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Research Article

Population Dynamics of Soft-Furred field rat, *Millardia meltada*, in Rice and wheat Fields in Central Punjab, Pakistan

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Abstract: Data on the abundance, reproduction, diet and damage index of the soft-furred field rat *Millardia meltada* were collected during the rice and wheat seasons. The abundance of *Millardia meltada* remained high at the post-harvest stage of the rice and wheat crops. The ploughing of fields did not affect the abundance of Millardia. The mean annual prevalence of pregnancy was 50% and the mean embryonic litter size 6.2 ± 0.4.

Millardia continued to eat wheat and rice grains over a long period even when there was no crop standing in the fields. The damage indices in rice and wheat crops were 17.8 and 28.3% respectively.

Key Words: *Millardia meltada*, abundance, reproduction, diet, rice, wheat, Punjab

Pakistan Orta Pencab'taki Buğday ve Prinç Tarlalarında Yumuşak Tüylü Tarla Sıçanı *Millardia meltada*'nın Popülasyon Dinamiği

Özet: Buğday ve pirinç mevsimlerinde, yumuşak kürklü tarla sıçanı *Millardia meltada*'nın bolluk, üreme, beslenme ve zarar endekslerine ait veriler toplandı. *Millardia meltada*'nın bolluğu, buğday ve pirinç ürünlerinin hasatı sonrasında yüksek bulundu. Tarlaları sürmenin *Millardia meltada*'nın bolluğu üzerinde etkisi olmadı. Ortalama yıllık gebelik görülme oranı % 50 ve ortalama yavru sayısı 6.2 ± 0.4 olarak belirlendi. *Millardia* tarlalarda buğday ve pirinç olmasa bile, buğday tanelerini tükekmeyi uzun bir süre sürdürmüştür. Pirinç ve buğday ürünlerinin zarar endeksleri sırası ile 17.3 ve 28.3 idi.

Anahtar Sözcükler: Millardia meltada, bolluk, üreme, beslenme, pirinç, buğday, Pencab

Introduction

The soft-furred field rat or, Metads, *Millardia meltada* (Gray), is confined to the Indian-Pakistan continent (1). In Pakistan, the Metads appears to have a rather restricted distribution, being mainly confined to Southern Sindh and the Northeastern part of the Punjab. Its reproduction in croplands has been studied (2-5). These have reported variations in its abundance, reproduction and diet only in sugar cane and rice crops fields respectively.

During a study of the biology of rodents in rice and wheat fields, *Millardia* were also collected from trap lines and studied. In this paper, the results of investigations pertaining to the density, reproduction and diet of *M. meltada* are reported.

Study Area

The study was undertaken in the Sheikhupura District (30º50'N, 73º16'E)situated near River Ravi. Rice is the principle summer crop and is grown from July to October. After the rice harvest, fields usually remain unploughed with stubble and scattered piles of sheaves until late December. The wheat crop remains in the fields from December to April/May. The ploughing of the post-harvest dry wheat field results in the formation of large clods, between which the smaller rodents find shelter. No other crop except for rice or wheat is grown at a time. Cultivated fields are spread over the entire landscape with a few pockets of wasteland.

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Materials and Methods

Collection of data

Metads were collected through three trapping schedules, i.e. regular bi-monthly trapping by the authors in the regular bi-monthly study area. Trapping sites were selected where rodent numbers were determined as high by fresh burrows, footprints, fresh fecal pellets and other signs. The second and third trapping schedules were the kill trap survey and rice rat control trials performed by Vertebrate Pest Control Institute (VCPI) staff on a bi-monthly basis in the rice and wheat fields of Punjab.

Trapping was undertaken at every stage of development of the rice crop i.e. vegetative, flowering, harvest, and post-harvest stages. During the wheat season trapping was undertaken only during the flowering and harvest crop stages. Each sample contained the same bias in which the authors selected the fields most likely to contain rodents out of five and six farms inspected. Only data gathered from regular trapping sites were included in the determination of trap success, while the information on reproduction and diet was based on the animals collected during the kill trap survey and rice rat control trials by VPCI personnel.

Data, particularly on bandicoot rats and *Mus* sp, were taken from the VPCI working reports and these animals were also collected by VPCI persomel through the kill trap survey and rice rat control trials in the rice and wheat fields of the Punjab.

Trapping methods

Kill trap survey and rice rat control trials were conducted on a bi-monthly basis by the staff of the VPCI in the rice and wheat fields. Fifty to 100 traps were set randomly in the fields after thorough inspection. Different baits were used for trapping the rodents, i.e. peanut butter, wheat pancakes and fresh onions. Traps were set in the evening and picked up in the morning for five to seven consecutive days. Data on abundance was gathered by using snap traps baited with wheat flour pancakes. Bi-monthly trapping was carried out in rice and wheat fields along the Lahore-Sheikhupura Road 16-26 km west of Lahore. Two or four trap lines were operated simultaneously. Traps were set in pairs 10-15 paces apart with 50 per trap line away from the edge of the field, 3-4 m under the crop covers. New farms were mostly selected for each bi-monthly sample, except in December when the same fields were trapped as the previous October. Trap success (abundance) was calculated as:

$$\text{Trap success (abundance)} = \frac{\text{Number of Metads}}{\text{Number of trap nights}} \times 100$$

Rodents were sexed, weighed, measured and dissected within 1h of collection. A Pesola spring balance was used for measuring body weight.

Parameters studied

For each animal collected the following information was recorded as appropriate: body weight, sex, condition of the vagina (perforate or imperforate), condition of the uterus (embryo count, scar count, nulliparous or estrus), position of the testis (scrotal or abdominal), and position of the cauda epididymis (tubules visible or invisible).

Animals were considered to be adult if the weight was greater than that of the smallest sexually mature animal using visibility of tubules or estrus stage (perforation of vagina and swollen uterus) as the criteria of sexual maturity. The number of young per female produced by the population was calculated from the pregnancy rate using Southwick's (6) procedure. This procedure uses the incidence of pregnancy, F, defined as:

$$F = P \quad (t / v)$$

where

P = the percent of adult females in the sample that were pregnant.

t = time in days over which the sample was taken.

v = time in days of gestation during pregnancy is microscopically visible.

In addition, the average number of young produced per adult female collected was determined by dividing the total number of placental scars and embryos by the number of adult females examined. The average number of young produced per adult female was determined as:

$$\text{Avg. young produced} = \frac{\text{Total placental scars \& embryos}}{\text{Total adult females}}$$

Here only those females that showed embryos and scars in their uteri were considered adult. The average adult age of females collected was estimated as:

$$\text{Avg. adult age (In months)} = \frac{\text{Number of young per female}}{\text{Number of young per female collected per year}} \times 12$$

This does not include the age to reach sexual maturity and is concerned only with the littering age of adult females.

For the study of the diet stomachs were preserved in the field in 10% formalin before examining their contents in the laboratory for microscopic analysis of various food items. The methodology for the study of habits and the calculation of the crop damage was undertaken following the procedure used by Lathiya (7).

All the food fragments examined were placed into 11 different food groups. Diet data were summarized. The relative frequency of each food item eaten by *Millardia* was determined by dividing the sum of fragments of the individual items by the total of all the fragments examined at a particular stage of the crop. An index of crop damage caused by *Millardia* only was made for the flowering and harvest stage, of the rice and wheat crop. Data on abundance, diet and stomach capacity were combined to estimate the percent of overall damage. According to Fulk et al. (4), *bandicota* were found to have a stomach capacity 8.2 times that of *Mus* sp and *Millardia meltada* and 4.6 times that of *Mus* sp. The parameters for the estimation of the damage index were calculated as follows:

A) Estimate of the portion of diet (rice or wheat) = $\dfrac{\text{Total fragments of reproductive parts of rice or wheat in stomachs of Metads at stage X}}{\text{Number of stomachs of Metads examined at stage X}}$

B) Estimate of abundance = $\dfrac{\text{Metads caught in stages X}}{\text{Total trap nights in stage X}}$

C) Factor, which equalized stomach volume of Metads = $\dfrac{\text{Mean dry weight of content of 10 stomachs of Metads.}}{\text{Mean dry weight of content of 10 stomachs of Mus}}$

Index of damage calculated at stage X as

$$\text{Stage X} = A \times B \times C.$$

No damage index was calculated for the pre-flowering stage as very little damage occurs before flowering, and rice plants cut during the pre-flowering stage can regenerate with little or no loss of yield. Thus four indices, two in rice fields and two in wheat fields, were calculated and the total of these was considered an estimate of all damage caused by Metads over both stages (flowering and harvest) of crop development.

Results

Abundance

The abundance of *Millardia meltada* seemed to be affected by breeding and largely unaffected by agricultural operations (Table 1, Figure 1 A,B).

Low abundance in April corresponded with a low reproductive rate in February.

Months of high abundance (December, February and June) followed months of high reproduction, and ploughing did not reduce abundance. *Millardia* were abundant in the freshly ploughed fields in June and evidence of this species (ie faecal pellets) could be found between clods of hard earth made by ploughing (Figure 1A).

Reproduction

Sex ratio and male fertility

Although the sex ratio was dominated by males, in both rice and wheat fields, there was a significant preponderance of males in the overall sample ($X^2 = 4.10$ $P < 0.05$) (Table 1). This ratio does not include juveniles (< 30g), which were trapped only in December and June. The males showed high fertility throughout the rice and wheat season, except in April when no male was trapped. The year-round male fertility in *Millardia meltada* was also reported by Tahir (10) working in several agricultural crop fields of Central Punjab, although he found it low in winter.

Weight and sexual maturity

Adult males become sexually active when they weigh between 50 and 100g, with some 84% having visible tubules between these weights compared to only four males weighing less than 50g. The smallest fertile male weight was 44g. Some 74% of females became perforate between 40 and 70g, compared to only four females at less than 40g. The smallest pregnant female weighed 34g. The females were first impregnated between 40 and 80g, 82% of this weight class having embryos or scars.

Table 1. Seasonal variation in abundance and reproductive rates of *Millardia meltada* in rice and wheat crops in the Central Punjab, Pakistan. (Number of animals caught and examined is shown in parenthesis).

				ADULTS = 30g		
Month/Crop/Condition	Trap nights	Abundance (%)	No. of animals examined	Males % Tubules visible	Females % Pregnant	Litter size
August/rice/vegetative	-	-	28	32.1(09)	67.9(19)	3.8
September/rice/flowering	0333	0.6(02)	09	33.3(03)	66.7(06)	6.5
October/rice/harvest	1169	1.5(17)	23	30.4(07)	69.6(16)	7.8
December/rice/post-harvest	0750	3.2(24)	20	50(10)	50(10)	6.3
February/wheat/flowering	0712	3.5(25)	25	60(15)	40(10)	7.0
April/wheat/harvest	0699	0.6(04)	04	0(0)	100(04)	8.0
June/wheat/post-harvest	0740	3.6(27)	20	50(10)	50(10)	5.0
TOTAL	4403	2.2(99)	129	41.8(54)	58.2(75)	6.2

Mean litter size = 6.2 ± 0.4, $X^2 = 4.10$, $P < 0.05$

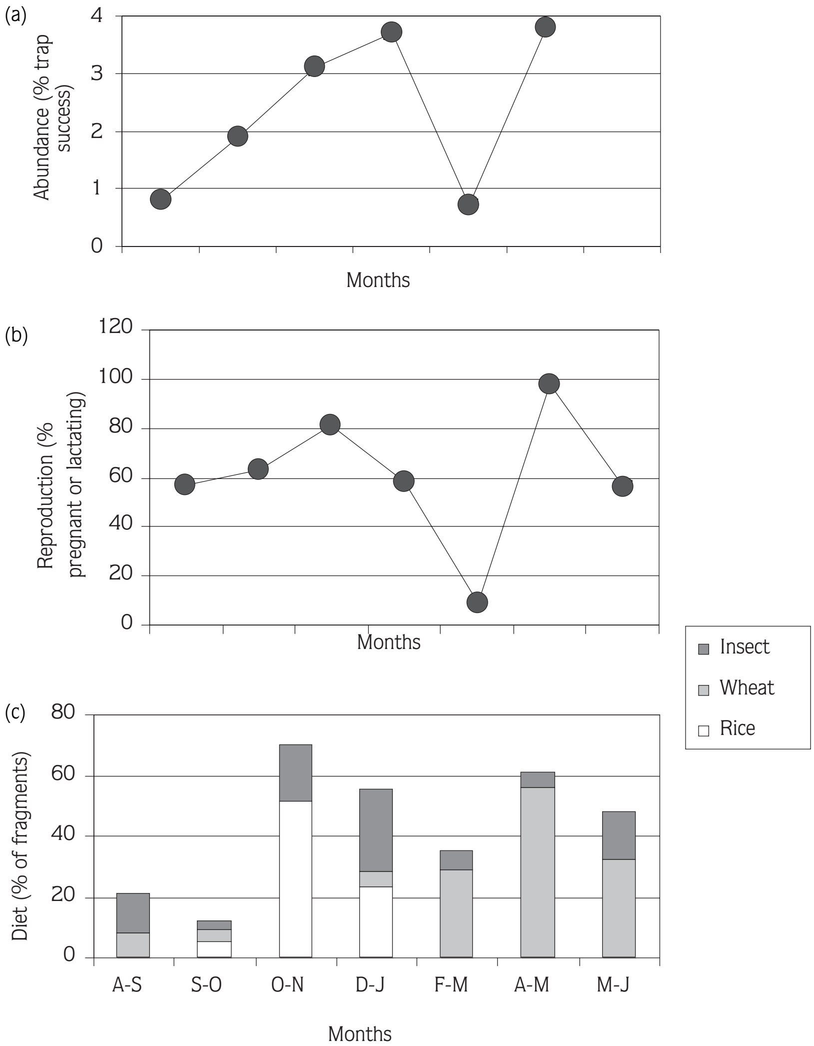

Figure 1. Seasonal variation in abundance, reproduction and diet of *Millardia meltada* from agricultural fields in Sheikhupura District, Punjab. Abundance data from August considered unrepresentative.

Litter size

The overall litter size as determined by embryo counts for the *Millardia meltada* population in the study (Table 1) was 6.2 ± 0.4, which is greater than ever reported in previous studies: 5.07 (10) and 3.44 (11). A litter of six young for the wild population in the Indian Punjab (11) is very close to the present estimate. Litter size varies not only in different species of rats but also in different localities and climatic zones (12).

Pregnancy and reproductive rates

Pregnancy rates (Table 1) were near or over 50% in all months except February, when the temperature was low (6 °C). The highest number (83%) of pregnant females was found at the time of the rice harvest in October and of the wheat harvest in April (100%). During these months the litter size also increased (Figure 1B).

The reproductive strategies in *Millardia meltada* are different from other rodents (*Bandicota bengalensis* and *Mus* sp.) living in rice and wheat fields as co-species. This rat had the highest reproductive rate (76.3 young per female per year), followed by *Bandicota bengalensis* (68.5%) and Mus sp. (37.1%). The estimated litter size produced by an adult female was 6.7. The life span of an adult female thus calculated was 1.1 months or 9.2% of a year, that is close to the 0.9 months reported for meltada by Smeit et al. (5) in sugar cane fields. Neither of these estimates include the average age that the female had reached before reaching sexual maturity and is concerned only with a one-year period (Table 2).

Diet

The percentage of rice content in the stomach was low in all months except October, the month of harvest, and December when it was 53.3% and 22.6% respectively (Table 3). In December 26.5% of the diet consists of insects. In other months that were adequately sampled, insects accounted for about 13 to 19% of the diet, except in February when insects were probably largely unavailable due to the cold weather. Wheat accounted for a large portion, (29.0, 59.3 and 36.2%) of the diet in February, April and June (Figure 1C).

Damage index

Bandicota benglalensis caused most of the damage to rice and wheat fields in the Central Punjab (8); *M. meltada* also contributed quite substantial damage (21.3% and 22.4%). Most damage to rice and wheat occurred when the grain was ripening instead of during the flowering stage. However in wheat fields *Millardia* caused more (16.7%) at the flowering stage since these species were specially abundant at that time and contained an important amount of wheat flowers in their stomachs (Table 4).

Discussion and Conclusion

A reduction in breeding in Metads during cold months was found, but otherwise a high pregnancy level was recorded. Breeding peaks coinciding with the maturity of agricultural crops and reproductive quiescence in winter were also recorded in previous studies (2-5,11,14). This rat had the highest reproductive rates and showed an incidence of pregnancy about twice that of *Bandicota* and *Mus* sp, but produces only slightly more litters per female per year and with a lower proportion of females with scars. This suggests a shorter lifespan in *Millardia meltada*.

Abundance in Metads was high at the flowering and post-harvest stage of wheat and low at the harvest stage. It also seemed to be affected by breeding activity. Like most rodents (8) the abundance of *Millardia* seems to be affected by breeding activity in the preceding one to two months. Low abundance in April was preceded by low pregnancy rates in the cold month of February. Months of high abundance (December, February and June) followed months of high reproduction. However,

Table 2. Reproductive performance of rodents in rice and wheat fields of the Central Punjab.

Species	% with scars	No. of young / emale collected	Incidence of pregnancy	Average litter size	No. of young / female / year	Mean adult age (months)
Millardia meltada	45.3	6.7	12.3	6.2	76.3	1.1
Bandicota bengalensis	49.2	9.8	6.6	10.5	68.5	1.7
Mus sp.	42.8	5.5	6.3	5.9	37.1	1.8

Table 3. Percent relative frequency of various food items in stomachs of *Millardia meltada* Collected from rice and wheat fields. (In parenthesis are number of fragments observed).

Month/ condition & crop		No. of stomachs examined	Rice V.P.	Rice R.P.	Wheat V.P.	Wheat R.P.	Insects	Seeds	Plant fibers	leaves	Flowers	Roots	Unknown fragments	Total fragments examined
Rice	August Pre-flowering	20	1.2 (22)	0.0	0.0 (123)	7.0 (246)	13.9 (500)	28.3 (136)	7.8 (35)	2.0 (55)	3.1 (357)	20.2 (292)	16.5	1766
Rice	September Flowering	03	0.4 (1)	5.8 (14)	0.0	2.1 (5)	3.4 (8)	12.0 (29)	5.4 (13)	0.4 51)	0.4 (1)	9.1 (22)	61.0 (147)	241
Rice	October Harvest	20	0.2 (4)	53.3 (855)	0.0	0.7 (12)	18.5 (297)	1.4 (22)	6.7 (1.7)	1.9 (30)	0.1 (3)	0.1 (1)	17.0 (272)	1603
Rice	December Post-harvest/ fellow fields	08	0.0	22.6	0.0 (89)	4.8	26.5 (19)	8.9 (104)	0.0 (35)	0.0	0.0	0.0	37.2	393 (146)
Wheat	February Flowering	22	0.0	0.4 (11)	0.4 (9)	29.0 (578)	4.3 (86)	1.2 (23)	7.0 (140)	21.2 (424)	4.0 (80)	3.3 (66)	29.0 (581)	1998
Wheat	April Harvest	04	0.0	0.0	0.0	59.3 (156)	3.4 (9)	0.0	3.4 (9)	14.5 (38)	0.0	8.8 (23)	10.6 (28)	263
Wheat	June Post-harvest/ fellow fields	24	0.0	0.2 (6)	0.0	36.2 (966)	12.4 (331)	1.5 (41)	14.2 (378)	4.0 (107)	1.8 (49)	0.2 55)	29.5 (788)	2671

Table 4 . Indices of damage to rice and wheat caused by Millardia meltada and other rodent species at two stages of crop development in Punjab.

RICE				WHEAT			
Month	M.m	Other rodents	Total	Month	M.m	Other rodents	Total
Flowering/ September	1.1% 0.2	9.6% 1.7	10.7% 1.9	Flowering/ February	16.7% 4.7	20.4% 5.8	37.1% 10.5
Harvest/ October	20.2% 3.7	69.1% 12.2	89.3% 15.9	Harvest/ April	5.7% 1.6	57.2% 16.2	62.9% 17.8
TOTAL	21.3% 3.9	78.7% 13.9	100.0% 17.8	22.4%	77.6% 6.3	100.0% 22.0	28.3

M.m = Millardia meltada

abundance remained low in the monsoon month of September in spite of adequately high (68%) pregnancy rates in the flooded rice field in the previous month (August), which was also the monsoon month. As the field started drying out near the harvest stage, a 1.5% increase in the population occurred in October because of high (69.6%) breeding activity in the preceding month (September). The low abundance in spite of high breeding rate in the previous month in the inundated rice fields could be related to the possibility that excess water in rice fields was unfavorable for the survival of young *Millardia*. The response of this rat to ploughing is also new information. Metads were abundant in the freshly ploughed dry wheat fields in hot months of June, and this means, *Millardia*, like *Mus* sp (9), can live under small and superficial covers and does not require deep burrows for survival. Similarly Prather (13) reported that the Metads quite commonly make a home in deep fissures and are content to hide under heaps of earthern stones formed in the hard ground during the hot months.

Beg and Shahnaz (14), working in the intercropping area in Central Punjab, ascribed seasonal fluctuations in Millardia concentrations to large-scale migration to and from the agricultural fields, following increases in or depletion of the crop cover and food. However, in the present study the trapping areas were under either rice or wheat crop covers and the fields were left fallow following the harvest till the preparation of the soil for the next crop.

Metads also recorded post-harvest feeding on grains. They probably utilized grains left on the surface after the harvest and which may have been available over a longer period. Rana and Advani (15) in India also reported that Metads fed on wheat grains in the absence of crops by entering the rural go-downs. Fulk et al. (4) suggested that Metads apparently either hoarded the grains (unlikely since they are not strong burrowers), or robbed *Bandicota* caches. Similarly Tigner (16) in the Philippines found that *Rattus rattus* mindanesis continued to eat rice as late as eight months after the harvest.

Most damage to rice and wheat occurred when the grain was ripening instead of during flowering. However, in wheat fields Metads' stomachs contained significant amount of flowers.

This study has confirmed the basic ecological differences between *Bandicota* and *Millardia* as suggested by studies in India and Pakistan. *Bandicota* invest nearly all of their reproductive efforts into the time when cereal grains are abundant, while Millardia reproduce at a higher and stable rate over the whole year, except for the cold months. *Bandicota* abundance is greatly affected by movement to and from surrounding habitats, while abundance in *Millardia* is more affected by reproduction of the resident population. *Millardia* abundance was little affected by ploughing, while *Bandicota* abundance was greatly reduced during ploughing.

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