bird in a tropical area. The family Columbidae as a whole exhibits a strong tendency to colonize in urban and rural areas. They acclimatized in a semi-arid area. In any ecosystem

abiotic factors are influences on population or individually. To understand this aspect in a proper way I have selected Rock Pigeon (*C. livia*) to study its some physiological selected aspects. Only one factor **'temperature'** was taken into consideration that how it influences individually with respect to energy deposition, moulting, breeding and even growth rate. These activities are inter- correlated also. Such work is not done in a tropical area. It will give a new dimension for further study. Each physiological process of a bird is internally also maintained through hormones, metabolism and overlapping energy related activities such as breeding and moulting, lipid index and gonadal activity.

STUDY AREA:

The study was conducted at Rajkot ($22^0$18' N, $70^0$47' E about 138 m above msl) located almost in the center of the Saurashtra region of the state of Gujarat. As Rajkot city falls in semi-arid zone, the climate is strongly periodic and seasonal. There are six seasons *viz.* winter, early summer, late summer, early monsoon, monsoon and post monsoon.

Climate of Rajkot is tropical arid to marginal semi-arid. It is characterized by low and erratic rains received primarily during the monsoon of June to September. The mean daily temperature range varied greatly in different seasons. The highest maximum temperature recorded at Rajkot was 47.8^0C on 15 May 1919 and lowest minimum temperature was 0.6^0C on 16 January 1935. Winter (December-January) is the period of cold weather. The daily minimum temperature was always below 19^0C and dropped on certain days as low as 7^0C. The daily maximum temperature ranged between 23 and 24^0C. Monthly mean for the maximum temperature ranged from 28 to 30^0C and that for minimum temperature ranged 12 to 15^0C. Early summer (February-March) is the transitional period between the winter and summer. The daily range in temperature was large, the daily maximum temperature ranged from about 24 to 41^0C and the daily minimum from 7 to 25^0C. Monthly mean for the maximum temperature was between 30 to 35^0C and that for the minimum temperature between 13 to 20^0C. Late summer (April-May) is the period of warm dry weather. During this period, the temperature did not drop below 18^0C and the daily maximum temperature was always above 11^0C and went up as high as 44^0C. The monthly mean of daily maximum temperature was between 36 and 42^0C and that for the daily minimum temperature was between 21 to 27^0C. During early monsoon (June-July), the daily maximum temperature was always above 26.6^0C and below 43^0C. The monthly mean of maximum temperature ranged from 32 to 39^0C and that of minimum temperature ranged from 25 to 27^0C. During late monsoon (August-September), the daily maximum temperature was always above 25^0C and below 38^0C. The daily mean temperature ranged between 27 to 29^0C. Post monsoon (October-November) is the transitional period between the monsoon and winter season. The daily minimum temperature was between 14 to 24^0C and the daily maximum temperature between 25 to 40^0C. The monthly mean of maximum temperature ranged from 30 to 37^0C and that of

minimum temperature from 16 to 23^{0}C. Other factors also were studied but not taken into account here. Table 1 illustrates mean minimum temperature ^{0}C, mean maximum temperature ^{0}C and seasonal average temperature ^{0}C for the study period (1979-1983).

MATERIALS AND METHODS:

Two colonies used for the study of breeding biology within a college premises at Rajkot. For experimental work, some birds were collected from Saurashtra University campus, which is established 1km northwest of the Rajkot city. Selected main parameters for study were thermoregulation, energy deposition, gonadal activity, breeding and moulting. For the study of lipid index in a form of energy deposition, 72 birds were collected from university campus. Before the sacrifice them, moult score was studied in each bird. Breeding activities and biology were studied in a breeding colony present in the college campus. Entire study was done during 1979-1983.

For the detailed study on the body weight and composition, 51 males and 22 females were collected over a period of one year (October, 1980 to September, 1981). Gonads were weighed to study GSI (Ganado-Somatic Index), seminiferous tubules and follicles (diameter) were examined periodically. The rest of the body was finely chopped up, dried in air oven and weighed. From the dry materials, lipids were extracted with ether in Soxhelet apparatus and weighed. Lipid and water index was calculated by the following formulae:

Lipid Index = Lipids / Lean dry matter

Water Index = Water / Lean dry matter

Several nesting pairs were ringed and recaptured from time to time so that the reproductive performance and moulting of individual birds could be monitored. In addition to it, other 75 birds were captured from University campus area and examined the moult. It was recorded as per the guideline of current B.T.O. recording system.

To study the effect of temperature on breeding, number of clutches laid and nesting success was counted. Average egg weight, incubation days were also studied in a breeding colony. 22 nest-boxes were made available to the ringed pigeons for breeding and 64 nests built by non-ringed birds. The contents of the boxes were checked daily during breeding as well as non-breeding seasons throughout 1979-1982. In non-ringed bird, colony nests were numbered and checked during 1981-1983. All the eggs during 1979-1982 were weighed with Pesola spring balance. Incubation days were calculated. The cloacal temperature of some chicks was recorded at regular interval throughout the nestling period to study thermoregulation. For fitting equation to growth rate followed as per Ricklife (1967).

RESULTS AND DISCUSSION:

Thermoregulation:

In Fig. 1 mean and range of body temperature of chicks of different age are graphically represented. For the first few (0-4) days of nestling life of chick was nearly poikilothermic and showed a wide variation in the body temperature. However, it could maintain the body temperature around 39 ^{0}C at the age of about 12 days. It was only after the age of 29 days that chicks maintained temperature at 41 ^{0}C without much variation. When chicks become adult, their physiology is affected by many internal as well as external factors. It is good example that during development of birds as a homoeothermic, how they change their thermoregulation from poikilotherm to homoeothermic. It indicates that this group is evolved from poikilotherm during their evolutionary path. Some poikilotherms avoid both heat and cold by underlying dormant in period of environmental stress. When temperature drops, lizards bask in the sun to achieve more temperature.

Energy deposition:

The seasonal changes in body weight of males collected from the University campus shown in Table 2. There were not enough females in my collections of different months and therefore their body weights were not analyzed. It shows that, it was maximal 322 ± 16.92 g in winter but declined up to late summer. During monsoon it was almost between 320 to 300 g. Effect of average ambient air temperature does not play any role on body weight of male pigeons (r = -0.31 i.e. negative low degree of correlation).

The total body lipid was at a maximal level during the non-breeding season in early monsoon. However, the amount of body lipids starts to decline regularly.

Lipid index is the ratio of the body lipids to the lean dry matter in different seasons. Table 2 shows that it was high during wet seasons in which July is the non-breeding period. In dry period, including peak period of breeding (March-April) it was low. Water index is also a ratio of the body water to the lean dry matter in the body. It remained almost constant during rainy period 2.41 to 2.43. During dry period, it was variable 2.34 to 2.53 (Table 2).

Each index is correlated to seasonal average ambient air temperature during the study period. Statistical correlation supports that there was a significant relation between temperature and amount of lipid in the body (r = +0.50) and lipid index (r = +0.61).

The experiment studies on *Passer domesticus* and *Zonotrichia albicollis* by Kendeigh *et al*. (1969) have shown that both the loss of energy (or weight) during the breeding night and temperature during the daytime are important in controlling the birds in the rate of feeding or total metabolized energy during the body. During early monsoon activity, for breeding is less hence it might be deposited to body as reserve energy.

The water index in the body of my pigeons were remained changed high during the dry seasons but remained almost constant during rainy period. Correlation between water index and average ambient air temperature was fairly positive with high degree of correlation. These observations indicate that the birds build up water reserve during dry season. The stored water may be crucial for the secretion of crop milk for the chicks.

Gonadal activity:

The present investigation on the gonadal activities of pigeon was undertaken to find out as to what extent the birds regress their gonads after each nesting during the breeding season and to determine the gonadal condition of birds during the non-breeding season.

Table 3 gives seasonal changes in the Gonado-somatic index in both the sexes. The Gonado-somatic index (GSI) in male was at peak levels during winter, post monsoon and early summer. It was moderately high in the summer and lowest in early monsoon (July is the non-breeding month). GSI in female was lowest in early monsoon, but highest in late monsoon and moderately high in the other seasons.

There was some degree of correlation between the diameter of the seminiferous tubules and reproductive stage of a testis. Table 3 reveal that mean diameter of seminiferous tubules was more in all the seasons except in the early monsoon when the diameter had been reduced to a very small size. It was highest when breeding season is at peak level during March. The ovarian follicles were small in early monsoon, but in the other seasons, some of the ovarian follicles had enlarged. It was highest in early summer and start to decline up to late monsoon.

The correlation between average ambient air temperature and GSI in males was insignificant ($r = -0.73$) as well as in females it was -0.30. Some way there was no effect of temperature on seminiferous tubules or ovarian follicles in male and female respectively. The gonadal regression may have been triggered by some external stimulus such as deterioration in the nutritional condition of the birds. The synchronous gonadal regression occurring in pigeons in monsoon seems to be an endogenous phenomenon.

Breeding season:

Table 4 shows that highest numbers of clutches were laid during early summer, it remained uniform with some fluctuation except during early monsoon. In pigeon, early monsoon is unfavourable because birds get less chance to found food for them as well as their progeny. Statistical correlation between seasonal average ambient air temperature and number of clutches laid is insignificant ($r = -0.51$). It means temperature is not a determinative factor for peak or low period of breeding season. Food is only the ultimate factor.

Breeding season of an avian population in a given area has a limited span and at each locality, it may vary seasonally and annually. The breeding season in birds is controlled by several environmental factors such as temperature, rainfall, relative humidity, photoperiod, availability of food, predators, etc. Those

environmental factors that control efficiency of breeding are called "ultimate factors" (Moreau, 1950, Thomson, 1950). No dought that temperature is also a factor which influences the reproductive success and was studied in detail by Burger (1948), Farner and Mewaldt (1952), Engels and Jenner (1956), Farner and Wilson (1957) and Immelmann (1963).

Average egg weight:

Mean weight of a freshly laid egg was found to be 17.08 ± 1.18 g for 131 eggs. The calculation of LSD (least significant difference) indicates that there was a significant ($p < 0.05$) seasonal trend in the mean egg weight. It was high in monsoon and low during late summer. Here, a decrease in the egg weight with the advance of breeding season seems to have been linked with the progressive depletion of the lipid reserve in the adults during the breeding season (see Table 4). Thus, there was no significant effect of temperature to average egg weight in a clutch ($r = -0.35$).

Incubation period is the interval between the laying of the first egg and hatching of that egg within a clutch. Table 4 gives the mean incubation period in different season. It was long in early monsoon and winter and remained almost same in other season. During the wet period the variation in incubation period were unrelated with the ambient temperature. Apparently, the incubation period was influenced by the ambient temperature, an increase in temperature corresponded with a decrease in incubation period during the dry season. However, during the wet season some factor other them the ambient temperature was also operating.

Incubation is the process whereby the heat necessary for embryonic development is applied to eggs after they are laid. Such heat is derived from the body of the parents.

Nesting success per female/year was highest during late summer and low during monsoon in other seasons it was remained constant. There was low degree of correlation of effect of ambient air temperature ($r = +0.42$). Mostly nesting success is influenced by parasites, foraging behaviour of parents and mortality causes.

Growth rate:

Growth rate (K) was maximum during early monsoon and monsoon period, moderately high in winter, early summer and post monsoon and low in late summer. Statistical analysis shows insignificant correlation between temperature and growth rate ($r = -0.17$). Actually, in pigeon monthly growth changes more or less follow the egg weight changes in different months. However, this correlation is statistically not significant.

Moult cycle:

The primary moult sequence was descendent type starting with P1 (innermost) and proceeding to P10, which was the last to moult. Generally, birds start to moult during winter. All the birds were moulting their

primaries by March and completed by August. The moult rates for several birds are plotted against the mean data (Fig. 2).

The moult rate was low during winter (December-January), which was soon after the moult started, there was about two fold increase in the moult rate during early summer and about three fold increase during April to June, but there after there was a progressively drop in the moult rate during July and August. The mean moult rate for a moult was correlated with the average ambient temperature (1981-82) and the correlation was statistically significant ($r = 0.86$; $P < 0.01$). Moulting is an energy demanding activity has been suggested by Kendeing (1949) that the major energy demanding activities of birds are spaced throughout the year in such a manner that they do not seriously overlap.

CONCLUSSION:

The study on the ecology of Rock Pigeon (*Columba livia*) was conducted in an urban area (Rajkot city during 1979-1983). It falls in semi-arid zone. Its climate is periodic and seasonal. The mean daily temperature range varied greatly in different seasons. Effect of temperature on different physiological aspects was monitored. Birds are originated from poikilotherm, which is supported by experiment on chicks of pigeons. It shows that for the first few (0-4) days of the nesting life of chick was nearly poikilothermic and showed a wide variation in the body temperature. However, it could maintain around 39 ^{0}C at the age of 12 days, and at the age of 29 days, chicks maintained temperature at 41 ^{0}C without much variation *i.e.* they become homoeothermic. It shows phylogenic relationship.

Effect of seasonal average ambient air temperature does not play any significant role on body weight of male pigeons, GSI in males and females, number of clutches laid by pigeon population, average egg weight in a clutch, incubation period, nesting success and growth rate. However, there was a significant effect of average air temperature on lipid and water index. The mean moult rate for a month in pigeon was statistically highly significant.

Above all parameters indicates that in pigeon different physiological activities are not only triggered by one factor but it is control by all external stimuli as well as all energy demanded overlapping activities.

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Table 1: Temperature recorded during study period at Rajkot city.

Seasons	Mean minimum temperature (oC)	Mean maximum temperature (oC)	Seasonal mean temperature (oC)
Winter	12.75	28.50	20.63
Early summer	16.00	32.25	24.13
Late summer	23.25	39.50	31.38
Early monsoon	25.75	35.75	30.75
Monsoon	23.75	32.75	28.25
Post monsoon	20.25	33.75	27.00

Table 2: The amount of body lipids relative to the lean dry matter (Lipid and Water indices) and body weight in pigeons.

Seasons	Lipid index	Water index	Amount of lipid (in g) Mean ± SD (n)	Body weight (in g) Mean ± SD (n)
Winter	0.14	2.34	10.81 ± 3.15 (09)	322 ± 16.92 (09)
Early summer	0.15	2.39	10.76 ± 3.45 (10)	302 ± 21.81 (13)
Late summer	0.16	2.53	10.59 ± 4.25 (08)	298 ± 29.41 (07)
Early monsoon	0.25	2.41	17.39 ± 4.76 (08)	320 ± 23.11 (10)
Monsoon	0.23	2.43	15.27 ± 8.43 (08)	312 ± 20.19 (07)
Post monsoon	0.21	2.43	13.60 ± 3.95 (06)	300 ± 10.26 (05)

SD = Standard deviation, n = Number of birds.

Table 3: Seasonal variations in GSI of male and female pigeons, diameter of seminiferous tubules in male pigeons and largest ovarian follicles in female pigeons.

Seasons	GSI		Diameter of seminiferous tubules (in µ)*	Diameter of follicles (in mm)*
	Males	Females		
Winter	0.448 ± 0.118 (09)	0.144 0.109-0.179 (09)	153 ± 50 (11)	2.45 2.0-2.9 (02)
Early summer	0.416 ± 0.131 (11)	0.140 0.120-0.159 (02)	167 ± 60 (13)	7.00 ± 6.93 (03)
Late summer	0.316 ± 0.099 (07)	0.117 ± 0.029 (04)	156 ± 43 (07)	3.34 ± 2.35 (05)
Early monsoon	0.079 ± 0.066 (08)	0.063 0.095-0.031 (02)	106 ± 43 (08)	1.25 1.00-1.50 (02)
Monsoon	0.273 ± 0.159 (07)	0.140 ± 0.114 (07)	163 ± 35 (07)	3.06 ± 0.45 (07)
Post monsoon	0.420 ± 0.230 (05)	0.271 0.037-0.504 (02)	140 ± 56 (06)	6.50 ± 4.40 (04)

Mean ± SD (n) or range (where the sample size is less than three).
SD = Standard deviation, n = Number of birds.
GSI=Gonado-Somatic Index.

Table 4: Number of clutches laid, average egg weight, incubation period and nesting success in pigeons.

Seasons	No. of clutches laid	Average egg weight (in g)	Incubation period (in days)	Nesting success	Growth rate
Winter	82	17.32	17.22 ± 1.11 (18)	0.27	0.18
Early summer	95	16.76	16.75 ± 0.68 (16)	0.26	0.17
Late summer	81	16.41	16.64 ± 0.67 (11)	0.39	0.15
Early monsoon	24	16.89	17.25 ± 0.46 (08)	0.27	0.19
Monsoon	80	17.78	16.80 ± 0.63 (10)	0.22	0.19
Post monsoon	75	16.92	16.55 ± 0.51 (20)	0.27	0.17

Mean ± SD (n); SD = Standard deviation, n = Number of birds.

Table 5: Moult score and effect of average air temperature

Months	Moult score / bird / day	Average air temperature oC
December	0.24 (01)	21.18
January	0.23 (01)	20.55
February	0.45 (05)	22.72
March	0.45 (12)	25.87
April	0.64 (14)	29.85
May-June	0.65 (05)	32.56
July	0.50 (08)	28.97
August	0.39 (03)	27.43

r = 0.86

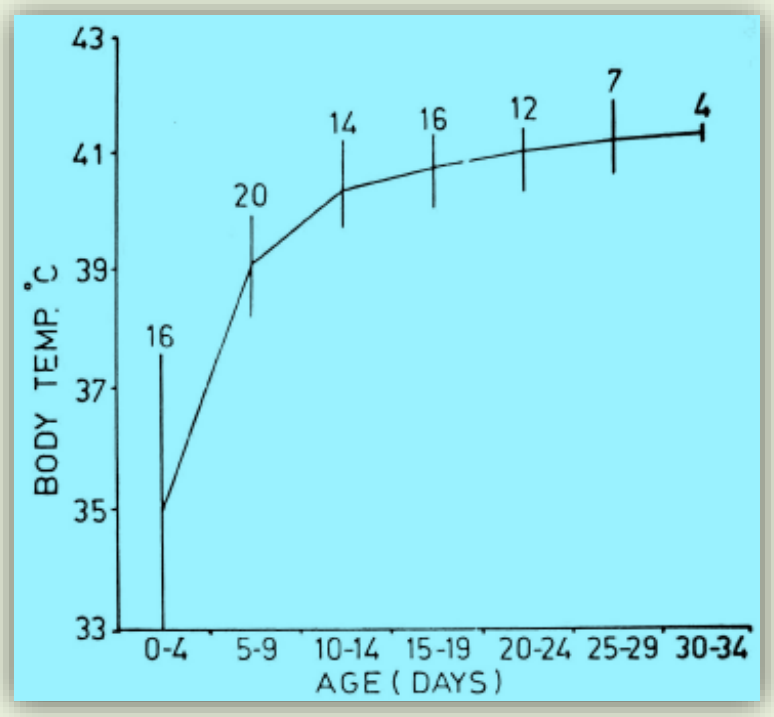

Fig. 1: The curve shows mean body temperature of unattended chicks of different age in the pigeon. The vertical lines indicate the range in temperature recorded. The numerals indicate number of chicks used

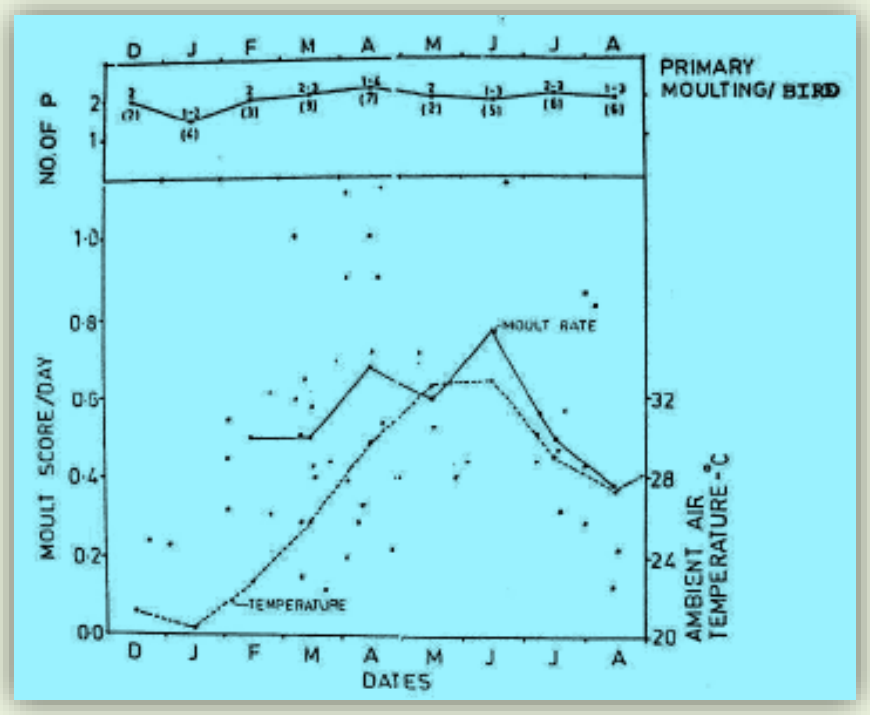

Fig. 2: Number of primaries moulting / bird (top) and primary moult rate of birds (bottom) in different months, in relation to the ambient air temperature.