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REPRODUCTION AND SURVIVAL OF THE RICEFIELD RAT *RATTUS ARGENTIVENTER* ON RICE PLANT DIET

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Abstract. Reproduction and survival were studied in caged individuals of the ricefield rat, *Rattus argentiventer,* on a diet of rice plants in various stages of growth. The female rat was reproductively active on diets consisting of rice plant at any stage of growth. However, the reproductive activity of the male rat was significantly influenced by the stage of the rice plant: the male was sexually active while feeding on the generative stages, but almost inactive while feeding on the vegetative stages. The percentage of males with enlarged scrotal testes began to increase on a diet of plants in the panicle primordia initiation stage and reached 100% by the milky grain stage. The male determines the breeding pattern of this species, and this is directly influenced by the males' food source. Male rats with a scrotal sac containing testes that were larger than 30 mm (measured externally on living rats) were always reproductively active. The survival of both sexes of the ricefield rat also corresponded closely with the growth stage of the rice plant. There were no significant differences in survival values between males and females feeding on different stages of the rice plant. Overall, the milky and ripening grain stages of the rice plant provided the best foods for the reproduction and survival of the ricefield rat.

Key words: Ricefield rat *Rattus argentiventer,* male rat, reproductively active, stage of rice plant, survival.

INTRODUCTION

Periodic eruptions of populations of the ricefield rat, *Rattus argentiventer* (Robinson and Kloss, 1916) cause serious economic losses to agriculture in Indonesia (GEDDES, 1992; HOQUE *et al.*, 1988; MURAKAMI *et al.,* 1990; SOEKARNA *et al.,* 1978). The density of the ricefield rat population fluctuates greatly throughout the year according to the stage of growth of the rice plant (TRISTIANI *et al.,* 1998). A previous field study found that there are two distinct population peaks each year, with each peak occurring two to four weeks after a rice harvest (TRISTIANI *et al.,* 1998). Birth and immigration are the important components that determine the population increase (SEBER, 1973; TRISTIANI *et al.,* 1998).

Numerous authors have investigated the effect of supplemental food or the quality of food on individual reproduction in different small mammal species (BOMFORD, 1987a, 1987b; TANN *et al.,* 1991; DUQUETTE & MILLAR, 1995). The reproductive performance of small mammals is affected by either the quality or the abundance of available food, and also by temperature and social factors (SADLEIR, 1969). Results from previous studies suggest that the nutritional quality of the rice plant also has an important influence on the rate of population increase in the ricefield rats (TRISTIANI *et al.,* 1998).

Although the general biology, breeding and control of the ricefield rat were studied in Malaysia by HARRISON (1951), LAM (1980) and BUCKLE *et al.* (1985), little is known of the population dynamics of this species in relation to the developmental stages of the rice plant. Specifically, there is little research that clearly examines the relationship between the reproduction and survival of rat populations and the stage of growth of the rice plant.

This study has two aims. The first is to look for a relationship between the reproduction and survival of the ricefield rat, and its diet on different stages of the growing rice plant. Secondly, we hoped to identify the growth stages that limit the reproduction and survival of these rats.

MATERIAL AND METHODS

The response of ricefield rats to diets consisting of rice plants at different growth stages was studied under laboratory conditions at Jatisari Field Station, West Java, Indonesia. Rats were live-trapped in adjacent rice fields and kept in separate cages measuring 460 x 350 x 190 mm. All captured rats were sorted and classified as adult males (=110 g), adult females (= 60 g), sub-adult males (41-109 g), sub adult females (41-59 g) and juveniles (= 40 g) on the basis of weight.

The temperature in the laboratory ranged from 22° C to 33° C (mean = 26.82° C) and the relative humidity ranged from 45% to 91% (mean = 73.13%). All experiments were carried out simultaneously in the laboratory, therefore conditions were the same across treatments.

During an initial twenty-four day quarantine period, the rats were fed unhusked rice and water was provided *ad libitum*. At the end of this period, all rats were sorted and only pre-pubertal rats which had not yet reproduced were used in this study.

After a 24-hour starvation period (water was continually available), the rats were provided with fresh rice plants in various stages of growth. Eight stages of the rice plant were tested:

Vegetative

1) seedling
2) three weeks after transplantation (3 wat)
3) maximum tillering

Generative

4) initiation of the panicle primordia (OTA, 1990)
5) booting
6) flowering
7) milky
8) ripening

In addition, a ninth diet, consisting of a combination of grass, weeds and grasshoppers, was also tested. Three common weeds/grasses of rice paddies (*Echinochloa crusgalli, Cyperus difformis* and *Cyperus serotinus*) were used in this last diet.

The plants were replaced each afternoon and the quantity of vegetable material remaining was measured the following morning. The rats were weighed twice daily. Groups of 30 rats each were fed separate, single stage material from the cropping cycle for a two month period or until the death of the rat. Two commonly cultivated varieties of rice (IR64 and Cisadane) were used. Out of a total 510 rats, there were 255 males and 255 females.

The following data were recorded for each rat: weight, sex, position of testes (abdominal or scrotal testes) for males, the presence or absence of vagina perforate and size of nipple for females. At death or at the end of the experiment, the size, weight, and condition of the testes and caudal epididymis were determined by necropsy. Males with enlarged scrotal testes and swollen, whitish epididymis were considered to be reproductively active. Females were classified as reproductively active if they had a perforate vagina and or large nipples.

RESULTS

Only one of the sixty males fed a vegetative stage diet (Cisadane variety) was found to be reproductively active, while all the males fed a milky or ripening stage diet became reproductively active five days after being put on this diet. An increasing proportion of the males fed on intermediate maturation stage diets of either variety of rice became reproductively active. However, rats feeding exclusively on the Cisadane variety developed more rapidly (the difference with diets in the booting stage was statistically significant (P>0.05)) (Fig. 1). None of the males became reproductively active on the grass/weed/

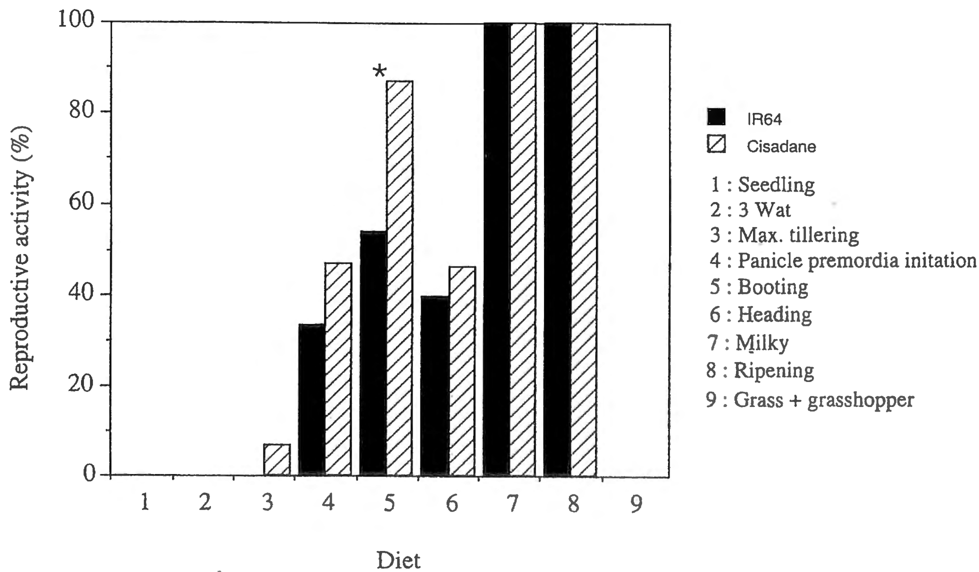

Fig. 1. – The percentage of male rats (*Rattus argentiventer*) that were reproductively active during various stages of the rice plant. [Asterisk denotes a significant difference between IR64 and Cisadane varieties (d.f.=1, P>0.05)].

grasshopper diet. In contrast, all the females became reproductively active (perforate vagina) on diets consisting of either variety of rice at any stage, as well as on the grass/weed/grasshopper diet.

Among the reproductive male rats, there was a further relationship between the relative development of the testes and the length of the scrotum containing descended testes. When the scrotal sac containing testes was larger than 30 mm (measured externally on living rats) the males were reproductively active (Fig. 2).

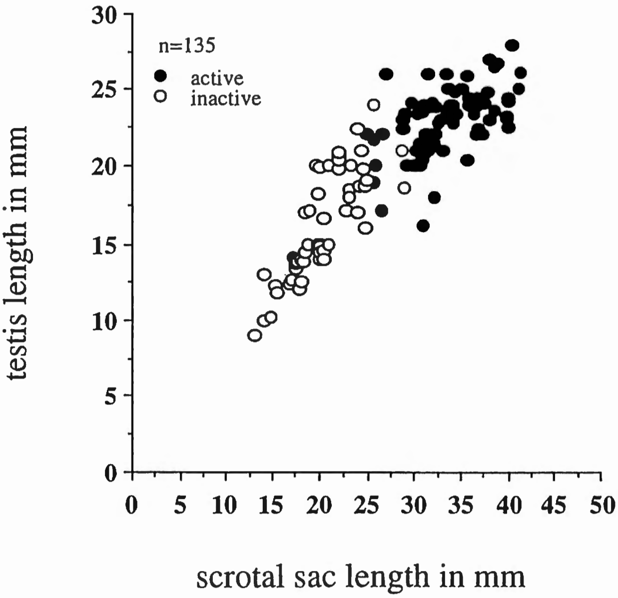

Fig. 2. – The relationship between index of testis (p-t index) to the reproductive state of the testis. (P-T index is the size of the scrotal sac with testis inside measured on the live rat from outside).

Rat survival was also affected by the stage of rice growth given. All the rats fed milky and ripening stages diets survived the two-month test (Table 1). Average survival times on diets of both the IR64 and Cisadane varieties in the booting stage were long, an average of fifteen and twenty days, respectively. Survival dropped sharply, to an average of five days, on a diet of plants in the flowering stage. The grass/weed/ grasshopper diet resulted in the shortest survival times, an average of four days. Although there were significant differences in survival due to differences in diet, there were no significant differences (at a 5% level) between the survival of males and females on the various diets (Table 1).

Relative daily food consumption was almost the same (not significant at a 5% level) from the early growth stage of rice plant to the flowering stage, but then decreased after the milky stage (Fig. 3). From the early growth stage of the rice plant to the flowering stage, there were no significant differences (at a 5% level) between the quantities of the two varieties consumed nor between quantities of each growth stage consumed.

TABLE 1

Rice plant variety	*Diet (Stage of rice plant)*	*Male[a] (mean ± 95% CL)*	*Female[a] (mean ± 95% CL)*
IR64	Nursery bed	10.3 ± 2.63	10.1 ± 1.95[ns]
	Tillering	9.0 ± 2.03	8.9 ± 1.91[ns]
	Max. tillering	8.8 ± 2.15	8.6 ± 1.80[ns]
	Panicle premordia	10.3 ± 2.10	10.2 ± 1.69[ns]
	Booting	15.2 ± 4.28	15.0 ± 4.03[ns]
	Flowering	5.3 ± 2.38	5.3 ± 1.47[ns]
Cisadane	Nursery bed	11.9 ± 2.18	11.3 ± 1.56[ns]
	Tillering	9.5 ± 2.22	9.5 ± 1.91[ns]
	Max. tillering	11.8 ± 3.59	11.1 ± 2.94[ns]
	Panicle premordia	12.0 ± 3.69	11.9 ± 4.16[ns]
	Booting	20.1 ± 2.79	20.0 ± 2.49[ns]
	Flowering	5.5 ± 2.87	5.3 ± 2.29[ns]
	Grass/weed + grasshopper	4.4 ± 2.21	4.3 ± 2.00[ns]

[a]n=15 for each experimental class
ns: Non significant differences between males and females at 5% level as determined by Chi-square analysis
Note: In the milky and ripening stages diet, all rats were alive at the end of the experiment.

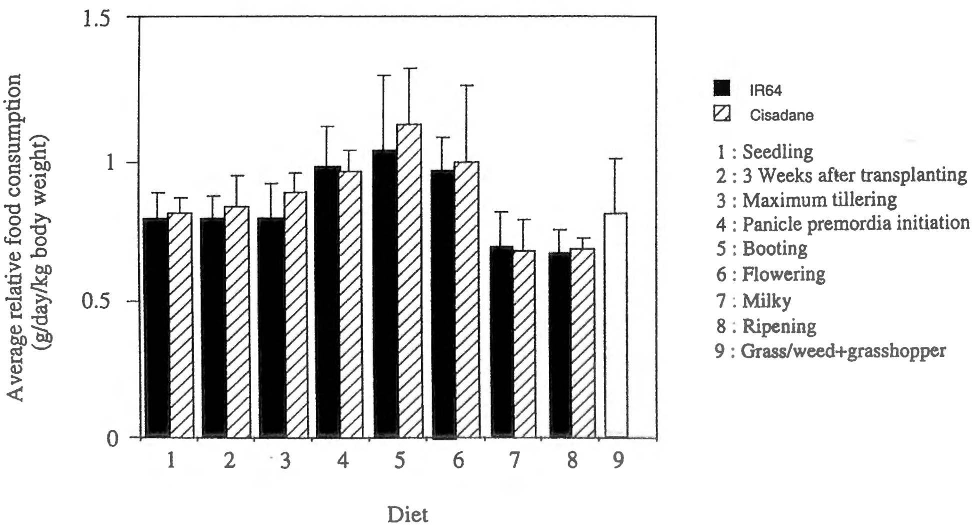

Fig. 3. – Average relative food consumption of the ricefield rat *R. argentiventer* for different stages of the rice plant [the vertical line is Standard Error (SE)].

DISCUSSION

The reproductive rate and population density of small rodents depend on the abundance and/or quality of food (TAITT, 1981; ANDERSON & JONASSON, 1986; DESY & BATZLI, 1989; LEIRS *et. al.*, 1994). The reproductive activity of male *R. argentiventer* was influenced by rice plant development; the males were only sexually active when feeding on rice plants in the generative stages of growth. The percentage of males with enlarged scrotal testes increased during the initiation of the panicle primordia, booting, and heading stages, and reached 100% by the milky stage. Some substances initiating male reproductive activity may be present in the the generative stage of the rice plant. Several small rodent species show similar sensitivity to their diets on green plants (PINTER & NEGUS, 1965; NEGUS & PINTER, 1966; BOMFORD, 1987a, 1987b). NEGUS & PINTER (1966) reported that adding fat extracts from wheat sprouts to laboratory diets increased the reproductive performance of *Microtus montanus*. DESY & BATZLI (1989) in their study of prairie vole reported that supplemental high-quality food significantly increased body growth rates, the proportion of adults in the population, reproductive activity, recruitment, and the population density of prairie vole.

This study found that when the length of the scrotum of ricefield rats containing descended testes was larger than 30 mm, the male was reproductively active. Reproductively active males had enlarged scrotal testes and swollen, whitish epididymides. The position of testes is a relatively accurate predictor of the reproductive status of males (MCCRAVY & ROOSE, 1992).

All the females were observed to become reproductively active on diets of plants from either variety of rice at any stage of growth, as well as on the grass/weed/grasshopper diet. Female rats almost always mature sooner than male rats. The results of a laboratory rearing study (MURAKAMI, unpublished) found that the earliest maturation of a female (perforate vagina) occurred at 28 days of age when the rat weighed 30 g. In contrast, the earliest maturation of a male rat was 59 days of age at a weight of 90 g. Females are ready to breed anytime after they mature (when they develop perforate vaginas) and remain reproductively active continuously (MURAKAMI, unpublished). In this study females were classified as reproductively active if they had a perforate vaginas. In this study we did not examine female pregnancy or lactation. However, it is known that females with perforate vaginas have a higher possibility of becoming pregnant if they mate with active reproductive males (MURAKAMI, unpublished). FIRQUET *et. al.* (1996) and KREBS (1966) noted that females with perforate vaginas are usually in breeding condition.

Since female ricefield rats mature sexually regardless of stage of rice plant, it is the reproductive condition of males that determines the breeding pattern in this species, and this is directly influenced by the males' food source.

When only grass and grasshoppers were eaten, male ricefield rats did not become sexually active and survival was low. Although laboratory experiments (SOEKARNA *et al.*, 1978) have found that rats fed exclusively on weeds, green rice stalks, crabs and snails had low survival (4-5 days), we did not attempt to determine why supplementing the diet did not enhance the reproductive activity of the ricefield rat *R. argentiventer*.

The results of our study show that the seasonal breeding of *R. argentiventer* coincides with the maturation of the rice crop. We conclude that associated nutritional factors are essential for reproduction. Similarly, TAYLOR & GREEN (1976) observed that seasonal patterns in the diet are very closely linked to reproduction of African rodents. MERGES (1972) showed that the pattern of reproduction of *Rattus rattus mindanensis* in the Philippines was very closely related to the growth of the rice crop.

The survival of both sexes of the ricefield rat was also closely related to the growth stages of the rice plant. Stages prior to the initiation of the panicle primordia stage were unfavorable food sources. Although survival increased with a diet of booting plants, there was a sharp drop at the flowering followed by an increase in subsequent stages. In their experiments, SOEKARNA *et al.* (1978) observed extended survival (up to 3 months) in rats fed exclusively on the green tops of younger plants.

Our study found that relative daily food consumption was almost the same from the early growth stage of rice plant to the flowering stage, but then decreased after the milky stage. It is presumed that the quality of the food increased from the milky to the ripening stage. BOMFORD (1987c) reported that milk-ripe seeds of rice plant were full-sized or nearly so, and their endosperm contains starch granules, they are still green and if squeezed exude a milky juice. Chemicals in milk-ripe seeds might signal the arrival of good food supplies to a granivore, just as chemicals in sprouts apparently give such a signal to herbivores (PINTER & NEGUS, 1965; NEGUS & BERGER, 1977; SANDERS *et. al.*, 1981).

While the ricefield rats were fed on rice plants in all stages of growth, the palatability and presumably the nutritive value differed between the stages.

Viewing Fig.1 and Table 1, we can note that, for the male rats, during the generative stage of rice plant, the longer they live, the more sexually active they become (Fig. 4).

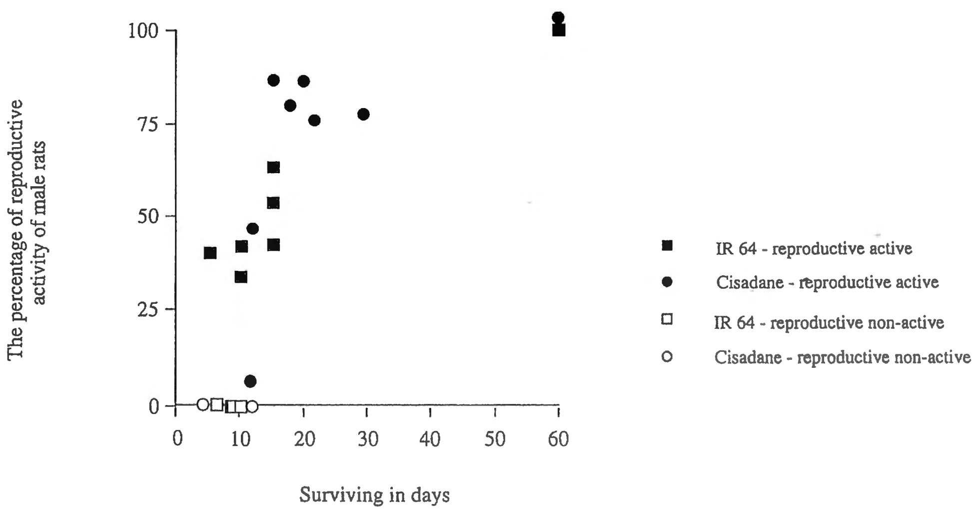

Fig. 4. – The relationship between the percentage of sexually active rats and survival of male rats during the generative stage of rice plant.

By observing the reproduction and survival of the ricefield rats under laboratory control diets of rice plants, we are able to show that the stage of the rice plants affects the reproductive condition and survival of the rats.

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