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Growth and Breeding Biology of Female Indian Gerbil (*Tatera Indica*): Reproductive, Biochemical and Histological Evaluation

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ABSTRACT

Average duration of pro-estrous, estrous, met-estrous and di-estrous stages in one oestrous cycle of female Indian gerbil, *Tatera indica* was found 0.61, 0.38, 0.62 and 1.37 days, respectively with total average duration of one cycle to be 2.99 days. Pairing of cyclic female gerbils with mature males resulted in 88% breeding success within gestation period of 21-24 days. Post-partum estrous was observed immediately after parturition in females not separated from males. Observations on onset of sexual maturity in female pups of seven different age groups (30, 45, 60, 75, 90, 105 and 120 days old) revealed significant increase in body weight and weights of ovary and uterus, plasma level of estradiol and activity of 3β-HSD in ovarian tissue with increasing age. Sexual maturity in female *T. indica* was attained at age of 3-4 months. It is therefore suggested to apply control measures before they reproduce and cause damage to crops.

Key words: Breeding, Histology, Postnatal growth, Sexual maturation, *Tatera indica*.

INTRODUCTION

The Indian gerbil, *Tatera indica* (Hardwicke, 1807) is a species of family Muridae and subfamily Gerbillinae of order Rodentia. It is one of the fifteen economically important species of rodents occurring in India (Sood and Guraya, 1976; Fitzwater and Prakash, 1978). In Punjab, *T. indica* constitutes about 10% of the total murid fauna (Chopra *et al*., 1996). It is the prominent pest species of wheat, oilseeds, groundnut and cotton fields particularly in arid and semi arid regions (Parshad, 1999; Singla and Babbar, 2015). As agricultural pest, it is known to cause 5-10% loss to various crops (Singla *et al.,* 2015). Besides, the species is also involved in transmission of zoonotic diseases (Singla *et al.,* 2008).

In Rajasthan, *T. indica* is found to breed all the year around. The percentage of pregnant females varied from 9.7-61%, the annual average being 29.7%. Breeding peaks occur during February, July-August and November (Jain, 1970). However, in Punjab, peak breeding seasons have been found to occur in the last week of March to mid-May and last week of August to mid-October coinciding with maturity of wheat and rice crops (Sood and Guraya 1976; Kaur and Bilaspuri, 1995). The breeding months observed in laboratory coincided with the peak breeding season of *T. indica* under field conditions that occurred from March to May (Singh 1961, Prakash *et al*., 1971).

Use of rodenticides and traps are the common methods of controlling rodent population in crop fields (Borah and Mallick, 2016), but there are reports of development of resistance against rodenticides in rodent populations (Garg and Singla, 2015). Under integrated rodent pest management programme, efficacy of some antifeedants and repellents have also been evaluated (Kaur and Singla, 2018; Kaur *et al*., 2018). For developing effective methods of rodent control, it is desirable to have knowledge about their reproductive behaviour and population growth. Methods based on manipulation of these aspects need the detailed study of breeding aspects and the reproductive cycle during different seasons and age periods. Age has significant effect on the structure and function of various components of reproductive systems in both male and female rodents. Substantial changes in testicular morphology, sex hormones and gamete production occur with aging (Bronson and Desjardins, 1977; Kim *et al.* 2002; Sandhu and Singla, 2019). Among the rodent pest species of economic importance, the members of the genus *Tatera* are relatively less understood (Mohan Rao, 1992). The present study was hence conducted to record growth and breeding biology of female *T. indica* through reproductive, biochemical and histological evaluation.

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MATERIALS AND METHODS

For present studies, Indian gerbil, *T. indica* of both sexes were live trapped from crop fields of villages Partap Pura and Ladhowal, district Ludhiana, Punjab (India) with the help of single catch wooden rat traps. Animals were used and maintained as per the guidelines of Institutional Animal

Ethics Committee. In laboratory, gerbils were weighed, sexed and kept individually in cages for 10-15 days for acclimatization. Food and water were provided *ad libitum*. Food consisted of a mixture of cracked wheat, powdered sugar and groundnut oil (WSO bait) in ratio 96: 2: 2.

Determination of estrous cyclicity of mature female gerbils

Estrous cyclicity of mature female gerbils (n = 10) was determined by observing cells flushed from the vaginal lining twice a day for 15 days. Vaginal flushing was taken by introducing a small amount (approximately 0.2 ml) of 0.9% sodium chloride solution into the vagina using a pasteur pipette. The animal was held from the skin on the neck with one hand whilst the hand holding the pipette was used to restrain the tail. The tip of the pipette was pushed gently into the entrance of the vagina to a depth of 2-5 mm and the fluid was flushed into the vagina and back into the pipette by gently squeezing and releasing the bulb of the pipette. One drop of resulting cell suspension was taken on glass slide and observed under the light microscope to determine the stage of estrous cycle. Duration of different stages (pro-estrous, estrous, met-estrous and di-estrous) as well as the duration of one oestrous cycle was determined. Different estrous stages of *T. indica* were recognized by the presence, absence or proportional numbers of following three types of cells:

Leucocytes

These were very small non nucleated cells having rounded shape (as seen in di-estrous stage).

Epithelial cells

These cells were also round in shape. Those seen at pro-estrous stage were mostly nucleated and with a granular appearance and those seen at met-estrous stage were non-nucleated and less granular.

Cornified (keratinized) cells

These cells were large, irregularly shaped and mostly non-nucleated (as seen at estrous stage).

Breeding of gerbils and establishment of breeding colonies

Large laboratory pens were used for breeding experiment. Mature male and cyclic female gerbils were paired in ratio 1: 1. Total 25 breeding pairs were formed in months of February, March and June, 2016. Food (consisting of cracked wheat, powdered sugar, milk powder and groundnut oil in ratio 94: 2: 2: 2 along with pre-soaked black gram seeds) and water were provided to each pair *ad libitum*. Body weight of female gerbils was recorded at weekly intervals during breeding. Females were observed for pregnancy and delivery of pups. Males were kept along with the females till parturition. The length of gestation period, number and sex of pups delivered were also recorded.

Resumption of postpartum estrous in female gerbils

In a separate experiment, immediately after first parturition, the female gerbils were divided into two groups of four each. In first group, the males were separated from females and in second group males were kept along with the females. In both the groups, vaginal smear of female gerbils was observed daily to determine the days for resumption of postpartum estrous. In second group, females were again observed for second time pregnancy and delivery of pups. In this group, males were kept along with the females till parturition. The length of gestation period, number and sex of pups delivered were also recorded.

Determination of onset of sexual maturity in female pups

Female pups delivered by different breeding pairs were weighed and grouped according to their age (30, 45, 60, 75, 90, 105 and 120 days). In each age group, there were four pups. Food (WSO bait) and water were provided *ad libitum*. Pups of different ages were observed for opening of vaginal orifice. All the pups in different age groups were sacrificed to record the following:

Weight of reproductive organs

Reproductive organs (ovaries and uterus) of pups were dissected out, cleared of fat and weighed with the help of calibrated electronic weighing balance to determine their weight in g/100g body weight. Ovaries of female gerbils of different age groups were also observed for the presence and number of corpora lutea.

Level of gonadal hormone

Whole blood (upto 1 ml) of all the pups in different age groups was collected through cardiac puncture and centrifuged at 3000 rotations per minute for 15 minutes. The supernatant plasma was collected in a separate tube and stored at -20^{o}C until analysis. Level of estradiol (ng/ml) was estimated in plasma using ELISA kit as per the manufacturer's protocol.

Specific activity of 3β-Hydroxy steroid dehydrogenase enzyme

Ovarian tissue of female gerbils was homogenized to estimate biochemically the specific activity (Units/mg of protein) of 3β-Hydroxy steroid dehydrogenase (3β-HSD) with some modifications in the method of Agular *et al*. (1992). Total proteins in the tissue were estimated by the method of Lowry *et al.* (1951).

Histology of ovarian tissue

The whole ovary of female gerbils of each age group (30, 45, 60, 75, 90, 105 and 120 days) was fixed in 10% neutral buffered formalin for 48 h and processed for paraffin block preparation by acetone benzene schedule (Luna, 1968). The serial sections of 5-6 µm thickness were obtained on glass slides with the help of rotary microtome and stained with Hematoxylin Eosin stains (HE) for histomorphological studies. HE stained serial sections of the ovary were assessed under the light microscope for number of primordial, primary, secondary, preantral, antral and atretic follicles along with number of corpora lutea at 100x magnification. The diameter (mm) of different kinds of

follicles and corpora lutea was also determined at 100x magification. Microphotographs were taken with the help of digital camera fitted on the microscope.

Statistical analyses

Values were determined as Mean±SD. Significance of differences in weight of reproductive organs, number of corpora lutea, levels of estradiol and total proteins, 3β-HSD enzyme activity and diameter and number of different follicles in the ovary of female gerbils among different age groups were determined at 5% level of significance using one way analysis of variance.

RESULTS AND DISCUSSION

The results of present study on growth and breeding biology of female *T. indica* as evaluated through reproductive, biochemical and histological parameters are presented herewith:

Duration of estrous cycle and its stages

The data on number of days for which different stages of estrous cycle of *T. indica* were observed within the period of 15 days as determined based on the examination of vaginal smear of 10 mature female gerbils is given in Table 1. Each stage was observed for about five times during the period of 15 days indicating the completion of five cycles. On average the pro-estrous, estrous, met-estrous and di-estrous stages were observed for 3.11, 1.88, 2.51 and 6.83 days, respectively in the total period of 15 days. The duration of each stage in one estrous cycle was 0.61, 0.38, 0.62 and 1.37 days, respectively with total average duration of one cycle to be 2.99 days.

Estrous cycles are characterized by morphological changes in ovaries, the uterus and the vagina (Hebel and Stromberg, 1986; Goldman *et al.,* 2007). These phases are usually identified according to cell types observed in vaginal smears. Many authors have classified the estrous cycle in different phases depending upon the type of cells (Long and Evans 1922, Grönroos and Kaupilla 1959, Hebel and Stromberg1986, Maeda *et al* 2000, Westwood 2008). Kaul and Ramaswami (1969) observed the duration of pro-estrous varying from 0.5 to 3 days (average 1.4 days), estrous 0.5 to 3 days (average 1.7 days), met-estrous 0.35 to 3 days (average 1.1 days) and di-estrous 0.5 to 10 days (average 1.9 days) with total duration of one estrous cycle to be 4.5 days in Mongolian gerbils. Ghosh and Taneja (1968) determined the length of one estrous cycle of *T. indica* to be 3-5 days. In laboratory rats, the duration of one estrous cycle varied from 4-5 days (Maeda *et al*., 2000).

Breeding success of female gerbils

The average body weight of male and female gerbils selected for breeding was 159.30 ± 21.64g and 155.09 ± 18.66g, respectively. Generally, the body weight of female gerbil was less than that of male gerbil in each pair (Table 2). The male and female gerbils selected in each breeding pair were collected from different locations and breeding success was found to be 88% i.e. 22 pairs bred successfully. Our earlier breeding experiment in laboratory using 24 pairs in the month of January and February, 2016 proved unsuccessful in which male and female gerbils in a breeding pair were collected from the same location. This may be due to the phenomenon of nepotism due to which they avoided inbreeding among the kins. Studies on Mongolian gerbils have demonstrated that related individuals (kins) do not breed with one another and they recognize their family and kins similar to other mammalian systems (Agren, 1984). Valsecchi *et al.* (2002) also reported kin discrimination and inbreeding avoidance in female Mongolian gerbils.

Kaur (2004) reported that though *T. indica* lives in colonies but forms monogamous pairs for breeding. Katherine *et al* (2011) also revealed gerbils to be monogamous generally. Paired gerbils usually begin to mate at about 3 months of age. Mating can be identified by a ritual of chasing and mounting, with both gerbils checking their undersides after each round. Pregnancy lasted for about 24 days and the litter consisted of 1 to 8 pups.

Record of body weight of female gerbils at an interval of 7 days during breeding in present studies revealed an increase in average body weight from 155.09g on the day of breeding to 214.95g after 21 days of breeding. Average litter size per breeding pair was found to be 5.14 with range 3-8 (Table 2). The average number of male pups (2.91)

Table 1: Duration of different stages of estrous cycle of *T. indica* within the period of 15 days.

Gerbils	Pro-estrous (days)	Estrous (days)	Met-estrous (days)	Di-estrous (days)
1	3.12	1.87	2.50	6.83
2	3.11	1.88	2.52	6.84
3	3.10	1.89	2.50	6.84
4	3.12	1.88	2.51	6.83
5	3.11	1.87	2.52	6.84
6	3.09	1.87	2.53	6.83
7	3.10	1.87	2.52	6.84
8	3.12	1.88	2.51	6.83
9	3.12	1.89	2.52	6.83
10	3.11	1.88	2.52	6.83
Mean±SD (Range)	**3.11±0.01 (3.09-3.12)**	**1.88±0.01 (1.87-1.89)**	**2.51±0.01 (2.50-2.52)**	**6.83±0.01 (6.83-6.84)**

Table 2: Breeding performance of *T. indica* under laboratory conditions.

Sr. No.	Body weight of female gerbils during breeding (g)				Gestation	Litter	Number of pups delivered	
	0 DAB	7 DAB	14 DAB	21 DAB	period (Days)	size	Male	Female
1	193	212	230	261	23	7	4	3
2	138	158	178	205	24	4	3	1
3	171	190	210	235	24	6	4	2
4	132	155	174	200	21	5	3	2
5	144	162	182	210	23	6	3	3
6	128	150	170	200	22	4	2	2
7	141	160	180	210	24	4	3	1
8	176	186	198	205	22	4	2	2
9	175	189	200	210	21	3	3	0
10	176	196	215	235	22	8	4	4
11	171	190	210	220	23	4	2	2
12	158	180	200	240	23	7	3	4
13	126	145	165	200	23	5	3	2
14	143	160	180	210	23	8	4	4
15	155	175	200	235	21	8	4	4
16	120	140	160	185	23	3	2	1
17	162	182	200	215	23	5	2	3
18	155	175	190	205	23	4	2	2
19	155	174	191	208	22	4	2	2
20	165	184	200	210	21	5	3	2
21	168	188	200	210	22	4	3	1
22	160	180	202	220	21	5	3	2
Mean±SD	**155.09±18.66**	**174.14±17.80**	**192.50±16.90**	**214.95±16.60**	**22.45±0.99**	**5.14±1.55**	**2.91±0.73**	**2.23±1.08**

DAB- Days after breeding.

delivered was generally more as compared to female pups (2.23). The mother constructed a nest using the jute and cotton kept in the breeding chamber on which the pups were delivered. Most of the parturitions usually took place during daytime between 12.00 pm and 5.00 pm. Lactation commenced immediately after delivery of pups and continued upto weaning. Average litter size of 4.4 ranging from 1-9 was observed in *T. indica* (Jain, 1970; Prakash *et al.,* 1971). Prater (1980) and Thomas and Oommen (1999) observed litter size of *T. indica* consisting of 1 to 10 young with 5 to 6 being the most common number.

Based on present breeding data, the gestation period of female gerbils was found to vary from 21-24 days with average of 22.45 days. Earlier, the gestation period of *T. indica* has been reported to be of 26-30 days (Jain 1970, Prakash *et al* 1971). Prater (1980) and Thomas and Oommen (1999) reported gestation period of 21 to 30 days in *T. indica*. However, in *Meriones hurrianae,* the period of gestation was found to be 28-29 days (Prakash 1981).

Postpartum estrous in female gerbils

Coming back of a female into heat within hours after giving birth is called postpartum estrus. After completion of a pregnancy, in some species ovulation and corpus luteum production occur immediately following the birth of the young. During present study, in the group of females kept with males even after first parturition, the female resumed estrous cycle immediately or within a day and came to heat resulting in mating with the male. This resulted in back to back pregnancy. The difference in two parturitions was found to be 21-23 days. The second litter was born just at the same time, the first litter was weaned (Table 3). The average litter size during second parturition was found reduced (3.00) compared to that during first parturition (6.50). Moreover, the pups of second litter were observed to be weak which may be because of stress on the mother. In some cases, more cannibalism of pups was observed when the male was not separated from the female after parturition. Whether the cannibalism of pups is more by the female or the male partner could not be known. The group in which males were separated from females after first parturition, the females resumed estrous cyclicity but the estrous stage was not observed immediately after parturition.

Smith (1993) reported that babies resulting from a back to back pregnancy live shorter lives and have far more health problems. Similar to present studies, Kaul and Ramaswami (1969) also reported that the female gerbil experiences heat period shortly after parturition. Norris and Adams (1981) recorded post partum mating in Mongolian gerbils while nursing the young ones. More than 70% of the post-parturient females mated, the majority on day 1 and the incidence of mating was unaffected by nursing. However, both fertility and fecundity declined as the number of young nursed increased. Studies of Katherine *et al*. (2011) also

Table 3: Determination of postpartum estrous in female *T. indica.*

Group	Sr. No.	Date of first parturition	Estrous stage				Date of second parturition	Litter size	Sex of pups		Difference in two parturitions
			1 DAP	2 DAP	3DAP	4 DAP			M	F	
I (Male not removed)	1	02.07.16	P	E	M	D	25.07.16	2	0	2	23 days
	2	05.07.16	E	M	D	P	26.07.16	4	3	1	21 days
	3	08.07.16	E	M	D	P	30.07.16	3	1	2	22 days
	4	09.07.16	E	M	D	P	31.07.16	3	2	1	22 days
Mean±SD								3.00±0.71	1.50±1.12	1.50±0.50	
II (Male removed)	1	01.07.16	D	D	P	M	-	-	-	-	-
	2	07.07.16	D	D	P	M	-	-	-	-	-
	3	10.07.16	M	D	D	P	-	-	-	-	-
	4	15.07.16	D	D	D	P	-	-	-	-	-
Mean±SD											

DAP- Days after parturition, P-Pro-estrous, E-Estrous, M-Met-estrous, D-Di-estrous.

revealed that female gerbils begin mating again almost immediately after giving birth.

Onset of sexual maturity in female pups delivered

Body weight and weight of reproductive organs

Female gerbils of different age groups (30 days, 45 days, 60 days, 75 days, 90 days, 105 days and 120 days) were sacrificed to record the weight of reproductive organs (ovaries and uterus). A significant ($P \leq 0.05$) increase in weight of ovaries and uterus was observed from day 30 to day 120 after birth indicating their development. The increase in weight of ovaries was 0.01 to 0.13g/100g bwt and that of uterus from 0.01 to 0.17 g/100g bwt. The number of corpora lutea was found to vary from 2 to 5 per ovary of female gerbils of ages 90 to 120 days (Table 4). The number of corpora lutea and hence the number of ovulations increased with increasing age of gerbils. The body weight was also found increased significantly ($P \leq 0.05$) with age. An increase in weight of organs with increasing body weight was found in present studies. Bailey *et al.* (2004) also reported a positive relationship between body weight and different organ weights. In present study, the vaginal orifice of pups of different ages was not fund to be open even by the age of 120 days. This may be due to the reason that all the female pups were kept individually in the laboratory cages.

Level of gonadal hormone and specific activity of enzyme

In overall, there was an increase in plasma level of estradiol in female gerbils of different age groups. This average increase in level of estradiol from days 30 after birth (0.45 ng/ml) to days 45 after birth (1.06 ng/ml) was statistically significant ($P \leq 0.05$) but the increase in level of estradiol from day 45 after birth to day 120 after birth was not found to be significant statically (Table 4).

Specific activity of 3β-HSD enzyme was estimated in ovarian tissues of female gerbils of different age groups. The results (Table 4) revealed a significant ($P \leq 0.05$) increase in total proteins and specific activity of 3β-HSD enzyme in female gerbils from day 30 after birth to day 120 after birth. Average total proteins (mg/g of tissue) increased from 2.60 at the age of 30 days to 17.01 at the age of 120 days. The average specific activity of 3β-HSD increased from 0.18 units/mg protein at the age of 30 days to 0.89 units/mg protein at the age of 120 days.

In the ovary, estradiol is formed by the conversion of testosterone by the enzyme cytochrome P450 aromatase. This enzyme occurs in granulosa cells. Estradiol production is regulated by the effects of FSH on P450 aromatase. 3β-HSD is a relative marker for the conversion of pregnenolone to progesterone (de La Iglesia and Schwartz, 2006). During follicular development, the level of estradiol and 3β –HSD increases. The cycle ends when estrogen peaks during pro-estrous, stimulating gonadotropin release to trigger ovulation (Freeman, 1988).

Ovarian development

Ovarian tissue of female gerbils at different age groups (30,

45, 60, 75, 90, 105 and 120 days) was fixed, processed, sectioned serially and stained to study the postnatal ovarian development. The data on different types of follicles found in gerbils of different age groups is given in Table 5. Primordial follicles predominated in the cortex region at the age of 30 days. Development of primary follicles started at the age of 30 days (Fig 1a) and increased at 45 days after birth. Development of secondary follicles (Fig 1b) and pre-antral follicles along with one antral follicle was found in gerbils of age 45 days. More number of pre-antral (Fig 1c) and mature antral follicles (Fig 1d) were found at the age of 60 to 75 days. The follicles started becoming atretic at the age of 90 days onwards (Fig 1e). Simultaneously, there was ovulation from 90 days onwards leading to formation of corpora lutea at ages 105 days and 120 days (Fig 1f). Primordial follicles were still found at the age of 120 days. In rats, the primordial follicles are still found at the end of reproductive life (Mandl and Shelton 1959).

The diameters of primordial, primary, secondary, pre-antral and antral follicles along with diameter of corpora lutea are given in Table 6. No significant difference was found in average diameter of different follicles among gerbils of different age groups.

Hayato Rai (1920) studied histology of ovaries of 39 rats from one day after birth to 947 days of age and noted first appearance of the corpora lutea at 64 days. They also

Table 4: Weight of reproductive organs, number of corpora lutea in ovaries of female gerbils, Level of estradiol and activity of 3β-HSD enzyme and total proteins of different age groups.

DAB	Body weight (g)	Organ weight (g/100 g body weight)		Number of corpora lutea in ovary	Estradiol (ng/ml)	Total protein (mg/g of ovarian tissue)	3 β HSD (units/mg protein)
		Ovary	Uterus				
30	40.33±1.52^{a}	0.01±0.001^{a}	0.01±0.001^{a}	-	2.60±0.09^{a}	0.18±0.001^{a}	0.45±0.05^{a}
45	53.67±3.78^{b}	0.01±0.001^{b}	0.04±0.05^{b}	-	4.26±0.19^{b}	0.38±0.01^{b}	1.06±0.11^{b}
60	72.67±2.52^{c}	0.01±0.0004^{c}	0.02±0.01^{c}	-	7.13±0.28^{c}	0.40±0.01^{c}	1.31±0.16^{b}
75	86.67±1.52^{d}	0.01±0.0002^{d}	0.13±0.01^{d}	-	9.8±0.28^{d}	0.49±0.07^{d}	1.66±0.28^{b}
90	101.01±1.00^{e}	0.07±0.04^{e}	0.15±0.01^{e}	2.00±0.01^{a}	12.66±0.94^{e}	0.57±0.03^{e}	1.86±0.32^{b}
105	121.33±1.55^{f}	0.12±0.03^{f}	0.16±0.01^{f}	4.00±0.02^{b}	16.49±0.23^{f}	0.69±0.001^{f}	1.96±0.15^{b}
120	142.33±2.08^{g}	0.13±0.10^{g}	0.17±0.02^{g}	5.00±0.03^{c}	17.01±0.02^{g}	0.89±0.003^{g}	2.05±0.07^{b}

Values are Mean±SD, DAB-Days after birth.

Values with different superscripts (a-g) in a column differ significantly at $P \leq 0.05$.

Table 5: The number of different follicles and corpora lutea in ovaries of female *T. indica* of different age groups.

DAB	Number						
	Primordial follicles	Primary follicles	Secondary follicles	Preantral follicles	Antral follicles	Atretic follicles	Corpora lutea
30	17	1	0	0	0	0	0
45	15	5	3	2	1	0	0
60	19	2	2	1	2	0	0
75	8	5	2	2	2	0	0
90	11	4	4	1	1	3	1
105	10	4	2	1	0	2	3
120	30	4	3	0	0	4	6

DAB-Days after birth.

Table 6: The Diameter of different follicles and corpora lutea in ovaries of female *T. indica* of different age groups.

DAB	Diameter (mm)						
	Primordial follicles	Primary follicles	Secondary follicles	Preantral follicles	Antral follicles	Atretic follicles	Corpora lutea
30	0.003±0.00	0.01	0.00	0.00	0.00	0.00	0.00
45	0.01±0.003	0.03±0.003	0.03±0.001	0.12±0.002	0.13	0.00	0.00
60	0.01±0.002	0.02±0.00	0.03±0.001	0.05±0.00	0.05±0.003	0.00	0.00
75	0.01±0.001	0.0240.003	0.04±0.002	0.09±0.014	0.08±0.002	0.00	0.00
90	0.01±0.004	0.0240.004	0.03±0.003	0.00	0.08±0.00	0.05±0.004	0.00
105	0.01±0.004	0.03±0.004	0.04±0.014	0.10±.00	0.00	0.05±0.004	0.08±0.003
120	0.004±0.002	0.03±0.002	0.05±0.009	0.00	0.00	0.06±0.01	0.09±0.01

Values are Mean±SD, DAB-Days after birth.

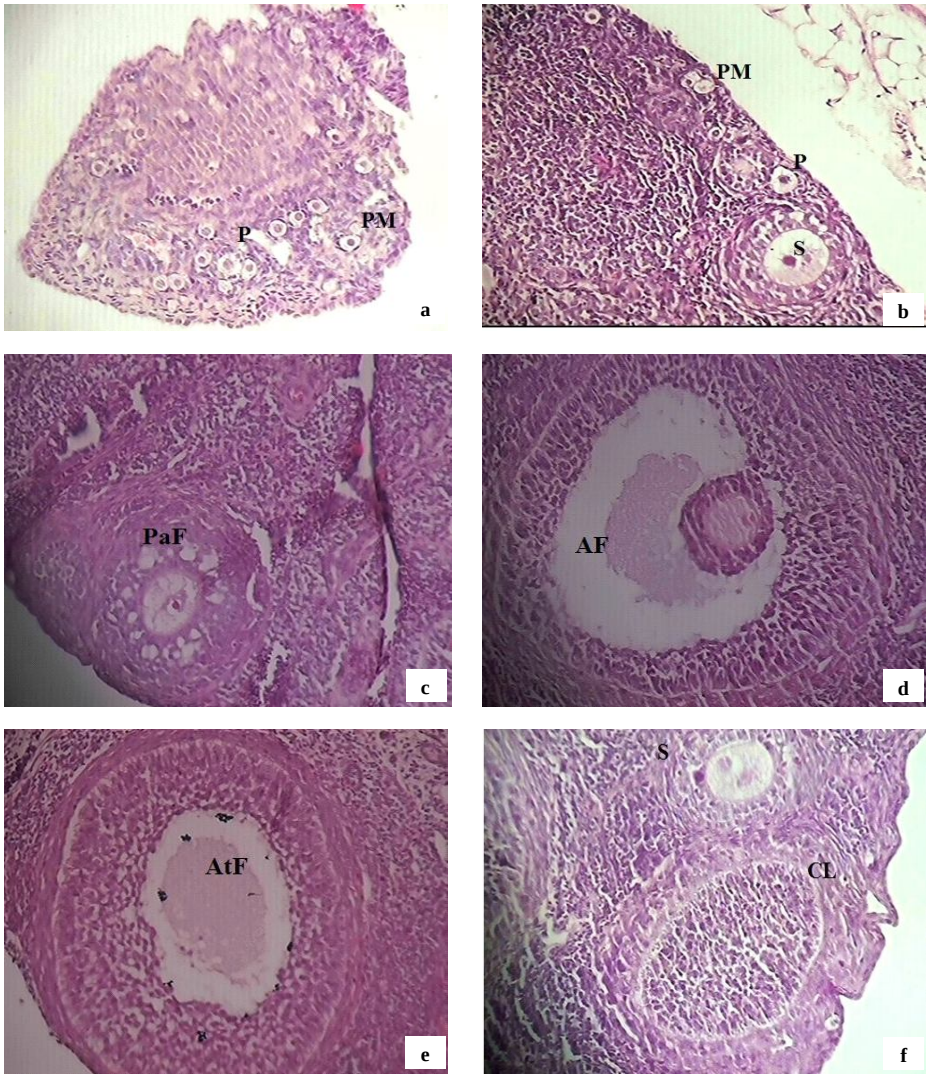

Fig 1: HE stained sections of ovaries of *T. indica* of different ages at 400x magnification showing different type of follicles, a) More number of primordial (PM) follicles and few primary (P) follicles at the age of 30 days, b) Primordial (PM), primary (P) and secondary (S) follicles at the age of 45 days, c) Pre-antral follicle (PaF) at the age of 60 days, d) Antral follicle (AF) at the age of 75 days, e) Atretic follicle (AtF) at the age of 105 days and f) Corpus luteum (CL) and secondary follicle (S) at the age of 120 days.

noticed that in the rat from 64 to 80 days the number of mature follicles ranged from 31 to 39 and this large number of follicles may be related to the attainment of sexual maturity since after 80 days the number of follicles tended to decrease. Norris and Adams (1974) studied ovarian development in relation to puberty and sexual maturity in Mongolian gerbils. They revealed that there was increase in ovarian weight between 30 and 40 days of age, after which there was little further change until corpora lutea appeared at 90 days and antral follicles were first recorded at 40 days of age. The uterus showed a rapid gain in weight between 30 and 60 days of age. The first Graffian follicles to appear at the age of 40 to 50 days were appreciably smaller than those recorded from 60 days onwards and 17% of the follicles were classified as atretic, their incidence being highest (31%) in animals aged 50 to 60 days and coinciding with the decline in follicle numbers. Stark (1973) reported ovarian development in gerbils aged 0 to 21 days. Picut *et al.* (2015) studied postnatal development in the rat ovary from day 0 onwards. Corpora lutea appeared at 38-46 days of age.

CONCLUSION

The present study demonstrated an important temporal coincidence between development pattern of ovarian tissues and related hormone and enzyme activity. Study depicts that the sexual maturity in female gerbils is attained at the age of 3-4 months. Finally, this study depicts the growth pattern and breeding biology of *T. indica* in temperate conditions which may be of help in effective management of this species in field conditions. It is suggested to apply control measures before they reproduce and cause damage to crops.

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