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ABSTRACT: Rodents cause significant economic loss to poultry by feeding on poultry feed, contaminating it, damaging eggs, attacking chicks and transmitting bacterial and protozoan diseases. A year long study was undertaken to generate data on population structure and dynamics of *Rattus rattus* inhabiting poultry. Peak density was observed during summer (April). Although rats bred throughout the year, maximum breeding occurred in December (Winter). Adults were preponderant and sex ratio tilted slightly towards females. The calculated annual productivity of female *R. rattus* was 69.59 young/female/year. The continuous availability of food and ample shelter well protected from predators and immigrants indicates behavioural regulation of population. The winter breeding contributed to summer peaks and the female preponderance could be due to dispersal of males.

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INTRODUCTION

Rodents pose a serious threat to poultry by feeding on poultry feed, contaminating it with their excrements, damaging eggs, attacking and killing chicks, causing structural damage to buildings, doors, windows, feed containers and transmitting/carrying several diseases. Even modern poultry buildings are vulnerable to rodent damage as they have been found to attack and nest in fibre glass or polystyrene insulated walls (Turner 1986). An annual loss of $50,000 is reported from a poultry producing 600,000 eggs a week. Loss estimates range from 0.57kg feed/day (Ahmed et al. 1984), 0.39-10% eggs (Khatri and Veda 1984, Soni and Rana 1988), 0.95 egg trays/day, 1.07 gunny bags/day (Chopra 1987) and approximately $13.61 loss/1,000 chicks (Rs. 94/1,000 chicks; Ahmed et al. 1984). With many poor and middle class farmers in India taking up poultry to supplement their income, the industry is poised to become a major income source to them. However due to financial limitations many farmers build poor quality sheds inside the crop fields and close to villages which naturally attracts both field and commensal rodents leading to considerable financial losses. Hence a preliminary investigation was undertaken to study the ecology and management of rodents in poultry. This paper reports the structure and dynamics *of Rattus rattus* population inhabiting poultry while results on feeding behaviour, toxicology and pest management will be reported elsewhere.

METHODS

The study was carried at two rearing and two layer houses of Central Poultry Breeding and Research Institute, Hesaraghatta, 25 km from Bangalore. Each house measuring 100' x 40' is constructed on a solid foundation with a 4' brick wall followed by wire mesh up to the asbestos roof on either side and stone walls at the front and rear. A horizontal 2' cement collar, projecting from the wall at 1.5' above ground level renders the shed rodent proof. The sheds are situated 20' apart in an open grassland. Water is made available in open, cement channels (4" x 2") running the whole length of the shed in front of the rooms housing chicks. Food in feeders is replenished three times a day.

The dynamics and structure of rodent population was studied in two rearing houses, RH1 and RH2 and the reproductive status in two layer houses, LH1 and LH2 housing 2,000 birds each. Data were collected from rats trapped every month over one year period from August 1988 to August 1989. Traps were laid in two parallel rows along the waster channels at 20' intervals. Three days baiting was followed by baiting on the fourth day. Rats caught from RH1 and RH2 were individually marked by toe clipping and released after recording their weight, sex and reproductive condition. From this, monthly changes in density, weight, sex ratio and adult/juvenile ratio for each sex and breeding status were projected. Population density was calculated as per Schnable index (Thompson 1982).

Based on reproductive condition the rats were classified into juvenile, sub-adult and adults. Rats weighing less than l00g with abdominal testes/unopened vaginal orifice were designated juveniles, those weighing 100-150g with scrotal testes/opened vagina but without uterine scars formed sub-adults while rats above 150g weight with scrotal testes/uteri with scars were considered as adults. Based on weights rats were also divided into five classes viz. those weighing less than 50g, 51-100g, 101-150g, 151-200g and above 200g for each sex.

In LH1 and LH2 removal trapping was carried out and population density was calculated by trap index method (Southern 1973). The trapped rats were transferred to laboratory for autopsy to record sex, age and reproductive status namely pregnant, lactating and embryo count in uterine horns. The prevalence of pregnancy (the total number of pregnant females/total number of fertile females x 100) of the rats was calculated (Govind Raj and Srihari 1987). The productivity (breeding potential) was calculated using the formula:

$N = L/G$

Where N = Number of litter produced
L = Length of breeding season in days
G = Gestation period in days.

Further, N was multiplied by observed peak prevalence of pregnancy which in turn was multiplied by average litter to give the annual productivity (Leicheleifner 1959).

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RESULTS

Species

Rattus rattus was the only species trapped inside the sheds. However isolated and sporadic burrows of *Bandicota bengalensis* and *Bandicota indica* were seen on the ground around the sheds.

Population Dynamics and Structure (RH1. and RH2)

Density expressed as Schnabel index varied from a minimum of 60 + 13.4/shed in the month of March to a maximum of 784 + 196/shed during April in RH1 (Table 1). In RH2 minimum density of 18 + 10. 4 rats/shed was in September and peak population of 90 + 12.2 occurred in August 1989 (Table 2).

Male/Female ratio—In RH1 females were caught more than males throughout the year except during August 1988 and October. In RH2 females were captured more during September and March-April and more males in other months.

Age—Among males, adults formed 62.8% of population while juveniles and sub-adults constituted 18.6% each in RH1. Among females, juveniles formed 6.75%, sub-adults 15.25% and the remaining 78.9% comprised of adults. Adult/juvenile ratio averaged 2.2:1. In RH2 adult males constituted 91.68% while sub-adults and juveniles formed 4.17% each of the population whereas all females trapped were adults.

Weight classes—In RH1, males weighing less than 50g formed 7.7% population; those weighing between 51-100g and 151-200g formed 30.8% each while 101-150g weight class constituted 28.2%. The remaining 2% was comprised of males weighing above 200g. Similarly the females weighing less than 50g and more than 200g constituted 3.6% and 5.5% respectively while those weighing between 5 l-100g and 101-150g constituted 29.1% each. The 151-200g class constituted 32.7% of the population.

In RH2 no captured rats weighed less than 50g and more than 200g; the males in the range of 101-150g and 151-200g constituted 41.66% of population each and the 51-100g group formed the remaining 2.52%. Females trapped belonged only to two classes namely 101-150g forming 51.17% and 151-200g constituting 45.83%.

Reproductive status of females—Pregnant females were trapped throughout the year except in October and January-February with a major peak in April and a minor peak in December in RH1. Lactating females were seen during August 1988 and from March to July with a peak in April while juveniles were caught only in August and September.

In RH2, pregnant females were seen during September, November and December, the peak being in September while lactating females were captured from September to October and March, the highest capture was in October.

Comparison of population in RH1 and RH2—Mean population was higher in RH1 than in RH2. The two sheds recorded similar results for the month of highest captures (August 1989), male peak (August 1988), higher adult population but differences were seen in occurrence of female peak i.e. during August 1988 in RH1 and October in RH2, only adult females being trapped in RH2, 101-200g weight class forming 90% population in RH1 against 151-200g forming the same percent in RH2.

Breeding Biology (LH1 and LH2)

Male/Female ratio ranged from 1:1 in October and May to 1:3 in May and the mean for the study period was 1:1.43 (Table 3).

Reproductive status—Maximum prevalence of pregnancy was seen in December while more than 50% females were either pregnant or lactating during October, December, January and April while minimum pregnancy was seen in September and June (Table 4). The monthly mean of embryos ranged from 2 (January-February) to a maximum of 11 in November

Table 1. Monthly population estimates (Schnabel Index) of *R. rattus* in rearing house 1.

Month & Year	Total number of rats trapped (n)	Total number marked (M)	Total recaptured (m)	Population estimation $N = \frac{Mn}{m}$	Standard error $SE = \sqrt{\frac{M2n(n-m)}{m3}}$	Confidence Limit (±)
August 1988	28	—	—	—	—	—
September	14	28	4	98	41.4	82.8
October	4	38	2	76	38.0	76.0
November	5	40	2	100	29.8	59.6
December	8	43	3	114.7	52.3	104.6
January 1989	—	48	—	—	—	—
February	—	48	—	—	—	—
March	5	48	4	60	13.4	26.8
April	16	49	1	784	196	392.0
May	3	64	2	96	39.2	78.4
June	3	65	2	97.5	39.8	79.6
July	11	66	5	145.2	47.9	95.8
August	28	72	9	224	61.5	123.0

Table 2. Monthly population estimates (Schnabel Index) of *R. rattus* in rearing house 2.

Month & Year	Total number of rats trapped (n)	Total number marked (M)	Total recaptures (m)	Population estimation $N = \frac{Mn}{m}$	Standard error $SE = \sqrt{\frac{M2n(n-m)}{m3}}$	Confidence Limit (±)
August 1988	6	—	—	—	—	—
September	6	6	2	18	10.4	20.8
October	10	10	4	25	9.7	19.4
November	5	16	2	40	21.9	43.8
December	3	19	2	28.5	11.6	23.2
January 1989	—	20	—	—	—	—
February	—	20	—	—	—	—
March	3	20	2	30	12.2	24.4
April	5	21	2	52.5	28.5	57.0
May	3	24	2	36	14.7	29.4
June	3	25	2	37.5	15.3	30.6
July	6	26	2	78	15.9	31.8
August	14	30	8	90	12.2	24.4

with an annual mean of 5.67. From August to November 1988 the mean number of embryos were comparatively higher compared to other months (Table 5). The annual productivity of female *R. rattus* calculated from trapped rats comes to 69.59 young/female/year.

DISCUSSION

From the trappings it is evident that *Rattus rattus* is the predominant species infesting and depredating poultry farms around Bangalore, although burrows of *Bandicota bengalensis* and *Bandicota indica* were occassionally seen around the poultry. Earlier studies also identified *R. rattus* as the major (Parshad et al. 1987, Soni and Rana 1988) and abundant species (Ahmed et al. 1984) occupying poultry in India. The less affecting other species are: *mus musculus* (26,73%), *Tatera indica* (16.56%) and *B. bengalensis* (12.67%) in poultry sheds situated amidst crop fields (Malhi and Sood 1983). The 100% occupancy by *R. rattus* in Bangalore could be due to the location of sheds away from crop fields and being surrounded by residential quarters.

Population peak seems to occur during summer as seen by peak numbers captured in April in RH1, March in RH1, May in LH2. This is in contrast to winter peaks reported for field rodents such as *B. bengalensis* (Spillet 1966, Sridhara and Krishnamoorthy 1979), *R. rattus bruenesculus* (Chauhan and Saxena 1982), *R. meltada* (Chandrahas and Krishnaswamy 1974), *Mus platythrix* (Chandrahas 1974) and *T. indica* (Chandrahas and Krishnaswamy 1974). However the species resembles squirrels, desert gerbils and murids of Punjab in exhibiting peak numbers in summer (Prakash and Kametkar 1969, Prakash 1971, Malhi and Sood 1983).

Rodents from temperate climates display seasonal breeding with young being born in late winter or spring continuing into summer or early autumn depending on the species. The benefits of such seasonal breeding include adequate or increased supplies of food, favourable climate, and protection from predators by good cover of growing vegetation. In the tropics the situation is different with slight variations occurring in environments like rain forests while in grass and woodlands seasonal rains result in favourable/adverse conditions. Post rain breeding peaks have been reported for *T. indica* (Chandrahas and Krishnaswamy 1974), *Meriones hurrianae* (Kaul and Ramaswamy 1967) and *Nesokia indica* (Gariyali and Saxena 1975). However year long breeding occurs in *B. bengalensis* (Spillet 1966, Chakraborty 1975), *T. indica* (Jain 1970), *R. rattus rufescens* (Rana et al. 1982,

Table 3. Sex ratio of *R. rattus* trapped from layer houses.

Month	Number of Males	Number of Females	Ratio of Males	Ratio of Females
August 1988	12	9	1.4	1.0
September	8	11	1.0	1.4
October	7	7	1.0	1.0
November	4	6	1.0	1.5
December	5	6	1.0	1.2
January 1989	2	4	1.0	2.0
February	3	6	1.0	2.0
March	6	18	1.0	3.0
April	7	14	1.0	2.0
May	8	8	1.0	1.0
June	8	16	1.0	2.0
July 1989	9	8	1.1	1.0
Total	79	113	1.0	1.43

Table 4. Breeding condition of *R. rattus* from layer houses.

Month	*R. rattus* trapped		Number Pregnant	Number Lactating	% Pregnant & Lactating	Prevalence of Pregnancy
	Total M	Adult				
August 1988	9	6	2	1	50.0	0.33
September	11	11	1	1	18.0	0.09
October	7	7	3	2	71.0	0.43
November	6	6	3	1	66.7	0.50
December	6	4	4	—	100.0	1.00
January 1989	4	4	3	—	75.0	0.75
February	6	6	2	—	33.0	0.33
March	18	18	4	1	27.8	0.22
April	14	14	6	3	64.3	0.42
May	8	8	3	—	37.5	0.38
June	16	16	2	1	18.8	0.13
July	8	8	2	2	1.0	0.25

Advani and Rana 1984), *Mus booduga* (Chandrahas 1974, Rao 1979) and *M. platythrix* (Chandrahas 1974). The annual variations in density in these species were attributed to predation, limitations on food availability, diseases, inter- and intra-species aggression. The monthly fluctuation of *R. rattus* population in spite of continuous breeding in the present study could be due to social stress and dispersal. Since the poultry sheds are devoid of any predators, have ample supplies of nutritious food, prevent immigration thus disease transmission, the main regulatory factor operating seems to be within the species and could be due to age, reproductive condition and social status as higher mortality rates are reported for juveniles, adult males and breeding females (Redfield et al. 1977), and it is well known that low survival rates characterise subordinate status. Dispersal is another factor exerting influence on population size and composition affecting birth and death rates, density, age, structure, sex ratio, social organisation and habitat utilization. It is more common among juveniles than adults. Several of the features of *R. rattus* population in the current investigation such as preponderance of females, higher adult numbers, around 90% of the population falling under 50-200g weight class could be due to dispersion of adult males in search of females and those of juveniles in search of newer habitats.

Table 5. Monthly variation in the number of embryos in the two uterine horns of *R. rattus.*

Month	No. of pregnant rats	Monthly mean number of embryos		Mean no. of embryos
		Rt horn	Lt horn	
August	2	6	3	9
September	1	4	6	10
October	3	6	3	9
November	3	6	5	11
December	4	3	4	7
January	3	—	2	2
February	2	2	—	2
March	4	2	1	3
April	6	2	1	3
May	3	2	1	3
June	2	2	2	4
July	2	2	3	5
		Annual mean		5.67

The higher incidence of pregnancy in the months of August to January and more or less same pattern of uterine embryo count indicate that *R. rattus* in poultry has retained the evolutionary pattern of breeding after the rains in spite of continuous food and protection from predators resulting in summer peaks. The annual productivity of 69.59 young/female/year is the highest reported for any Indian rodent studied which could be due to ideal conditions of survival and reproduction inherent in poultry sheds.

The minimum number of rats are seen during the months of January-February and September. These are also the months when breeding is lowest. Rodent control operations can be taken up during these months in poultry farms. Unlike in fields where annual control is adequate in view of seasonality of food availability, poultry farms with constant food supply require two rodent control operations a year to check the fast growing populations as seen by the annual productivity rates. The results presented in this paper indicate the months of February and September as ideal for such control.

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