THE 1975-76 RODENT OUTBREAK IN A NORTHERN SENEGAL IRRIGATED FARMLAND

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ABSTRACT

In West Africa, two rodent species are well adapted to wet environments: *Arvicanthis niloticus* and *Mastomys huberti.* Populations of these animals were surveyed in a Northern Senegal irrigated farmland by monthly trappings during the 1975-76 rodent outbreak.

The study of the relative variations of rodent number allowed us to know the mechanism of the population: during the first year, an outbreak increase from an exceptionally long breeding period with high fecundity rate was amplified by rice and wheat farming succession; outbreak occurred the second year during rice farming, when population level was at a minimum and reproduction rate was very high; densities decreased quickly in the dry season when there were no irrigation and farming.

Mastomys and *Arvicanthis* population dynamics present some differences; the maximum density levels are almost identical, but because of the bigger size of *Arvicanthis,* population of this species is more important in biomass.

INTRODUCTION

Northern Senegal, particularly Senegal River Region, is in the Sahelian climatic zone. The climate is dry tropical, with a very short rainy season entirely concentrated on the summer months, while the rest of the year is a nine-month dry season.

The average yearly temperature is 28°C, but the wet season is a little warmer and the dry season breaks up into a cool period from November to March and a warm period from April to June (Fig. 1).

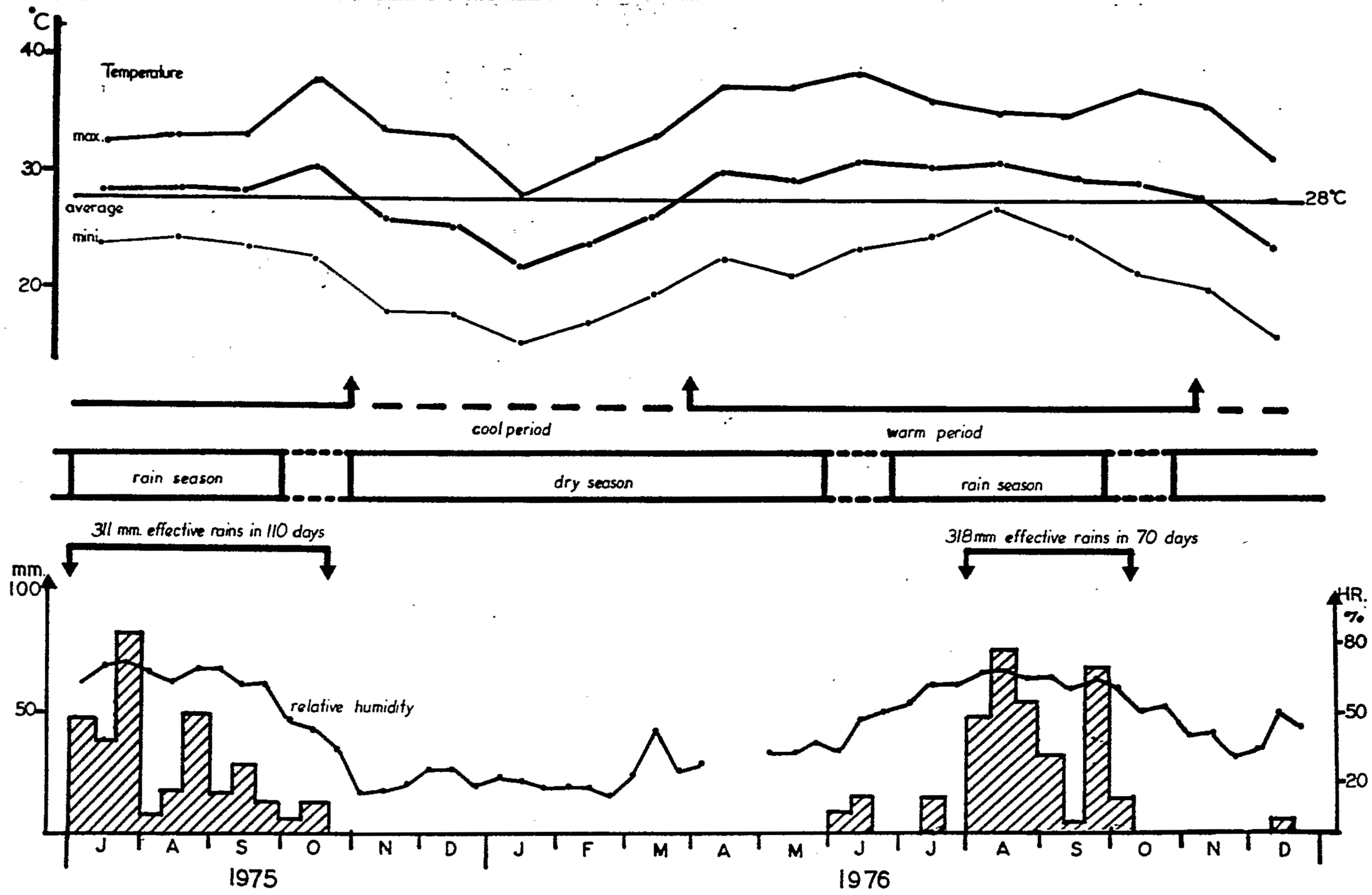

Figure 1. Yearly climatic characteristic in the Senegalese Sahelian Zone.

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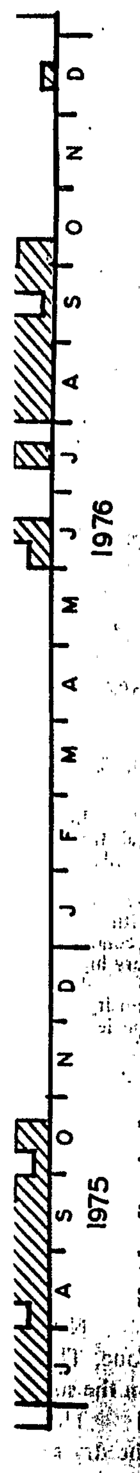

Figure 1. Yearly climatic characteristic in the Senegalese Sahelian Zone.

The average yearly rainfall (350 mm) in the Senegal River Region does not permit rainfarming every year, because of irregular yearly rainfall (Fig. 2) and the problems of fairly often disastrous distribution of rains within the wet season. Hence, the farming communities settle on the flood-plain of Senegal River, where they take advantage of land depressions to extend their farming season up to December. Today, an ambitious agricultural development program allows irrigation of numerous basins to increase the areas farmed in rice, wheat, sugarcane, and tomatoes. When the proposed dams are constructed, there will be irrigation yearly, and the farming period increased to nine months.

The extension of irrigation networks is particularly favorable to rodent population growth, especially the muridae which are well adapted to wet conditions. Rodents find food and shelter in fields. Prolonged farming period lengthens rodent reproduction. Rodents in irrigated fields are more abundant than in dry savannah. Rodent outbreak in the climatic zone increases rat populations tremendously which may result to catastrophic farm crop damage.

We witnessed such rodent outbreaks in 1975 and 1976 in an irrigated basin, planted with rice, wheat, and tomatoes, at Savoigne in the Senegal River Region.

This paper describes the phenomenon in wheat and rice irrigated fields.

MATERIALS AND METHODS

Farming cycle

Trapping was conducted every month from January 1975 to July 1976 in several plots within a 300-ha irrigated farmland. Every three-hectare plot was surrounded by a network of flooding canals and drains. The plot edges were covered with weeds, which served as good habitats for rodents. The fields were plowed end of June; rice seeds sown in July and germinated in August after the Senegal River started rising. The fields stayed flooded during the rice growth, and drained only in November when the rice ripened. The harvest was up till mid-December. At this time, when there was no water, the farm was abandoned for the remainder of the dry season. A second tillage could have been possible if there was adequate water reserved for secondary crops like tomatoes and wheat which need less water than rice. Wheat was planted instead of rice in Savoigne in December 1974 and January 1975.

Wheat must be sown in December and harvested in March to obtain good production because wheat does not tolerate high temperatures at the sprouting stage. Wheat sown in January and harvested in April does not give good results.

Wheat fields were flooded 12 hours every week during the growing period, and irrigation was closed three weeks before harvest. In May and June, fields and irrigation were drained.

In June, fields were plowed and vegetation along the edges burned.

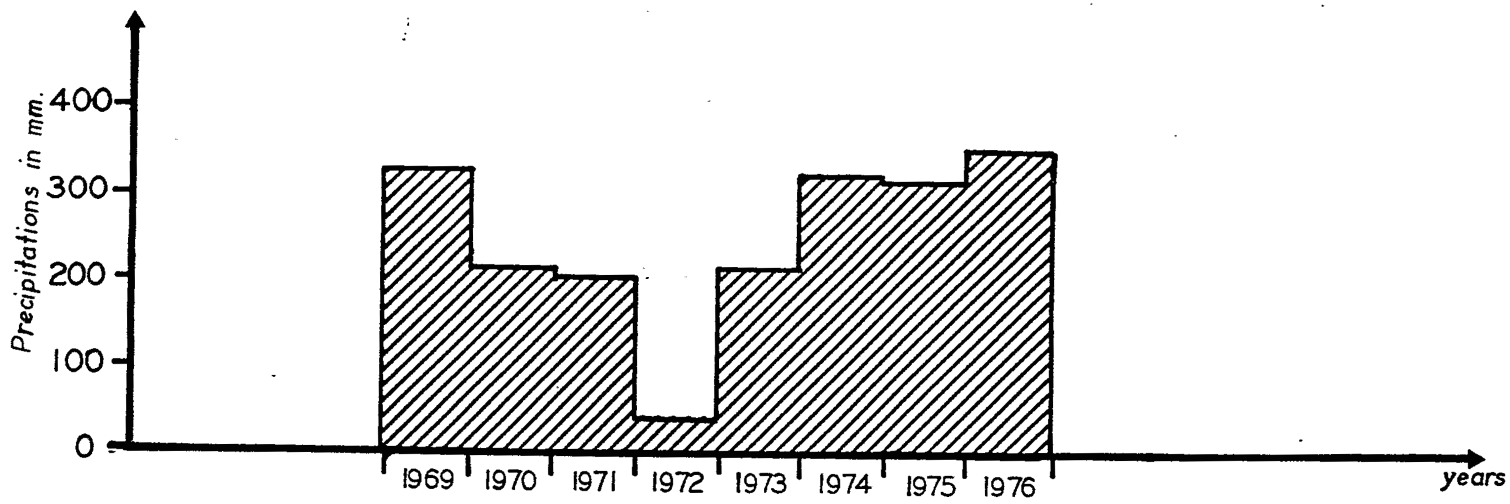

Figure 2. Yearly rainfalls from 1969 to 1976 in the Senegalese Sahelian Zone

Methods of assessing rodent populations

a. Removal trapping

Four plots of rice and wheat were surveyed using removal trapline method for three days every month for 18 months.

Trapping was done in two different ways:

1) traplines on possible accessible field edges
2) traplines on the inner fields

Two traplines on the edges (irrigation network) were laid out on both sides of the fields. Each 50-meter had 20 traps; the distance between two traps being 2.5 m.

Live traps were baited with peanut butter three successive days at about 5:00 p.m. and were inspected every morning at about 10:00. Rodents caught were killed with chloroform. Traps were set the whole day to catch diurnal as well as nocturnal species. Traps closed without catch were not counted. Three-day catches were reported in terms of 100-m trapline yield.

The distance of 2.5 m between two traps was an arbitrary choice, the proximity between traps avoiding trapping saturation. We changed trapping location monthly to avoid trapping the same place in two successive months. The 100-m trapline yield was only a relative index, but the monthly variations of this value gave a good idea in rodent abundance.

b. Marking methods

The concept of density is ambiguous when the environment has such a discontinuity in space and time. If it is possible to get an absolute density value, be specific about the actual environment of the trapped rodents, for example, irrigation network or inner field. When animals are concentrated in a particular habitat, report the density on this habitat to a theoretical area including all possible environment in their relative proportions.

To obtain a good idea of actual rodent abundance, we trapped using Petersen-Lincoln method. The rodents caught in three days on a trapping grid were marked and released.

The fourth day, the grid was replaced by two traplines and the rodents caught were removed three days more, but only the first two-day catches were taken into account, because the population structure on the third day was too modified.

This method used the density level rather than the actual size of rodent population, but was adequate to take counter measures.

Rodents caught and killed were identified, sexed, measured and weighed. Autopsies were made to determine reproductive parameters. Eyes were preserved in formalin to determine individual ages by the weight of their dry lens.

Only two rodents were present in irrigated fields: *Mastomys huberti* (Petter, 1977) and *Arvicanthis niloticus* Desmarest. These two rodents adapted well to wet environments and increased in irrigated fields. Water-filled ditches did not prevent rodent movements because these species could swim and dive very well.

Arvicanthis niloticus Desmarest

The Nile Rat has been a well-known pest for a long time but very few studies were made about this species (Taylor, 1968; Badran, 1972; Ibrahim, 1972; Taylor & Green, 1976). *A. Niloticus* is a medium-sized rat, weighing 120 to 150 g and has a body length of 140 to 170 mm (Rosevear, 1969 and Kingdom, 1974). It is herbivorous and needs seeds for food. This species is a major pest in rice and wheat fields. It can live in dry environments provided it finds free water or wet food.

Arvicanthis is both diurnal and nocturnal. You can see its kind in dikes in full daylight.

When grass gives convenient shelter, *Arvicanthis* builds only grass nests but when vegetation is abundant, settles in available cavities such as soil crevices or burrows of other species. These cavities are developed in complex burrows with many galleries and rooms. Every burrow can shelter several individuals (probably a family) and make a network of routes from the different entrances. Very high burrow density may destroy the dikes.

Arvicanthis can breed any time for as long as there is food. Breeding season varies from four months in natural conditions to nine months in irrigated farmland.

The litter size averages six, with a maximum of 12. The litters occur six weeks apart but this gap can be reduced to four weeks when a female is pregnant and lactating at the same time. The first litter is normally produced at the age of three months. We observed, however, the first pregnancy in natural conditions at two months old.

Theoretically, a female can have four or five litters in one year with an average life expectancy of only nine months and a rapid turn over (Poulet and Poupon, 1978).

Mastomys sp.

We have two species of *Mastomys* or multimammate mice in Senegal. *Mastomys erythroleucus* with 38 chromosomes lives in the bush savannah of the south sahelian zone; *Mastomys huberti*, with 32 chromosomes, adapts very well to wet environments such as marshes and flooded farmland.

Mastomys huberti is a small-sized rat, weighing 50 to 60 g and 130 to 110 mm in length. Its diet is very similar to that of the *Arvicanthis'*, it is principally herbivorous with granivorous tendencies. *Mastomys* needs water more than does *Arvicanthis*. *Mastomys huberti* is strictly nocturnal. This species digs burrows in the dikes around the flooded fields and in the drained rice or wheat fields before harvest.

Mastomys is very prolific. The litter size averages 10, with a maximum of 19. The female can be pregnant at six weeks and the time between two litters can be only four weeks (Hubert and Adam, 1975).

RESULTS AND DISCUSSION

This paper only gives an account of variations in rodent abundance.

Table 1 shows the number of rats caught monthly in terms of 100-m trapline yield, around the fields in the irrigation network, and in the inner fields.

Table 2 shows individual average weights. Weights varied with the age structure of the population. Weight was low in a young population while the average weight reached the old adult weight.

Table 3 gives the relative biomass in terms of 100-m trapline yield. Biomass enables us to compare different sizes of species; variations of general rodent biomass give us a good idea of the level of rodent food needs.

Table 4 shows the results of two trappings with Petersen's method to evaluate density levels and biomass before the 1975-76 farming cycle. These trappings were conducted only in the irrigation network between plowed fields. The rodents were concentrated in the network and densities could be assessed per hectare of network or per hectare of available area (network and the two half contiguous fields).

Figures 3, 4 and 5 show variations in rodent number and biomass during the 1975-76 farming cycles.

Table 2 and Figures 3 and 4 illustrate irrigation network as a permanently suitable environment for rodent populations. Flooded fields were inhabited temporarily when crops were available. Thus, wheat and rice did not attract rodents before the ear period. This time rodents were coming and going between network and fields. After draining, rodents settled in the fields where food was abundant, and returned to the network at plowing time.

January to May 1975 Wheat Farming

The number of *Arvicanthis* on the irrigation network increased from 20 to 60 individuals per 100-m trapline due to prolonged breeding period. Since October, every adult female more than three months old bred regularly. In March and April, the average fecundity rate reached eight; in spite of this high rate, the increase in number was relatively low, because most individuals were not adults.

Arvicanthis was absent in wheat fields in February, began incursions when wheat was in ear in March, and settled in the fields end of March. Some wheat fields harvested this time had relatively little damage (20%). Most fields sown too late, in January, were not ready for harvest while the rodents were foraging, cutting every wheat stem and carrying ears into the burrows. Soon these fields were totally damaged.

Mastomys went into the fields before *Arvincanthis* and disappeared very quickly when the fields were drained. *Mastomys* were often more numerous than *Arvicanthis,* but because of the great weight difference, *Arvicanthis* was the more dangerous species as shown in Figure 5.

May to August 1975 No Crop Time

Dry season ended with plowing and clearing of irrigation by burning. In July, rice was sown before the first rains.

Rodent populations decreased since there was no reproduction and life conditions were bad due to food shortages, drought and a high predation level.

Mastomys disappeared before *Arvicanthis,* which were concentrating on the irrigation network. Petersen Index (Table 4) shows the decrease of *Mastomys* number and the

Table 1. Variations of the rodent abundance in terms of 100-m trapline yield (in number of individuals), during the 1975-1976 outbreak, in the irrigated fields of Savoigne Farm, Senegal.

Date	Trapping number	Farming stage	Irrigation network *Arvicanthis*	Irrigation network *Mastomys*	Inner fields *Arvicanthis*	Inner fields *Mastomys*
1975		Wheat farming				
February	1	irrigated fields	20.0	73.3	–	–
March	1b	wheat earing	33.1	57.9	0.7	36.3
March	3	drained fields	25.1	33.1	14.0	44.3
March	2	& harvest	32.6	19.8	38.2	24.0
April	9	dry & abandoned fields	60.7	66.5	7.9	116.9
May	13	" "	51.4	79.6	44.7	97.5
May	17	" "	54.7	58.2	–	–
1975		No farming period dry season				
June	24	plowed fields	75.3	16.6	–	–
July	28	" "	68.3	18.3	–	–
August	30	" "	42.9	42.9	–	–
1975		Rice farming				
August	32	rice sown	18.5	16.4	–	–
September	38	flooded fields	14.0	15.0	0	12.1
October	44	" "	18.1	3.9	–	–
November	50	" "	47.2	19.4	–	–
December	56	drained fields	13.6	7.5	–	–
1976		No farming period dry season				
January	62	plowed fields	29.2	82.7	22.9	59.0
February	68	" "	37.8	77.8	32.0	36.0
March	74	" "	41.3	63.0	–	–
April	84	" "	16.0	2.7	5.0	0.0
May	87	" "	10.2	1.1	.0	1.1
June	92	" "	2.1	1.0	.0	.0

concentration movements of *Arvicanthis* in the network. The number and biomass of *Arvicanthis* written in terms of available area (= network + fields) showed no increase, but only stagnation and concentration. *Arvicanthis* survived the drought longer than *Mastomys* and decreased strongly in August, when food was not available and rains destroyed the dike burrows.

September to December 1975 Rice Farming

Rice seeds sown before the first July rains were eaten by rats around the fields on a five- to ten-meter wide boundary strip.

Table 2. Variations of the average individual weight in every sample of rodent population during the 1975-1976 outbreak.

Date & trapping		n°	Irrigation network: *Mastomys*	Irrigation network: *Arvicanthis*	Inner fields: *Mastomys*	Inner fields: *Arvicanthis*
			Average Individual Weight in Grams			
1975	II	1	33	105	–	–
	III	1b	35	140	–	–
	III	3	35	129	28	125
	III	2	37	133	29	105
	IV	9	40	132	33	100
	V	13	34	140	29	110
	V	17	27	105	–	–
	VI	24	24	101	–	–
	VII	28	28	118	–	–
	VIII	30	35	114	–	–
	VIII	32	40	116	–	–
	IX	38	43	130	43	–
	X	44	59	144	–	–
	XI	50	68	98	–	–
	XII	56	51	135	–	–
1976	I	62	41	120	40	81
	II	68	37	124	21	104
	III	74	28	109	–	—
	IV	84	20	93	–	93
	V	87	–	115	–	–
	VI	92	–	75	–	–

The September flood concentrated rodent populations only in the irrigation network.

After the rains, weed growth on the dikes gave food and shelter to rodents. The new breeding season began in September. The fecundity rate was very high; the *Arvicanthis* average litter size was 10 and the *Mastomys* average litter size, 13. All individuals were adult and all females were breeding. With these conditions, the *Arvicanthis* population multiplied by five between October and November, and *Mastomys* population, by six. In November, the young rodents were weaned because of excessive population pressure in the irrigation network. Rodents settled in the flooded rice fields in spite of the presence of water. Rice stems were cut both to make runways and shelters and to eat the panicles. Damage was 80 to 100 percent.

Trapping results gave a very bad representation of this phenomenon. Trapping yield was low during the breeding period and rice heading from October to December. The reasons were not understood. The low catch could have been due to trap shy-

Table 3. Variations of rodent biomass in terms of 100-m trapline yield (in kg) during the 1975-1976 outbreak.

Date & Trapping	n°	Irrigation network *Masto-mys*	*Arvi-canthis*	Other Rodents	Inner fields *Masto-mys*	*Arvi-canthis*	Other Rodents
1975 II	1	2.4	2.1	4.5	–	–	–
III	1b	2.0	4.9	6.9	1.1	e	1.1
III	3	1.1	3.2	4.3	1.2	1.7	2.9
III	2	0.7	4.3	5.0	0.7	4.0	4.7
IV	9	2.6	8.0	10.6	0.8	3.9	4.7
V	13	2.7	7.2	9.9	2.8	3.7	6.5
V	17	1.6	5.7	7.3	–	–	–
VI	24	0.4	7.6	8.0	–	–	–
VII	28	0.5	8.0	8.5	–	–	–
VIII	30	1.5	5.0	6.5	–	–	–
VIII	32	0.7	2.2	2.9	–	–	–
IX	38	0.6	1.8	2.4	0.5	.0	0.5
X	44	0.2	2.6	2.8	–	–	–
XI	50	1.3	4.6	5.9	–	–	–
XII	56	0.4	1.8	2.2	–	–	–
1976 I	62	3.4	3.5	6.9	2.4	1.8	4.2
II	68	2.9	4.7	7.6	0.8	3.3	4.1
III	74	1.8	4.5	6.3	–	–	–
IV	84	.0	1.5	1.5	.0	0.5	0.5
V	87	e	1.2	1.2	e	.0	e
VI	92	e	0.1	0.1	.0	.0	.0

ness during the breeding period, low capture probability of young, or the attractiveness of rice ears.

The breeding period was very short and only old animals were breeding. Animals born in October, were weaned in November and reached adult age in December. Probably because of excessive density, new generations could not breed.

January to June 1976 Dry Season

After rice harvest loss, Savoigne farming area was drained. The fields were plowed and abandoned till the beginning of July 1976 farming cycle. Rodent populations decreased very quickly because no food was available and breeding was not possible. In June, density levels were so low which made it difficult to catch any rodent.

Table 4. Rod netw

May 1975. I

Densities Individuals/Hect
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Biomass Weight (kg)/Hect
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June 1975. Irri

Densities Individuals/Hect
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Biomass Weight (kg)/Hect
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Table 4. Rodent density and biomass evaluations by Petersen's Method on the irrigation network in May and June 1975 (calculated values and ranges)

	Mastomys	*Arvicanthis*	Other Rodents
May 1975. Irrigation network 22 meters wide.			
Densities Individuals/Hectare			
A	698 (567-889)	818 (643-1144)	
B	175 (142-222)	205 (161-286)	
Biomass Weight (kg)/Hectare			
A	18.6 (15.1-23.7)	85.9 (67.5-120.3)	104.5 (82.6-144.0)
B	4.7 (3.8- 5.9)	21.5 (16.9- 30.0)	26.2 (20.7- 35.9)
June 1975. Irrigation network 11 meters wide.			
Densities Individuals/Hectare			
A	260 (242-384)	1414 (1313-1537)	
B	39 (37- 58)	215 (199- 233)	
Biomass Weight (kg)/Hectare			
A	6.4 (5.9-8.0)	144.0 (133.8-156.6)	150.4 (139.7-164.6)
B	1.0 (0.9-1.2)	21.9 (20.3- 23.8)	22.9 (21.2- 25.0)

A: per hectare of irrigation network only
B: per hectare of theoretical available area (network + fields)

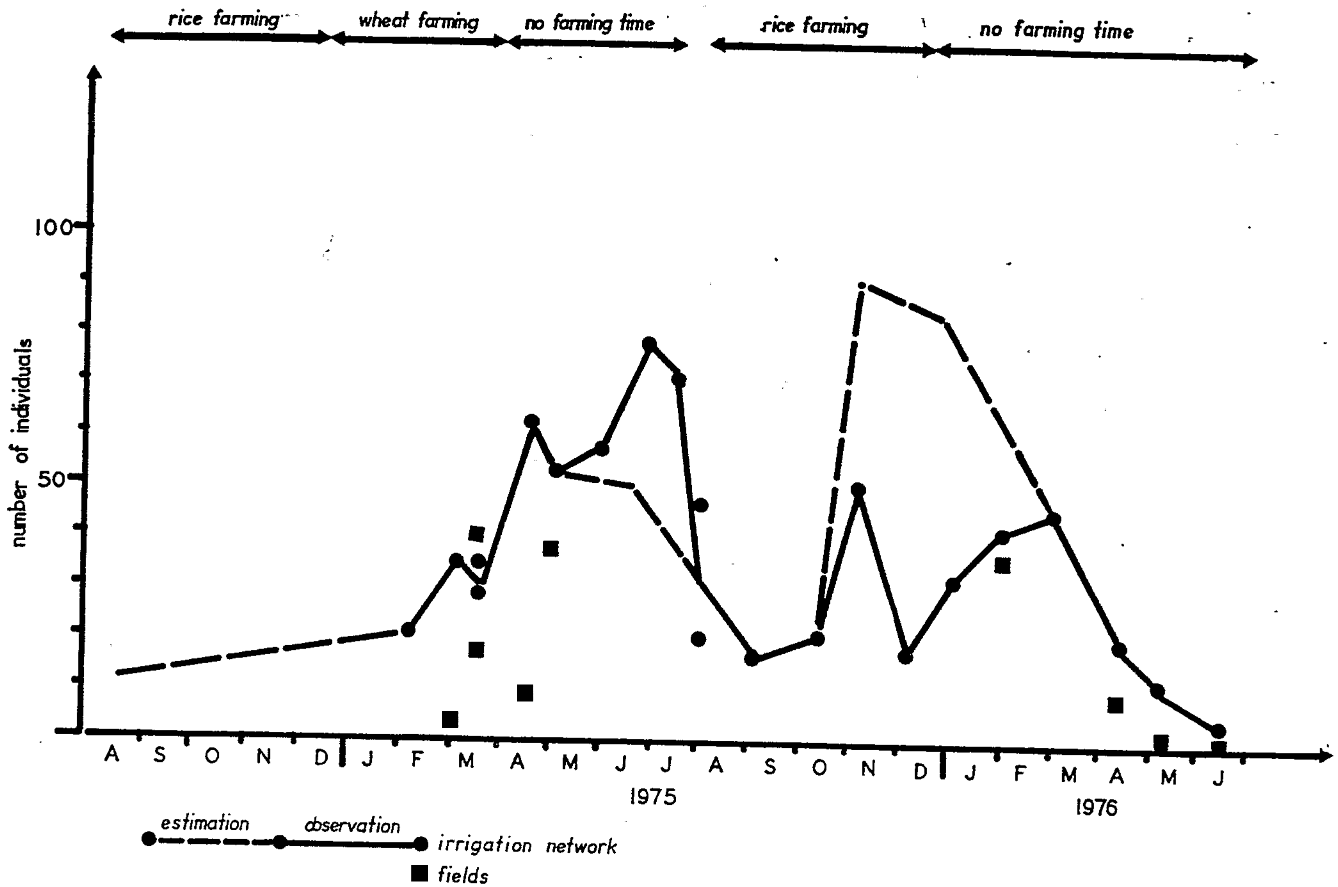
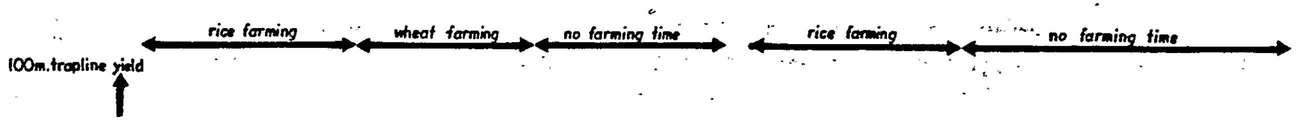


Figure 3. Observed and estimated 100 m-trapline yield variations in number of *Arvicanthis* during the 1975-1976 farming cycles.



— fields

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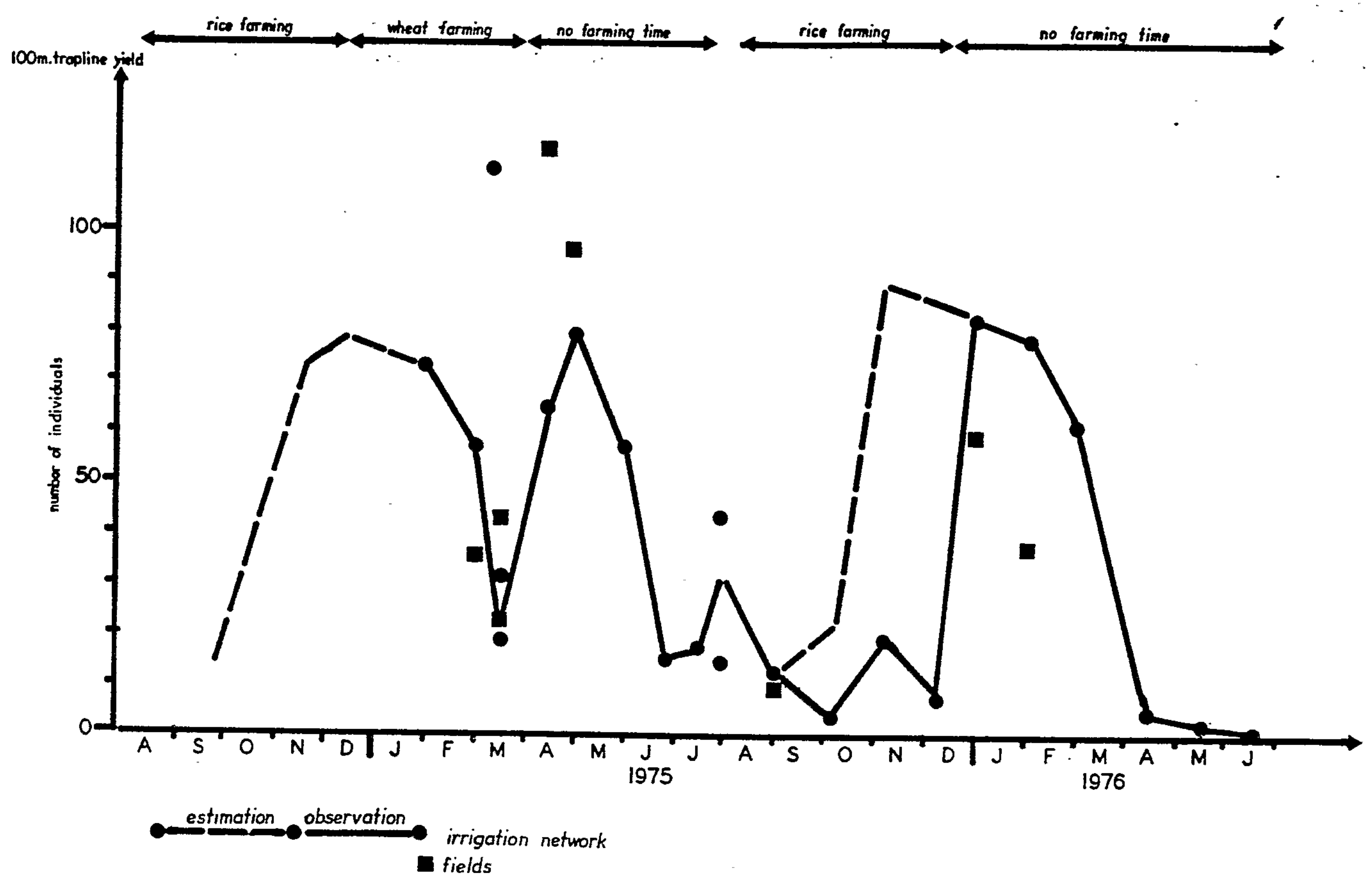

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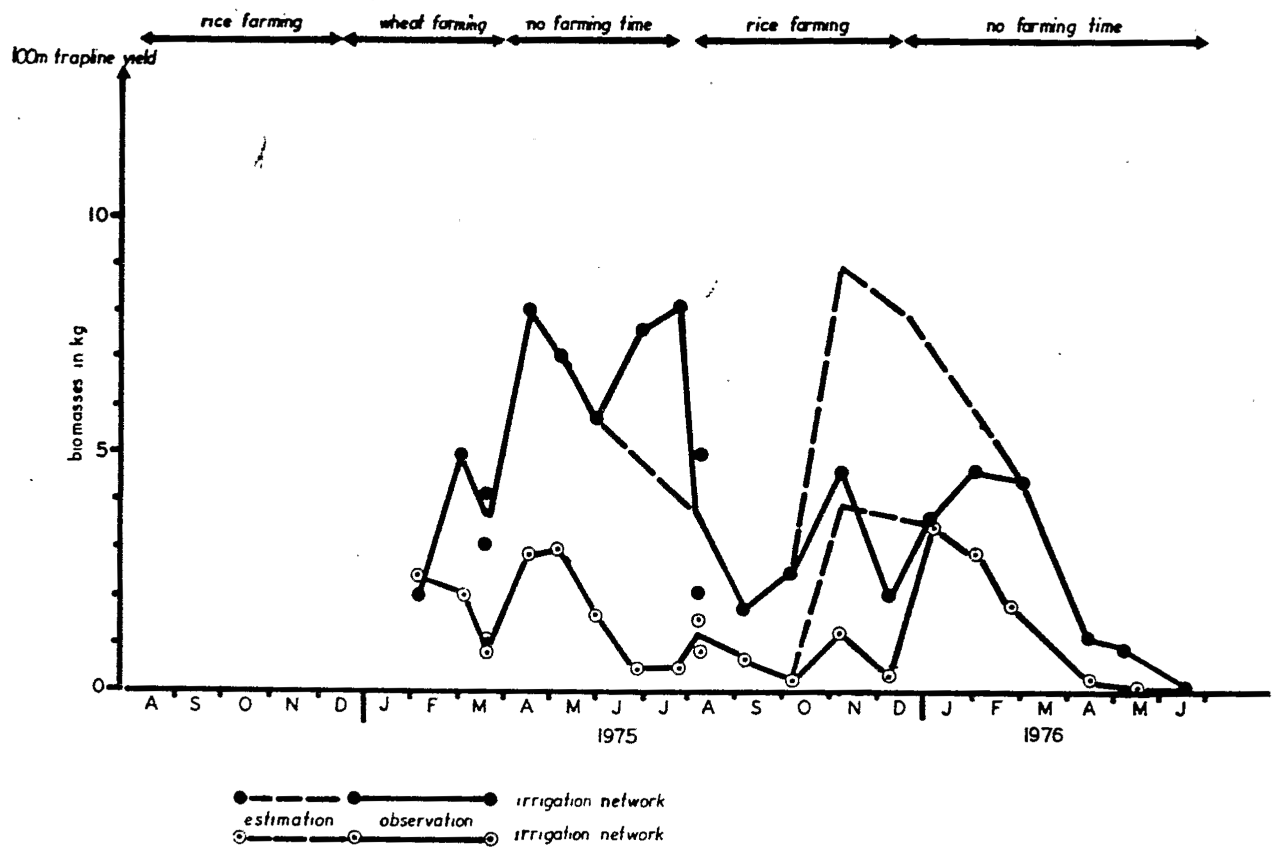

Figure 5. Observed and estimated 100 m-trapline yield variations in biomasses of *Arvicanthis* and *Mastomys* during the 1975-1976 farming cycles.

Figure 5. Observed and estimated 100 m-trapline yield variations in biomasses of *Arvicanthis* and *Mastomys* during the 1975-1976 farming cycles.

CONCLUSION

The monthly rodent trappings during the 1975-76 farming cycles enabled us to learn the mechanism of the rodent outbreak populations in the flooded farmlands. We observed three phases.

1. Increase of population density level during the first annual farming cycle. This increase resulted from an exceptionally long breeding period with a high fecundity rate.
2. The outbreak resulted from a very intensive breeding with a very high density at the start of breeding.
3. Density level quickly decreased when no food was available.

This outbreak occurred in the same way in natural areas as in farmland. In the farmland, the maximum density level was higher than in the natural areas because the food was available almost all year round.

We do not know the minimum density level at the beginning of the 1974-75 farming cycle. After the January 1975 rice harvest, *Mastomys* density was already high. This could be explained by the high fecundity rate of this species.

Arvicanthis increase was slower. This increase was going on during the wheat cycle and the maximum population density level occured only by the end of April.

Mastomys density decreased quickly between rice farming and wheat farming, and increased again during wheat farming.

Mastomys density fluctuations are very important. High mortality rate in dry environment is balanced by high fecundity rate during wet farming times. We may see two peaks of *Mastomys* abundance in one year, if two farming cycles occur during the year.

On the contrary, *Arvicanthis* fluctuations are slower, and it takes exceptional events like prolonged breeding with high fecundity rate to see high density increases.

Arvicanthis turnover is slower than *Mastomys. Arvicanthis* outbreaks are rarer than *Mastomys'*, but because of *Arvicanthis'* bigger size its outbreaks are disastrous.

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