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REPRODUCTIVE BIOLOGY AND POPULATION DYNAMICS OF INDIAN GERBIL RAT *TATERA INDICA* IN WHEAT CROP

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ABSTRACT

***Tatera indica,* the Indian gerbil rat trapped during different growth stages of wheat crop, revealed that maximum mature gerbils (80-100%) were trapped during later growth stages (panicle initiation-preharvest+ lean period). While, 25 and 50% pregnant ones as well as 100 and 75% cyclic gerbils were collected during dough and preharvest stages, respectively. The weight of ovaries (13.00-19.00 mg/ 100 gbw), number and diameter of various follicles such as primordial (13.00-16.75; 19.57-19.98 µm), primary (6.50-7.33; 93.12-96.07 µm), secondary (2.75-3.67; 204.42-216.95 µm), pre-antral (2.75-3.50; 277.63-332.57 µm), antral (3.25-3.67; 474.44-499.98 µm), atretic (3.00-3.50; 211.49-247.33 µm) and corpus luteum (3.50-5.50; 622.24-629.76 µm) were significantly more during later growth stages i.e. dough, preharvest stages and lean period. The sperm motility (89.50-89.67%), viability (92.50-92.67%) and count (119.67-131.75 millions/ ml) was significantly more during dough and preharvest stages. The diameter of seminiferous tubules (203.68- 229.44 µm), number of spermatogonia (16.67-17.50), elongating spermatids (85.67-88.50) and elongated spermatids (81.00- 89.50) were significantly more during panicle initiation, dough and preharvest stages. Thus, control operations of *T.indica* should be done during tillering/ panicle initiation stage before the initiation of their peak breeding activity during dough/ preharvest stages**

Key words: Wheat crop, growth stages, *Tatera indica*, population dynamics, reproductive biology, male, female, ovaries, follicles, sperm, motility, viability, seminiferous tubules, spermatogonia, spermatids

Rodents are agricultural pests that belong to the class Mammalia and order Rodentia. In India, 46 genera and 103 species of rodents are reported (Pradhan and Talmale, 2011). Cao et al. (2002) reported that rodents caused 25% grain loss in the field during preharvest period and 25-30% loss of grains during post-harvest. Rodents have high breeding rate and many of them show increase in the population depending on accessibility of food (Pradhan and Talmale, 2011). Hasanuzzaman et al. (2009) observed more rodents at grain filling than at the ripening stage of wheat. Sarwar et al. (2011) observed that rodents established during initial stage of crop and reproduced during germinating stage and becomes abundant at the preharvest. The Indian gerbil *Tatera indica* is the most conspicuous pest species in the fields of wheat, oilseeds, groundnut and cotton especially in arid and semiarid regions (Parshad, 1999). It was found to be most prevalent as field rodent in the arid zone of district Hisar of Haryana (Neetu et al., 2021). The reproductive peaks and the length of the breeding season in the Indian gerbil is adjusted to the local climatic conditions. The peaks of reproductive activity of *T. indica* was observed in March-April and July-September in Punjab which are periods of moderate temperature (Kaur and Bilaspuri, 1995). Govinda Raj and Srihari (1987) reported that breeding pattern of the South Indian gerbil varied with rainfall and temperature as well as availability of food. During peak reproductive periods the rate of pregnancy was high and larger litters were produced (Beg et al., 2010). The gerbils affected the wheat fields in fairly good numbers from sowing through the heading and maturation period (Khan and Beg, 1986). For effective control of rodents in crop fields, the rodent control operations should be done before the initiation of their breeding activities. Sandhu and Singla (2020) suggested for applying rodent control measures before they reproduce and damage the crop. The present study assesses the population trend and reproductive status of *T. indica* at different growth stages of wheat crop so that control operations could be done before the peak breeding activity.

MATERIALS AND METHODS

The present study was carried out at village Barewal Dogra, District Ludhiana, Punjab during December 2017 to May 2018 focusing on growth stages of wheat crop i.e. sowing, tillering, panicle initiation, dough, preharvest and lean period. The temperature and rainfall data was obtained from the Department of Climate Change and Agricultural Meteorology, Punjab

Agricultural University, Ludhiana. *Tatera indica* of both the sexes were live trapped from different growth stages with the help of single wooden rat catch traps placed near the burrow openings. The population trend was studied by recording the number of live burrows/ acre as well as by calculating trap index calculated from total, male and female gerbils. The pregnancy was observed by appearance of blood in the vaginal fluid during the initial stages of pregnancy and prominent mammary glands indicating advanced stage of pregnancy. The non-pregnant gerbils were checked for their oestrous cyclicity for 12-15 days through collecting the vaginal smears. The gerbils were dissected; ovaries as well as uterus of female gerbils and testes, epididymis, seminal vesicles and prostate gland of male gerbils were collected. The weight of the organs was expressed as g/ 100g body weight.

The sperm parameters (motility, viability and count) were recorded from the cauda epididymal fluid (Salisbury et al., 1978). The ovaries and testis were processed for making haematoxylin and eosin stained histological sections (Luna, 1968). The number and diameter of primordial, primary, secondary, pre-antral, antral, atretic follicles and corpus luteum were observed in serial sections of ovaries. The diameter (µm) of different types of seminiferous tubules (30 of each rat) across the major and minor axis was taken in histological sections of testis. The diameter of lumen of seminiferous tubules was also assessed. From different types of seminiferous tubules, the number of spermatogonia, spermatocytes (leptotene, zygotene, pachytene and diplotene), elongating spermatids, elongated spermatids, round spermatids and sertoli cells were observed. The different growth stages of seminiferous tubules and their cells were identified (Guraya and Bilaspuri, 1976; Segatelli et al., 2004). The values were determined as Mean± SE. Significance of parameters was determined using one way ANOVA (p=0.05).

RESULTS AND DISCUSSION

The monthly mean temperature was minimum during tillering (12.32ºC) and maximum during lean period (29.05ºC) mean rainfall was maximum during panicle initiation (10.8 mm) and lowest during preharvest stage (2.32 mm). No rainfall was recorded during dough stage. The no. of burrows/ acre (13/ 14) and total trap index (11.11%) was more during sowing and tillering stages as compared to later stages (Fig. 1). However, only 37.5% gerbils were found to be mature during these growth stages. The minimum trap index

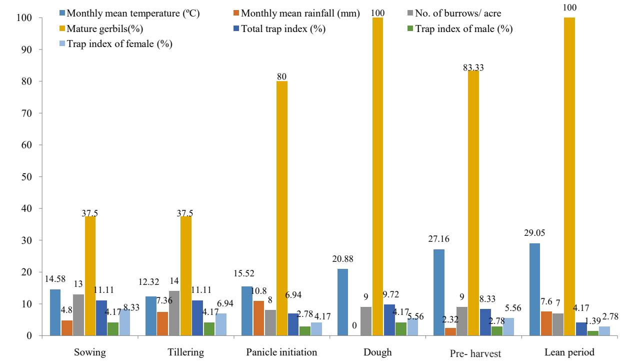

Fig. 1. Population dynamics of *T. indica* on wheat

of 4.17 was recorded in the lean period. 80-100% mature gerbils were recorded during later stages i.e. panicle initiation, dough and pre-harvest stage and lean period. The trap index of female gerbils was found to be higher than that of male during all growth stages. The population of *T. indica* decreased and maturity increased with the growth of the wheat crop. Andreassen et al. (2021) mentioned that increase in population of small rodent to be associated with abundant food resources. The maturity of gerbils was found to be low during the earlier growth stages in December and January because of the lower temperature as well as lack of the abundant food.

The pregnant female gerbils i.e. 25% and 50% were collected during the dough and preharvest stage respectively (Table 1). The maximum pregnancy in the spring season observed in earlier studies coincide with the dough and preharvest stage (Hussain et al. 2002; Beg et al. 2010). The pregnant gerbils were not trapped during the sowing, tillering and panicle initiation and this finding is in accordance with that of Khan and Beg (1986). Similarly, Singh and Kaur (2020) found that pregnant bandicoot rats were not trapped during initial stages of wheat crop i.e. during tillering and panicle initiation stages. The gerbils were 100, 75, 66.7, 50, 40 and 33.3% cyclic during dough, preharvest, panicle initiation, lean period, tillering and sowing stages, respectively. The cyclic rats can undergo reproduction and prevalence of more cyclic rats indicates the high breeding activity. The body weight of female gerbils differs non-significantly in different growth stages and was maximum during lean period (150.50 g). The weight of paired ovaries (13.00-19.00 mg/100g bw) was significantly more during dough, preharvest stages and lean period. The maximum weight of the uterus observed during dough stage (51.00 mg/ 100g bw) varied significantly from other growth stages and lean period. Hussain et al. (2002) observed significantly

Table 1. Reproductive biology of female and male *T. indica* in wheat

Female

Crop stage	Pregnancy (%)	Cyclic rats (%)	Body mass (g)	Weight of organ (mg/ 100g bw)		No. of follicles							Diameter of follicles (µm)						
				Ovaries	Uterus	Primordial	Primary	Secondary	Preantral	Antral	Atretic	Corpus luteum	Primordial	Primary	Secondary	Preantral	Antral	Atretic	Corpus luteum
Sowing (n=6)	0	33.3	112.83± 13.61^{a}	6.00± 0.001^{a}	41.00± 0.004^{a}	6.00± 0.52^{a}	3.50± 0.43^{a}	2.33± 0.21^{a}	1.20± 0.18^{ab}	1.17± 0.17^{a}	0.67± 0.21^{a}	1.33± 0.21^{a}	16.88± 0.60^{a}	55.39± 1.21^{a}	125.11± 1.23^{a}	237.82± 1.38^{a}	252.07± 2.77^{a}	332.75± 3.55^{a}	388.58± 1.77^{a}
Tillering (n=5)	0	40	132.50± 2.50^{a}	7.00± 0.002^{a}	46.00± 0.000^{a}	6.50± 0.50^{a}	3.50± 0.50^{a}	2.00± 0.00^{a}	1.50± 0.50^{ab}	1.00± 0.00^{a}	0.71± 0.50^{a}	1.50± 0.50^{a}	16.65± 0.60^{a}	54.45± 1.20^{a}	126.55± 1.30^{a}	236.95± 2.53^{a}	257.94± 1.30^{a}	337.00± 2.57^{a}	389.21± 0.34^{a}
Panicle initiation (n=3)	0	66.7	124.00± 16.00^{a}	9.00± 0.002^{b}	49.00± 0.007^{a}	7.50± 0.50^{a}	3.50± 0.50^{ab}	2.50± 0.50^{ab}	1.50± 0.50^{ab}	2.00± 0.00^{a}	1.50± 0.50^{a}	1.50± 0.50^{a}	16.65± 0.60^{a}	54.45± 1.20^{a}	126.55± 1.30^{a}	236.98± 2.53^{a}	257.94± 1.30^{a}	337.00± 2.57^{a}	389.21± 0.34^{a}
Dough (n=4)	25	100	138.00± 8.65^{a}	13.00± 0.001^{c}	51.00± 0.003^{b}	16.75± 0.63^{b}	7.00± 0.41^{c}	2.75± 0.25^{ac}	2.75± 0.48^{bc}	3.25± 0.48^{b}	3.00± 0.41^{b}	3.50± 0.65^{b}	19.98± 0.68^{b}	94.92± 1.93^{b}	204.42± 2.82^{b}	332.57± 3.87^{b}	499.98± 6.63^{b}	211.49± 14.93^{b}	625.37± 1.72^{b}
Pre-harvest (n=4)	50	75	147.67± 2.40^{a}	19.00± 0.001^{c}	49.00± 0.001^{a}	13.00± 0.15^{c}	7.33± 0.33^{c}	3.67± 0.33^{d}	3.00± 0.58^{bc}	3.67± 0.33^{b}	3.33± 0.33^{b}	3.67± 0.33^{b}	19.57± 0.75^{b}	96.07± 1.91^{b}	216.95± 9.03^{b}	277.63± 1.60^{c}	480.22± 4.18^{c}	223.34± 2.44^{bc}	629.76± 3.02^{b}
Lean period (n=2)	0	50	150.50± 3.50^{a}	19.00± 0.003^{c}	42.00± 0.001^{a}	15.50± 0.50^{bc}	6.50± 1.50^{bc}	3.50± 0.50^{d}	3.50± 0.50^{c}	3.50± 0.50^{b}	3.50± 0.50^{b}	5.50± 1.50^{c}	19.70± 0.06^{b}	93.12± 0.75^{b}	206.01± 1.65^{b}	286.18± 1.57^{c}	474.44± 1.20^{c}	247.33± 3.02^{c}	622.24± 0.90^{b}

Male

Crop stage	Sperm parameters			Body weight (g)	Weight of organ (g/ 100 g bw)				Diameter of seminiferous tubules (µm)			Diameter of lumen (µm)	Number of different cells in seminiferous tubules								
	Motility (%)	Viability (%)	Count (million/ ml)		Testes	Epididymis	Seminal vesicles	Prostate gland	Major axis	Minor axis	Average		SG	SC	L	Z	P	D	EL	ED	RS
Sowing (n=2)	63.50± 1.50^{a}	66.50± 1.50^{a}	61.25± 0.75^{a}	118.50± 11.50^{a}	0.27± 0.12^{a}	0.20± 0.02^{a}	0.15± 0.01^{a}	0.06± 0.01^{a}	134.43± 0.91^{a}	125.64± 3.09^{a}	130.03± 2.00^{a}	61.13± 1.08^{a}	14.50± 0.50^{a}	6.50± 0.50^{a}	25.50± 1.50^{a}	31.50± 1.50^{a}	43.50± 1.50^{a}	43.50± 1.50^{a}	68.00± 1.00^{a}	74.00± 1.00^{a}	92.50± 1.50^{a}
Tillering (n=3)	62.00± 0.63^{a}	64.00± 0.63^{a}	63.95± 0.92^{a}	117.50± 1.58^{a}	1.11± 0.03^{b}	0.26± 0.01^{a}	0.31± 0.04^{a}	0.09± 0.003^{a}	135.28± 1.59^{a}	185.19± 2.83^{b}	160.24± 1.09^{b}	65.57± 1.50^{a}	15.33± 0.33^{a}	7.00± 0.58^{a}	25.67± 0.67^{a}	32.67± 0.88^{a}	43.33± 0.88^{a}	45.33± 0.88^{a}	67.33± 1.20^{a}	73.67± 0.67^{a}	92.33± 0.88^{a}
Panicle initiation (n=2)	66.50± 1.22^{a}	68.50± 0.41^{a}	64.50± 0.41^{a}	111.50± 9.39^{a}	0.89± 0.23^{b}	0.26± 0.04^{a}	0.47± 0.23^{a}	0.10± 0.01^{a}	237.23± 1.41^{b}	189.62± 1.00^{b}	213.43± 0.20^{c}	75.04± 1.22^{ab}	17.00± 1.00^{b}	6.50± 0.50^{a}	30.00± 7.00^{a}	33.50± 1.50^{a}	42.50± 0.50^{a}	44.00± 1.00^{a}	86.00± 1.00^{b}	81.00± 1.00^{b}	93.50± 0.50^{a}
Dough (n=3)	89.67± 1.86^{b}	92.67± 1.33^{b}	119.67± 1.23^{b}	140.67± 10.33^{b}	1.12± 0.05^{b}	0.41± 0.01^{b}	0.92± 0.15^{b}	0.09± 0.004^{a}	243.09± 4.51^{b}	164.26± 10.86^{c}	203.68± 7.18^{c}	83.61± 3.64^{b}	16.67± 0.33^{b}	5.67± 0.67^{a}	25.00± 1.15^{a}	32.33± 0.88^{a}	42.00± 0.58^{a}	47.00± 0.58^{a}	85.67± 1.76^{b}	87.67± 2.03^{b}	94.67± 1.20^{a}
Pre-harvest (n=2)	89.50± 0.50^{b}	92.50± 1.50^{b}	131.75± 1.08^{c}	150.50± 3.50^{c}	1.27± 0.02^{b}	0.41± 0.01^{b}	0.90± 0.02^{b}	0.09± 0.003^{a}	278.41± 3.07^{c}	180.48± 3.17^{bc}	229.44± 0.05^{c}	107.97± 13.55^{c}	17.50± 0.50^{b}	6.50± 0.50^{a}	24.50± 1.50^{a}	34.50± 2.50^{a}	43.50± 0.50^{a}	46.00± 1.00^{a}	88.50± 0.50^{b}	89.50± 2.50^{b}	92.50± 1.50^{a}
Lean period (n=1)	90.00*	95.00*	135.42*	147.00*	1.21*	0.41*	0.75*	0.072*	281.47*	177.31*	229.39*	94.42*	16*	6*	24*	35*	42*	47*	87*	91*	96*

Values Mean ± SE except pregnancy and cyclic rats; Values with different superscripts (a-c) in a column differ significantly ($p \leq 0.05$); SG-Spermatogonia, SC-Sertoli cells, L-Leptotene, Z-Zygotene, P-Pachytene, D-Diplotene, EL-Elongating spermatids, ED-Elongated spermatids and RS-Round Spermatids; Values are Mean±SE; Values with different superscripts (a-c) in a column differ significantly at $p \leq 0.05$; *No Mean ± S.E for single value and cannot be compared statistically reduced weight of ovaries during winter season as compared to spring season coinciding with sowing-tillering and dough-preharvest stage, respectively. Sarli et al. (2015) reported that ovarian mass was significantly lower in winter in the Baluchistan gerbil.

The histomorphological studies of ovaries revealed all types of follicles during different growth stages of the wheat crop; their number varied- such as primordial (13.00-16.75), primary (6.50-7.33), secondary (2.75-3.67), pre-antral (2.75-3.50), antral (3.25-3.67), atretic (3.00-3.50) and corpus luteum (3.50-5.50); as well as diameter of follicles such as- primordial (19.57-19.98 µm), primary (93.12- 96.07 µm), secondary (204.42 -216.95 µm), pre-antral (277.63-332.57 µm), antral (474.44-499.98 µm), atretic (211.49- 247.33 µm) and corpus luteum (622.24-629.76 µm) were significantly more during later growth stages i.e. dough, preharvest stage and lean period which indicated progressive folliculogenesis in *T. indica* during this time period. The long day length and high temperature had a strong effect on the progesterone level which resulted in increase in diameter of corpus luteum during April and May (Hussain et al*.,* 1994). In the present study, diameter of corpus luteum was found to be more during later growth stages i.e. dough, preharvest stage and lean period when the temperature was high as well as when the day length increased. Dantas et al. (2021) reported that environmental factors such as photoperiod, temperature and rainfall could impair or contribute to the quality of reproductive parameters of rodents.

The sperm parameters such as motility (89.50-89.67%), viability (92.50-92.67%) and count (119.67-131.75 millions/ ml) were significantly higher during dough and preharvest stages as compared to initial growth stages i.e. sowing, tillering and panicle initiation (Table 1). The body weight was maximum during preharvest stage (150.50 g) and it varied significantly from all other growth stages. The mature wheat grains (as food for the gerbils) were available in the crop fields during preharvest stage which were absent during tillering and panicle initiation stage and also the temperature was optimum during the later growth stages. These might be the reasons for increased body weight of male gerbils during the later growth stages. Similarly, Sarli et al. (2015) reported that the body mass of Baluchistan gerbil was significantly low during winter (December-January) as compared to spring (March-April). The weight of testes (0.89- 1.27 g/ 100g bw) was significantly high during tillering-preharvest stages as compared to sowing stage. The weight of epididymis (0.41 g/ 100g bw) and seminal vesicles (0.90-0.92 g/ 100g bw) was significantly high during dough and preharvest stages as compared to initial growth stages i.e sowing, tillering and panicle initiation. The sperm parameters were also found to be significantly high during these stages. However, the weight of prostate gland varied non-significantly during growth stages. Hussain et al. (2002) reported occurrence of infertile *T. indica* males with decrease in size and weight of reproductive organs i.e. testes and seminal vesicles during winter season as observed during sowing stage now. Khan and Beg (1986) reported that the fertile male gerbils were recorded in all the months of the year except December.

The histomorphological studies of testis revealed diameter of seminiferous tubules (203.68- 229.44 µm) was significantly higher during panicle initiation, dough and pre-harvest stages (Table 1). The male rodents increased the testicular volume and seminiferous tubule diameter, thus improving spermatogenesis efficiency during reproductive seasons which coincides with present results of significantly more testicular weight and seminiferous tubular diameter during panicle initiation, dough and preharvest stages (Muteka et al., 2018). The number of sertoli cells, zygotene, leptotene, pachytene, diplotene and round spermatids were non-significantly different during different growth stages. However, number of spermatogonia (16.67- 17.50), elongating spermatids (85.67- 88.50) and elongated spermatids (81.00- 89.50) was significantly more during panicle initiation, dough and preharvest stages which indicated active process of spermatogenesis due to the favourable temperature at these growth stages. Sarli et al. (2015) reported that diameter of seminiferous tubule was significantly smaller in winter as compared to the other seasons and observed that both rainfall and temperature had a significant positive influence on the diameter of the seminiferous tubules. Similarly, in the present studies the diameter of the seminiferous tubules was found to be less during initial growth stages of wheat crop due to low temperature of the winter season.

Thus, *T. indica* showed peak breeding activity during later growth stages of wheat crop i.e. dough and preharvest stage due to favourable temperature conditions as well as proper food availability. Hence, to control the Indian gerbils and its damage at preharvest stage in the wheat crop fields, rodenticides or rodent control operations should be applied/ followed during tillering/ panicle initiation stage i.e. before the initiation of peak breeding activity of the gerbils.

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