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THE UNIVERSITY OF OKLAHOMA GRADUATE COLLEGE

ASPECTS OF THE BEHAVIOR, ECOLOGY AND PHYSIOLOGY -- OF THE RICE RAT <u>ORYZOMYS PALUSTRIS</u>

A DISSERTATION SUBMITTED TO THE GRADUATE FACULTY in partial fulfillment of the requirements for the degree of DOCTOR OF PHILOSOPHY

Ъy

(DICK) IE TURNER STALLING Norman, Oklahoma

ASPECTS OF THE BEHAVIOR, ECOLOGY AND PHYSIOLOGY OF THE RICE RAT <u>ORYZOMYS PALUSTRIS</u>

APPROVED BY vnest ۶. م tim

DISSERTATION COMMITTEE

ACKNOWLEDGEMENTS

Appreciation is extended to Dr. Charles C. Carpenter, my major advisor, for encouragement, advice and patience throughout the course of this study. Additionally I wish to thank Drs. Keever Greer, Loren G. Hill and Victor Hutchinson, other members of my committee, for their critical review of this work and additional advice. Appreciation is also expressed to the administration of Northwestern State University for time off from the fall of 1970 until the fall of 1973 to pursue my degree.

Financial support for this work was initially provided, the summers of 1968 and 1969 at The University of Oklahoma's Biological Station, by a NSF Academic Year Extension Grant received in 1968 and supplies and travel were paid for largely from a Baldwin Study-Travel Award received in 1972. During my tenure at the Norman campus personal financial support was provided by a graduate teaching assistantship.

I also want to thank Dr. Robert Clarke for encouragement and direction in seeking my doctrate. To my parents, Mr. and Mrs. E. E. Stalling, and brother, Clyde, for encouragement to continue my education and especially to my grandfather Clyde Turner who nurtured my love of nature. Also to special friends, Loyce and David Van Ness for several days of board and room over the years.

Lastly, but most importantly, a special note of appreciation to my wife A. Emmalea Stalling for patience, understanding and hours of work in

making this journey possible. Also to her, Richard and Marcia for years of financial sacrifice and help to make this adventure a reality.

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Paper I

Effect of dehydration on water turnover rates and hematocrits in the rice rat <u>Oryzomys palustris</u>

- prepared using style for Physiological Zoology

Paper II

Aspects of the ecology of rice rats (<u>Oryzomys palustris</u>) and house mice (<u>Mus musculus</u>) in west central Louisiana

- prepared using style for Ecology

Paper III

Aspects of the ethology of the marsh rice rat, Oryzomys palustris texensis

- prepared using style for The Journal of Mammalogy

PAPER I

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EFFECT OF DEHYDRATION ON WATER-TURNOVER RATES AND HEMATOCRITS IN THE RICE RAT, ORYZOMYS PALUSTRIS

EFFECT OF DEHYDRATION ON WATER-TURNOVER RATES AND HEMATOCRITS IN THE RICE RAT, <u>ORYZOMYS PALUSTRIS</u>

Dick T. Stalling

INTRODUCTION

<u>Oryzomys palustris</u> is the sole representative in the United States of a large genus (100 species - Martin and Guilday, 1967; 58 species - Arata, 1967) that is found throughout Central and South America as well as on the Galapagos Islands. The fossil record of <u>O. palustris</u> (Stalling, 1977b) shows extensive distributional retreat in the United States during the late Pleistocene and Recent periods, causing a hiatus separating it from the Mexican subspecies (Hall, 1960). This species appears to fill a unique ecological niche in the United States.

Little physiological research has been done with this species. Conaway (1954) reported the estrous cycle had an average length of 7.62 ± 0.19 days. Gupta and Shaw (1956) demonstrated species susceptibility to periodontal disease, Sealander (1964) compared three blood parameters of rice rats with those of several other species of small mammals. Childs and Cosgrove (1966) examined pathological conditions in three species of rodents, including <u>0. palustris</u>, in radioactive areas. Sharp (1967) studied assimilation of five diets by rice rats.

Because of the distinctive behavior and ecology of <u>O</u>. <u>palustris</u> (Stalling, 1977a) it was decided to investigate water turnover rates in hydrated (hyd.), dehydrated (dehyd.), and rehydrated (rehyd.) animals. Determination of the effect of dehydration on hematocrit values was also studied. Bartholomew (1958) stated "the relation of physiology to distribution in terrestrial vertebrates is neither direct, simple, nor obvious." Information from this study should further understanding of this species present United States distribution.

Daily water exchange rates, figured on the basis of water "consumed", allows error due to water wasting and what Hudson (1962) calls "drinkers". Pace's, <u>et al</u>. (1947) use of tritiated water (TOH) in the measurement of total body water offered a practical method of determining daily water exchange, and its use was demonstrated by Thompson (1952). Other tracers have been used and compared to TOH (Reid, <u>et al</u>., 1958), and various advantages of TOH were noted. This technique has been verified in several species of mammals by Yousef, et al. (1974).

Frequently, the maximal water conservation in a species occurs if a period of transition from one level of water intake to another is allowed to occur (Hudson, 1962; MacMillen and Lee, 1969). Haines, <u>et al</u>. (1973) investigated this acclimation period in <u>Mus musculus</u> exposed to chronic water restriction and reported on changes in food intake, urine composition and exchange of body water. Kutscher (1968), Horowitz and Borut (1970), and Hartman and Morton (1973), investigated the effect of dehydration on plasma volume and body fluid characteristics in eight species of small rodents.

A notable sparsity of information on wild small mammal hematocrit values existed, with the minor exceptions of Foreman (1956) and Youatt,<u>et</u> <u>al</u>. (1961), until Sealander's 1964 paper which included 34 species and re-

presented 25 genera. Since then limited hematocrit values have been added to this species list: Neal and Wood (1965), Childs and Cosgrove (1966) and others. Sealander (1964) discussed some factors affecting hematocrits, but he did not examine the effect of dehydration. Kutscher (1968) demonstrated sequential hematocrit and plasma volume changes in four species of rodents following total withdrawal of free water. Hartman and Morton (1973) conducted a similar study in a montane and two desert ground squirrels incorporating analysis of blood potassium and sodium levels.

METHODS

MAINTENANCE AND HOUSING

Animals used in this study were field captured adults or subadults, maintained in captivity at least two months and were selected randomly from captive rats available at the time. Animals were individually maintained, during the study, in two pound coffee cans fitted with a hardware cloth top. Hung inside these were small hardware cloth baskets, which were kept filled with Purina Lab Chow. Water, when supplied <u>ad libitum</u>, was available from a nozzled bottle. Cans were kept in a Percival constant temperature cabinet under continuous conditions of vapor pressure deficit = 16 mm Hg (25°C, rel. hum. 25%) and lighting cycle L:D = 11:13. Can bedding, consisting of wood shavings, was changed every other day during tests and every fourth day during non-test periods.

EXPERIMENTAL PLAN AND TECHNIQUES

Water-turnover procedure.--Group one, consisting of six adult males, was given food and water <u>ad libitum</u> before and during the study. One month of adjustment in the constant temperature cabinet, was allowed before TOH injection. Animals were removed from cans and weighed every other day to check for weight stability. Weight stability occurred within one week. Due to weight changes with defecation and urination, animals were induced to eliminate by moving the stainless steel weighing cube up and down rapidly three times before weighing.

Group two, consisting of six male and six female animals, was allowed a two week period of adjustment in the constant temperature cabinet with

weighing every third day. Food and water were <u>ad libitum</u> during adjustment. Following this period, water boxtles were removed, weights taken and desired weights calculated for a 12-15% weight loss by water restriction. For an eight day period water was given as a 3.5 - 11 g piece of 1% agar with amount depending upon the daily determined weight of an animal. This daily weighing and agar watering regimen was continued following injection with TOH to insure the animals maintained weight at 85-88% of original.

Group three, mix male and five female animals were the survivors of group two. At the termination of experiment II water was returned <u>ad</u> <u>libitum</u>, for five days to the dehydrated animals allowing them to regain the mean group weight as determined by weights taken every other day. They were then injected with TOH for the rehydration study.

Injection of TOH and Blood Sampling.--Following the indicated adjustment periods, each animal was injected with 25 μ l of 0.52 μ Ci/ μ l TOH, intraperitoneally. Body weights were determined prior to injection and before each subsequent blood sample. Blood samples were obtained at the following intervals succeeding injection time "0": group 1 at 1, 2 and 4 hours and 2, 4 and 6 days; group 2 at 2, 4 and 6 hours and 3, 6 and 9 days; and group 3 at 2¹/₂ hours and 2, 3 and 4 days. Blood was collected from tail incisions into 50 μ l heparinized capillary tubes and yielded 10-25 μ l of plasma following centrifugation. Hematocrits were determined on all samples.

Plasma was transferred from collection capillary tubes to calibrated micro pipettes. Plasma then was placed in a standard liquid scintillation vial containing 10 ml toluene/butyl PBD/PBDO scintillation mixture with a solubilizer (Beckman TLA Flouralloy with 32 BBS-3). Samples were **quenched** to the same degree, and no efficiency correction was made.

Counting was for 20 minutes or 1% standard deviation with a liquid scintillation spectrometer (Beckman LS-133). The biological half life of TOH (T $\frac{1}{2}$, days) was determined from a linear regression between the log of cpm/ml plasma water versus time (t) in days. The fraction of body water exchanged daily (λ) was determined by the equation:

$$\lambda = \frac{\ln 2}{T_2^1}$$

Total body water of the three groups of animals was estimated using the following relationship:

$$\frac{\text{TBW}}{\frac{A_{o}}{A_{o}}} = \frac{\text{Cts}_{i}}{\frac{A_{o}}{A_{o}}}$$

where TBW = total water content in ml, $Cts_1 = cpm$ injected, t=time in days. A_0 = antilog of the zero intercept of the log cpm/ml vs. t regression. Three rehydrated animals were also killed following their use, and desicated in a vacuum oven at $100^{\circ}C$ to constant weight, for direct determination of body water. Fat was removed by soxhlet extraction with petroleum ether and the defated tissue redried to constant weight.

The water turnover rate was determined using the following relationship:

WTR = TBW $\cdot \lambda$

where WTR = daily water turnover rate in ml/day. Both TBW and WTR were normalized by dividing by body weight. All statistical tests were done in accordance with Sokol and Rohlf (1969) or Zar (1974) using a Monroe 1860 programmable printing calculator for most calculations. Unless otherwise stated, statistic group means were compared using Student's t test or a Model II ANOVA accompanied, when necessary, with a Newman-Keuls multiple range test for location of divergent group means. A probability of less than 0.05 was considered sufficient for rejection of the null hypothesis.

Hematocrit.--Hematocrits were determined on all blood samples from the three groups. Hematocrits were also determined for 21 adult or subadult animals captured at the Natchitoches, Louisiana fish hatchery during the first two weeks of January 1973. Blood from the last group was obtained from the toe stubs following toe clipping.

RESULTS

Water-turnover rate (WTR).--There were no statistical differences between sexes with regards to body weight, TBW or WTR and therefore the data were pooled. Hyd. rice rats weighed more and had greater TBW than did dehyd. or rehyd. animals (Table 1). Hyd. and rehyd. rats showed equivalent measures of water turnover (Table 1) but these same measures, biological half life of water (t_2), daily water turnover (WTR) and daily water turnover per weight (WTR/g^{0.82}), in dehyd. rats were significantly different from the hyd. and rehyd. values. Dehyd. rats had one-half the daily exchange of hyd. and rehyd. animals and this was the result of approximately a one-third decrease in the rate of water exchange (t_2) and a 7.3% reduction in volume of body water (0.01<P<0.02).

The proration of daily water turnover by weight $^{0.82}$ corrects for variation in body weights. The power of 0.82 is that determined by Macfarlane (1965) and is very close to that determined by other investigators (Richmond, <u>et al.</u>, 1962; Holleman and Dietrich, 1973). Water turnover per weight $^{0.82}$ in dehyd. rice rats was about 70% that of hyd. and rehyd. animals (Table 1; 0.001 < P < 0.005) with the latter groups having statistically equivalent values.

The six males and five females composing the dehydration group weighed an average of 55.6 g at the beginning of the experiment (Fig. 1). Imposition of water restriction caused weight reduction to 47.5g during dehydra-

tion blood sampling (Fig. 1). Inadvertent failure to inject one female with TOH during this period required recomputation of the starting weight to 56.8 g. When water was returned to the animals, they regained the weight deficit in three days (Fig. 1). Males and females showed no significant difference in weight.

Corpse body water and fat.--Total body water (Table 2) determined directly by dessication fell only 1% below the mean value obtained for the 11 rehydrated animals using the TOH method. This difference was not significant. Percentage of body fat varied considerably, but fat free water content, as expected, varied only slightly over 2% with both males higher than the female.

Hematocrits.--Shown in Table 3 are mean hematocrits, N values and sampling times based on TOH injection (day 0). With exception of one comparison, rehyd. = 3 days, male and female hematocrits were the same. Due to small sample size it was felt that perhaps sampling was nonparametric, thus a Mann-Whitney two tailed test was run to further test for a difference. For this pair $0.05 = (U \ge 15) < 0.1$ thus, due to border significance these hematocrits will be considered the same. A single classification ANOVA was used on each pooled sample to test for differences among groups. For hyd. and rehyd. there was no difference in their respective sequential samples. In the dehyd. however, P < 0.001 showing sequential difference in the hematocrits. A Newman-Keuls test revealed that hematocrits on day zero differ from those on days three, six, and nine and that the third-day, sixth-day, and ninth-day hematocrits are equal.

Comparison of day "0" values for the four groups showed a difference (P<0.001). Rehyd. was different from all others, dehyd. \$\ne\$ field and hyd.= dehyd. or field. At the 0.1 level of probability, however, dehyd. = field.

DISCUSSION

In Table 4 are shown <u>ad lib</u>. WTR/kg^{82} for several North American rodents. The water expenditure of <u>0</u>. <u>palustris</u> ranks close to other fresh water marsh and tundra species. There is no indication that the species is unusual with respect to its expenditure of water under <u>ad lib</u>. conditions. The Richmond<u>et al</u>. (1962) equation for water exchange in placental mammals predicts a daily exchange of 123 ml/kg^{.8}/day; while the rice rat exchanges water at a slightly greater rate than this, it nevertheless, has an appreciably smaller rate of water exchange than either the semiaquatic muskrat (<u>Ondatra zibethicus</u>) or the mesic adapted white-footed mouse (<u>Peromyscus</u> <u>leucopus</u>). It is concluded that the <u>ad lib</u>. water requirements of rice rats is not so large that the species would be restricted to moist or semiaquatic areas for that reason alone.

Ecologically of greater importance than <u>ad lib</u>. water exchange would be the capacity of a species to adapt to sporadic periods of low water supply. Limited water supply, such as found in prairies, as a result of seasonal precipitation or of periods of drought would impose a need for water conservation on endigenous species. Unfortunately few studies of WTR under restricted water conditions have been conducted under sufficiently similar conditions to permit comparison between species. Comparison of the <u>O. palustris</u> data can be made to those from <u>P. leucopus</u>, (Chew, 1951) the California vole, <u>M. californicus</u> (Church, 1966) and the house mouse,

<u>Mus musculus</u> (Haines, <u>et al.</u>, 1973) because water restriction was imposed on these species in a manner similar to the present study.

<u>P. leucopus</u> expends unusually large volumes of water under <u>ad lib</u>. (Table 4) but is capable of reducing its expenditure 3.5 times when acclimated to water scarcity. <u>M. musculus</u> expends a moderate volume of water under <u>ad lib</u>. conditions and can reduce that volume approximately 2 fold. <u>O. palustris</u> and <u>M. californicus</u> have similar <u>ad lib</u>. WTR's (Table 4) and are also similar in their capacity to reduce water expenditure, that is, about 1.5 times.

The fact that P. leucopus and M. musculus are comparatively adaptable to varying supplies of water while M. californicus and O. palustris are not may relate to the wide distribution of the former two species and to the more restricted distributions of the latter two. P. leucopus is found through most of the United States east of the 112° longitude in hardwood and brushland habitats (Hall and Kelson, 1959). Precipitation, within its distribution, varies from 80" to 20" annually. M. musculus, an Old World migrant, is associated with man over the entire United States and is frequently found in buildings such as granaries and warehouses where xeric conditions persist. O. palustris is distributed in the southeast quarter of the United States and M. californicus is found in western and central California and southwestern Oregon. Rainfall in O. palustris territory is no lower than 25" annually, yet some M. californicus are found in areas where annual precipitation approaches 10". Church (1966) believed that the later required free water, regardless of food type. Pearson (1960) reported a correlation in M. californicus, a burrower, above ground dry season (summer) activity and the availability of dew. He also noted increased early morning daylight activity when dew was the only free water available.

Marsh (1962) showed seasonal weight changes and attributed them to dehydration-rehydration during the wet and dry seasons.

In <u>O. palustris</u> Stalling (1977a) noted, as have others, the sparsity of activity after midnight and no daytime activity. Typically, it is an above ground or arboreal nester with nests and contents exposed to drying effects of the sun and wind.

Hematocrit .-- The state of hydration affected the hematocrit with initial readings showing dehyd. > hyd. > rehyd. Plasma loss during dehydration was not determined, but Kutscher (1968), Horowitz and Borus (1970) together discussed plasma volume changes in eight species of rodents during dehydration. Hematocrit in dehyd. animals decreased significantly between day 0 and the remaining samples. This was probably due to enhancement of plasma volume as the animals became better adapted to water restriction; such enhancement was observed in house mice (Haines, unpublished data). Kutscher (1968) felt that some circulating red cells were removed during water deprivation. Perhaps blood viscosity homeostasis may necessitate this loss. The three blood samples taken on day 0, plus associated waste, probably resulted in at least a 0.30 ml blood loss. This loss could further have stimulated ADH production which was undoubtedly high at the time of initial sampling. Guyton (1976) noted that in humans a 10% blood loss promoted a moderate increase in ADH, advantageous due to its pressor affect. Ames and Van Dyke (1952) noted the ability of Dipodomys to increase blood ADH titre in response to stressful conditions i.e. heart puncture. The greatest decrease in dehyd. hematocrits occurred in the females and this is believed due to strictly a size factor. Thus further water conservation and tissue fluid shifts lowered the hematocrit to a value approximating that of the hydrated animals.

A general inverse relationship between rodent species weights and hematocrit values was noted by Sealander (1964), Neal and Wood (1965) and Lee and Brown (1970). For purposes of comparison with wild and hydrated values a regression line with 95% confidence and prediction limits was prepared from Sealander's (1964) data. Data from nine species (ten subspecies) of cricetine rodents using arcsine transformation of hematocrit percentages was employed. Not used in this regression were Sealander's 0. palustris values, species where less than two non-pregnant adult values were available, species obtained from over 1,500' elevation or ones that were shipped to his lab. Data from this study as well as rice rat data of Childs and Cosgrove (1966) fall well above the prediction belts (Fig 2). Sealander's O. p. palustris values fall below the 95% prediction belt. After personal correspondence, I feel these low values were because the animals became dehydrated during shipment from Tennessee, and upon receipt were given water ad lib. for 2 or 3 days before being run. As seen in this study, rehydration decreases hematocrits. The one 0. p. texensis value of Sealander, well above the prediction belt, was trapped in Arkansas and not subjected to shipping dehydration before testing.

An obvious adaptative value of a high hematocrit in the species would be an increased oxygen carying capacity for an animal that frequently ceases ventilation for several seconds while swimming under water. Fifteen second underwater swims have been noted several times in escaping wild rats. However, Clausen and Ersland (1968) concluded that in eight species of diving mammals which have been worked with, including the European beaver, (<u>Castor fiber</u>) and the water vole, (<u>Arvicola amphibius</u>) no general pattern of adaptation to diving is found as far as the respiratory properities of the blood is concerned." Whether <u>O. palustris</u> proves to be an exception to

this statement awaits further work.

Body fat.--Mean fat content of the three rehydrated animals, changed to per cent lipid content of dry body weight (32.79%) is higher than that reported by Connell (1959) or Fleharty, <u>et al</u>. (1973) for five other species of cricetid rodents, however lab conditions may have been conducive to lipogensis. Sharp (1963), for summer captured <u>O. palustris</u>, listed higher kilocalorie per gram dry weight values than Fleharty, <u>et al</u>. (1973) for 12 other species of small mammals. If these high values for rice rats are considered indicative for the species this may be an adaptation for increased buoyancy and insulation.

SUMMARY

The purpose of this study was to investigate WTR in <u>Oryzomys</u> <u>palustris</u> under <u>ad lib</u>. and restricted conditions, to follow hematocrit changes and to attempt to tie these data in with known ecological and behavioral characteristics of this species.

No statistical differences were seen in the WTR of males compared to females in the dehydrated or rehydrated animals. The WTR of hydrated, dehydrated and rehydrated animals in m1/Kg 82 day were 140.3, 94.9 and 158.1 ml respectively. Of known WTR in North American rodents, rice rats fall in the middle of <u>ad lib</u>. turnover rates. When water conservation is challenged (restriction) their improvident physiology becomes evident.

As noted from the literature, <u>Microtus californicus</u>, has the same restricted and <u>ad lib</u>. WTR as <u>O</u>. <u>palustris</u> yet, due to the former's burrowing activity and dew lapping behavior, it is capable of inhabiting more xeric areas.

Red cell loss during dehydration appears evident following rehydration. Blood viscosity homeostasis may necessitate this loss. High hematocrits as well as high body fat content were noted in this species when compared to other cricetid rodents. The adaptative advantages of both characteristics to a small swimming mammal were noted.

ACKNOWLEDGEMENTS

Thanks is extended to Dr. Charles C. Carpenter, my major professor and to Drs. Keever Greer, Loren Hill, Victor Hutchinson and especially Howard Haines for critically reviewing the manuscript. A special vote of thanks to Dr. Haines for the hours spend aiding me in obtaining and analyzing the water turnover data and for the use of his lab facilities during this study. I also wish to thank my wife for time spent typing and retyping this manuscript.

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TABLE 1

TOTAL BODY WATER (TBW), BIOLOGICAL HALF LIFE OF WATER (t^{1}_{2}) , WATER TURNOVER RATE (WTR), AND WTR $/kg^{\cdot 82}$. DAY IN RICE RATS WITH THREE VARYING CONDITIONS OF HYDRATION

Condition	N	Weight (g)	TBW (Z)	t ⁱ z (days)	WTR (m1/day)	WTR /Kg ^{.82} (ml/Kg ^{.82} .day)	
Hydrated	6	75.5 <u>+</u> 4.3	72.7+1.7	2.25+0.04	16.9 <u>+</u> .90	140.3 <u>+</u> 3.1	
Dehydrated	10	49 .9<u>+</u>3. 5	65.4 <u>+</u> 1.7	2.83+0.14	8.0 <u>+</u> 0.42	94.9 <u>+</u> 4.6	
Rehydrated	11	56.5 <u>+</u> 3.6	70.2 <u>+</u> 2.1	1.91 <u>+</u> 0.10	14.9 <u>+</u> 1.29	158.1 <u>+</u> 11.6	

Mean + SE

TABLE 2

WATER AND FAT CONTENT OF THREE

REHYDRATED RICE RATS

Sex	Weight (g)	Total Water (Z)	Fat (g)	Fat (Z)	Fat Free Water Content (Z)
M	53.1	70.7	4.3	8.1	77.0
м	67.1	67.3	9.5	14.2	78.4
F	57.4	69,9	4.7	8.2	76.1
x	59.2	69.3	6.2	10.2	77.2

.

TABLE 3

HEMATOCRIT PERCENTAGE VALUES FOR ALL

GROUPS OF RICE RATS SAMPLED

		Time Following TOH Injection		
Condition				
	day. 0	day 2	day 4	day 6
Hydrated	50.0+0.8 N=7	48.2 <u>+</u> 1.0 N=6	48.1+0.6 N=6	48.7 <u>+</u> 0.7 N=6
	day 0	day 3	day 6	day 9
Dehyd.	52.1+0.4 N=12	49.0 <u>+</u> 1.0 N=11	49.5+0.9 N=11	48.5 <u>+</u> 0.5 N=10
	day 0	day 2	day 3	day 4
Rehyd.	46.4 <u>+</u> 0.7 N=11	47.5 <u>+</u> 1.1 №=10	46.3 <u>+</u> 1.4 N=8	45.3+0.9 N=11
Field	49.7+0.5 N=21		**************************************	

Mean <u>+</u> SE
TABLE 4

WATER TURNOVER RATES OF SELECTED NORTH AMERICAN RODENTS UNDER <u>AD LIBITUM</u> AND LABORATORY CONDITIONS.

<u>Ref</u>	Species	0.82 *ml/Kg	Habitat, Location
7	Dipodomys merriami	19	Low DesertNev.
7	" deserti	21	Low DesertNev.
7	" microps	35	Low-High DesertNev.
6	Liomys salvani	70	Dry Trop. For Nicaragua
7	Spermophilus teretiacaudu	<u>is</u> 82	Low Desert Nev.
7	Ammospermophilus leucurus	93	Low-High DesertNev.
5	Peromyscus maniculatus	98	VariableWisconsin
7	Neotoma lepida	101	Desert-Dry WoodsNev.
4	Mus musculus (x)	120	VariableOklahoma
3	Rattus norvegicus (x)	124	Lab Strain
7	Spermophilus lateralis	128	Montane ForNev.
5	Rattus norvegicus (x)	131	River BanksAlaska
5	Dicrostonyx groenlandicus	133	Dry ScrubAlaska
8	Oryzomys palustris	140	MarshesLouisiana
2	Microtus californicus	150	Marsh-Dry HillsCalif.
5	" abbreviatus	167	TundraAlaska
5	" pennsylvanicus	187	Taiga-TundraAlaska
5	Ondatra zibethicus	191	SemiaquaticAlaska
7	Eutamias palmeri	192	Montane ForNev.
5	Microtus oeconomus	207	Taiga & TundraAlas.
1	Peromyscus leucopus	227	WoodlandsIllinois

*Calculated from data (x)Introduced Old World species 2. Church, 1966

3. Dicker and Nunn, 1957

4. Haines, Ciskowski and Harms, 1973

5. Holleman and Dieterich, 1973

6. Hudson and Rummel, 1973

7. Yousef, Johnson, Bradley and Seif, 1974

8. This paper

FIGURE LEGENDS

- Figure 1. Mean, standard error and range values for weights of <u>O.</u> <u>palustris</u> run in dehydration and rehydration experiments. Indicated are starting weight means and desired 88% and 85% dehydration lines. Failure to inject one animal in the dehydration group with TOH required recalculation of the starting weight in the group.
- Figure 2. Linear regression with 95% prediction and confidence limits for nine species (11 subspecies) of cricetine rodents based on data from Sealander (1964) with plotted wild and hydrated <u>O. palustris</u> values from this study and Childs and Cosgrove (1966).





PAPER II

ASPECTS OF THE ECOLOGY OF RICE RATS (ORYZOMYS PALUSTRIS)

AND

HOUSE MICE (MUS MUSCULUS) IN WEST CENTRAL LOUISIANA

ABSTRACT

Post-1900 U.S. trap records for the rice rat (Oryzomys palustris) are indicated in relation to mean (1899-1938) frost free days, annual precipitation and elevation. Relationships and inter-relationships are proposed for these physical factors as to how they affect rat distribution. A three year trapping study was carried out to evaluate various parameters of a west Louisiana rice rat population. Over 96% of the study area's small mammal population consisted of rice rats and house mice. Typically, May and August trapping success was less than 2%; consequently, for yearly comparisons January received primary emphasis. Cyclic changes in both species populations were noted with habitat disturbance considered the prime causative factor for the rice rats, and weather and lack of a "place to live" considered the prime factors for house mice. Expected age category changes were seen in both species as population's growth rates changed. Population weight changes were noted for both species with weather and mean population age considered the main factors. Due to the linear nature of the study area, home ranges were not calculated but distances between 1st and last capture indicated, with no significant difference noted between the species or for sexes within a species. Time between captures showed no statistical difference between sexes, for either species, but between species was highly significant, P<0.001. The reproductive status for both species, in general, followed the expected trend of higher percentages in expanding populations and low percentages in decreasing populations. The effectiveness of the drainage ditches as barriers was noted as ditch crossings between the 1st and last captures for recaptured animals. No significant differences between sexes were

noted for this movement, but a difference was seen between species. Mathematical analysis of distribution, from trapping results, employed appropriately either ANOVA, Newman-Keuls multiple range test, t-test or intercorrelation analysis to compare sets of data. In general, rice rats showed narrower selectivity for habitat variables than did the house mice. Comparatively speaking, shallower and narrower ditches were preferred by rice rats, as well as more water surface coverage, more advanced aquatic successional stages, less nutria activity, lower banks, greater variability in bank vegetational width and shorter height of bank vegetation. Data from the Oklahoma outdoor pen helped to support the theory that warm weather trapping success of rice rats is directly related to available food and that population estimates at this time can be very inaccurate. Frequent nest examination of the outdoor population produced no evidence of food hoarding for this species.

ASPECTS OF THE ECOLOGY OF RICE RATS (ORYZOMYS PALUSTRIS) AND

HOUSE MICE (MUS MUSCULUS) IN WEST CENTRAL LOUISIANA

Dick T. Stalling

The Eacent distribution of the genus <u>Oryzomys</u> (Cricetidae) ranges throughout South America, northward through Central America, Mexico to eastern Kansas, eastward to New Jersey and the entire southeastern United States to the southern tip of Florida (Walker, <u>et al.</u>, 1968). Six species are also recognized from the Galapagos (Orr, 1966) and one species from the tip of lower California (Hall and Kelson, 1959). In the "continental United States" two species were once considered present: <u>Oryzomys couesi</u> found only at the southern tip of Texas and <u>Oryzomys palustris</u> in the southeastern, eastern and south central part of the United States. Hall and Kelson (1959) indicated North American distribution of these two species as shown in adopted Figure 1.

Hall (1960) proposed that <u>O. couesi</u> was only subspecifically different from <u>O. palustris</u> and this is now generally accepted. The number of recognized extant species in this genus, due to lack of work on the numerous South American types, varies widely as to the authority (Martin and Guilday, 1967:100; Walker <u>et al.</u>, 1968: almost 100; Arata, 1967:58).

Little work has been done on any aspect of the biology of $\underline{0}$.

Figure 1. North American distribution of <u>Oryzomys palustris</u> and <u>Oryzomys couesi</u>, modified from Hall and Kelson, 1959.



palustris, including its ecology, in part due to its distribution, supposed difficulty of maintance in the lab (Steward, 1957), and difficulty in trapping during the warmer months.

Initial studies on <u>0</u>. <u>palustris</u> were restricted to very generalized discussions of habits, habitats and associated small mammals as noted in Svihla (1932), and Hamilton (1946). Ecological relationships between <u>0</u>. <u>palustris</u> and other mammals occupying the same habitat have been studied only limitedly as each species is commonly considered an isolated entity. Goodpaster and Hoffmeister (1952) briefly mentioned relationships between this species and the cotton rat (<u>Sigmodon hispidus</u>). Harris (1953) discussed relationships of rice rats, the meadow vole (<u>Microtus</u> <u>pennsylvanicus</u>) and the muskrat (<u>Ondatra zibethica</u>) in Maryland tidal marshes. Joule and Jameson (1953) studied the effect of numerical experimental manipulation of sympatric populations of the cotton rat (<u>Sigmodon hispidus</u>), the harvest mouse (<u>Reithrodontomys fulvescens</u>) and the rice rat in a southeast Texas coastal prairie.

Other studies which are either directly or indirectly important to an understanding of the ecology of the rice rat are numerous. Hamilton (1946) described development of young in captivity up to three weeks of age. Worth (1950) discussed general aspects of maintaining captive populations. Conaway (1954) studied the estrous cycle and development to sexual maturity, Carlton (1958) examined food habits of small mammals including rice rats, in the rice rats in the rice fields of Bolivar County, Mississippi. Birkenholz (1963) observed movement and displacement in a small population of rice rats in a marshy Florida grassland. Limited mark and recapture work was carried out by Svihla (1931), Erickson (1949), Pournelle (1950) and Harris (1952) on this species. Lidicker (1965) com-

pared density regulation in confined populations of four species of rodents including <u>0</u>. <u>palustris</u>. Sharp (1967) examined rice rat food ecology in a Georgia salt marsh and concluded that in the summer months their trophic niche is that of a carnivore.

Negus, <u>et al</u>. (1961) studied the ecology of <u>O. palustris</u> on Breton Island, an isolated "desert" island, in the Gulf of Mexico, 60 miles southeast of New Orleans, Louisiana. The basic thrust of their work concerned population fluctuations and correlations with adrenal weights and reproductive factors. Several differences, other than type of habitat, can be noted between the Breton Island rice rat population and the Natchitoches Parish population used in this study: 1) Breton Island was an undisturbed habitat; 2) substantial numbers of rice rats were present on the island and this was the only small rodent on the island thus constituting an ideal natural small mammal community to study; and 3) being insular in location, possibilities for appreciable immigration and emigration of animals were precluded in the Negus, <u>et al</u>. (1961) study.

The purposes of this study were: 1) through searching the literature and via correspondence plot the sites of rice rat captures in the United States since 1900, concentrating heavily on peripheral areas, and attempt to correlate this distribution with temperature, mean annual precipitation, and altitude; 2) to locate a suitable area in Natchitoches Parish, Louisiana for a population study and to study various population parameters via mark and recapture methods for three years; 3) to attempt to mathematically correlate distribution of rice rats in the study area for two successive Januarys as evidenced by capture, with selected environmental variables to see what variables are apparently most important in habitat selection by this species; and 4) maintain a penned population outdoors in

central Oklahoma from mid summar to early winter to study trap response in relation to artificial food availability.

From the start of this study it was obvious that the house mouse, <u>Mus musculus</u> (Muridae), was quite abundant in the study area selected, thus the second and third purposes previously stated were expanded to include this species. Ecological studies on this Old World migrant have been fairly numerous, due to its cosmopolitan distribution and importance as a pest. Notable studies in the United States on populations associated with man's activities include Brown's (1953) study on social behavior and population changes on a Maryland farm. Young, <u>et al.</u> (1952) noted very localized movements in <u>Mus</u> populations inhabiting buildings and Reimer and Petras (1967) showed that territorial defense by males is the main factor contributing to this restricted movement. Resulting deme formation, with inter-deme movement by only females, was noted by Selander (1970).

Natural (feral) populations of house mice in the United States typically have been studied in relationship to species of native mice. Two notable exceptions to this have been Brenhey's 1963 study of breeding cycles and age structure in five feral <u>Mus</u> populations near San Francisco Bay and Smith's 1954 Mississippi study on reproduction. Myers (1974) showed that feral populations, unlike building populations, are not divided into stable closed genetic units.

Several studies of ecological interactions between <u>Mus</u> and native small mammals have been carried out. Howell (1954) discussed populations and home ranges of 5 species of small mammals in an east Tennessee old field. Aspects of ecological interaction between <u>Microtus californicus</u> and <u>Mus</u> <u>musculus</u> have been seen in several notable studies: 1) Pearson's (1963) study of the history of two local outbreaks of feral house mice;

2) Lidicher's (1966) study that followed an island population of <u>Mus</u> to extinction; 3) De Long's study near San Francisco Bay; and 4) Quadagno's (1968) study in the same area as De long, but giving primary considerations to home range size. Ecological relationships of 5 species of small mammals, including <u>M. musculus</u> on a barrier beach was noted by Shure (1970). Several authors (Caldwell, 1964; Gentry, 1966; and Briese and Smith, 1973) have noted interactions between <u>M. musculus</u> and the old-field mouse <u>Peromyscus polionotus</u>. The latter authors felt a place to live and its probable interaction with predation was the most important variable determining the occurrence of these two species.

METHODS AND MATERIALS

Post 1900 Distribution and General Environmental Factors

From mid 1969 to early 1971, more than 130 letters of inquiry were sent to mammalogists, college biology departments and museums in the United States. Included in the letters were rice rat records I had from their area and a request for site, sex, and standard measurements on specimens in their collection that had not been reported in the literature. A total of 94 replies were received. University museums visited personally included Kansas University, Louisiana State University, The University of Oklahoma, and Texas A. and M. University. Successful trapping in three peripheral sites by the author helped to acquaint me with general environmental factors present in these areas.

All post 1900 trap records were first located on state road maps using available information and then transferred to a Department of Commerce U. S. map noting only county boundaries. Identical Department of Commerce maps were used in preparing the mean annual precipitation and mean frost free day maps, county by county, from the 1941 Yearbook of Agriculture, which incorporates 40 years of weather data (1899-1938). A latitudinal map of the areas involved were prepared from Marschner (1936) using a pantograph to insure accuracy.

Selection of a Study Area

During the spring of 1968, sample trapping was undertaken in Natchitoches Parish, Louisiana, primarily in the vicinity of the city of Natchitoches, in an attempt to locate a suitable area for the proposed population study. Desired was an area where water would not be a limiting factor during the drier summer months and where human disturbance would be expected to be miminal. After sample trapping 25 areas in the parish, Figure 2, it was decided that the east and west drainage ditches outside the Natchitoches National Fish Hatchery (Figure 3) would be used. This 97 acre facility lies at the south edge of Natchitoches. Permission was granted by the hatchery manager to drive on the dikes to improve access to the east side. Several habitat changes - burning, fence removal and mowing were carried out by hatchery personnel, despite my objections, during the study.

Description of Study Area

The city of Natchitoches lies in the alluvial plane of Red River and specifically the hatchery soil is of the Gallion-Norwood Association. The Hatchery was opened in 1936 and is classified as a warm-water hatchery. The facility contains 53 ponds for a total of 53 acres of water. Cane River Lake, to the north, serves as the water source. During the summer months dikes and other grassy areas were mowed biweekly, thus maintaining a coverless condition in the hatchery.

The drainage ditches, due to the general flat topography, constantly held water from rains and this was supplemented by seepage from the hatchery ponds. Region 1 drainage (east ditch) was southerly, with Region 2 drainage (west ditch) southeasterly, the later draining through Region 3. Water from these three regions joined about two miles south with drainage into an

39 .

Figure 2. Areas sampled in vicinity of Natchitoches, Louisiana to select a final study area and as lab supply areas.



Figure 3. Aerial view of Natchitoches National Fish Hatchery. Indicated are the four regions trapped: (A) road with 10 m culvert separating regions 2 and 3; and (B) hatchery facilities.



unamed bayou which in turn flowed southwesterly to Old River. Region 4 (south ditch) drained almost entirely into the east ditch, but also joined the west ditch and during heavy rains some water did flow to the west.

The east ditch lay due north and had a drop of 1"/chain to the south. The west ditch lay at 333° NNW and had a drop of 5"/chain to the SSE. The south ditch lay in a SW direction of 222° and had a drop of 2"/chain to the NE. The average elevation of the study area was 115' above sea level. The hatchery was surveyed by the author and Dr. Charles Viers with the aid of a forester's compass, Abney level, altimeter and a 1 chain (66') tape.

Weather

General weather observations were made during the period of setting out traps and at 11 p.m. Conditions noted were cloud cover, air borne moisture, temperature and general wind conditions. Weather data presented in appendix I was recorded by Natchitoches City Power Plant 4 kilometers from the study area. Since on site observations and recordings at the study area were not possible during most of the year, the Power Plant data was used almost solely for discussion of long range effects of weather.

Trapping Procedure

All trapping employed Sherman folding traps that were baited with a mixture of peanut butter and corn meal. Cotton was placed in the traps when a night temperature below 10°C was expected. Traps were set out before dusk, and except in the early period of sample trapping, were not run again before dawn. All successful traps were labeled in the field as to station number, and all traps were brought to the lab. A piece of lab rat chow was placed in successful traps immediately. The animals were anesthetized, weighed, measured, number toe clipped following Baumgartner (1940) and sexed as soon as possible upon returning to the lab. Animals were returned to the field and released at their trap station generally by 11 a.m.

Aging of rice rats was based on categories modified from Negus <u>et al.</u> (1961) which employed both total length and weight - Juvenile 4210 mm, 432 grams; SubAdult 205-230 mm, 30-55 grams; and Adult 230 mm, 255 grams. Aging of house mice employed the two categories proposed by Brown (1953) based only on weight - Immature 412 grams; and Mature 212 grams. Reproductively active females were considered those with a perforate vagina and/or lactating. Reproductively active males possessed either scrotal or inguinal testes.

Initially only regions 1 and 2 were trapped, but regions 3 and 4 were added in May 1971 and January 1971, respectively. It was hoped that these added regions would aid understanding of population movements between regions and the effectiveness, as a barrier, of the roadway with a 10 meter long metal culvert tube between regions 2 and 3. All regions' trap stations were surveyed and staked prior to initial trapping.

Numbered wooden stakes were placed 50 feet (15.25 m) apart on each side of the ditches used. This station distance, on a ditch side, was also

used by Negus <u>et al.</u> (1961). Totaling distance between stations and 7.63 m on either end - region 1 extended for 43 pairs of stations (655.75 m), region 2 for 29 pairs (442.25 m), region 3 for 8 pairs (122.00 m) and region 4 for 12 pairs (183.00 m). Therefore 86, 58, 16, and 24 were the numbers of trap sites present respectively.

Trapping frequency of regions 1 and 2 prior to leaving the state August 1970, was designed to study short term movement in an area. It consisted of five days of continous trapping in a region, with the limited traps available, and thus moving to a new region of the ditch for a repeated series. This sequence continued in April, May and early June 1969. Limited trapping was then reinitiated in late December following acquisition of sufficient traps to cover all of a region in a night.

Trapping, after leaving the state, was repeated each January, May and August during two week visits. Each trap site each period was trapped two or three times depending on the time aviiable and weather conditions. These sample times were spaced three or four days apart, for a region, to allow time for dispersal of released animals.

Vegetation

All regions had a vegetational survey each August, noting vegetational types prior to winter. A mounted plant collection was made and used for succeeding identification work. Over 100 species were identified using the five botanical references listed and the help of Dr. Robert E. Noble and Dr. Dana R. Sanders. General vegetational descriptions of regions and their changes over the sampling period follow:

<u>Region 1</u>. This 655 m long region, in the initial year of 1969, had a very shallow ditch, average depth of 12 cm, width of 3.1 m which was choked with large amounts of both living and dead rice cutgrass (Leersia

oryzoides) and Johnson grass (Sorghum halepense). Cat-tails (Typha latifolia) grew in the ditch near the south end and there only a 40 m long region was so vegetated. Small numbers of pennyworts (Hydrocotyle ranunculoides) grew throughout the ditch in the more open areas. The north end differed from other parts in that black willows (Salix nigra) grew up to 13 m tall and adequately shaded the ground to keep it bare and the water open. Vegetation adequate to hide small mammals, extended to the edge of a cotton field. The dominant vegetation on the banks was Johnson grass with cut grass being abundant near the water. On the east bank southern dewberry (<u>Rubus trivialis</u>), elderberry (<u>Sambucus canadensis</u>) and baccharis (<u>Baccharis salicins</u>) grew in widely separated clumps.

In January 1970 local levee board work crews, with the use of draglines and bulldozers, cleared and deepened the ditch denuding all vegetation from this region except for the southern 150 meters. Trapping was halted for the entire region until January 1971. Vegetation at this time was represented by a sparse growth of goldenrod (Solidago altissima), lesser ragweed (Ambrosia artemisiaefolia), and a few widely scattered sump weeds (Iva ciliata) on the denuded banks. As expected, vegetational recovery was rapid and by the end of the 1972 growing season, Johnson grass was again the dominant vegetation on the east bank with several areas of dewberry and elder-berry growth. Beggarlice (Desmodium ciliare) was a common understory plant. Cat-tails were the major aquatic plants with sizable clumps scattered the length of the ditch. Several species of sedges including Scirpus rubricosus. S. eriophorum, Eleocharia, Carex and rushes (Juncus) were common along the ditch margins. Upon the banks, clumps of broomsedge (Andropogon virginicus) were noted and at the north end baccharis was common. Tractor mowing down to the "edge" of the water,

at the west bank, was started in March 1972. Due to the seral stage, the widest variety of plant species were present during the growing season of 1972.

Average width and depth of water in the ditch, following the 1972 growing season, was 2.5 m and 22 cm respectively. Width of cover producing vegetation on the west bank, due to mowing, averaged only 25 cm with a 6.3 m average width on the east bank.

Region 2. This 442 m long region's ditch was located 25 m from the edge of Louisiana Highway 1, but was the most consistent producer of rice rats. Mowing by highway crews three or four times during the summer months kept the cover vegetation width on the west bank to 2.2 m for all trap years. Initially, in 1969, the east bank cover vegetation had an average width of 2.4 m from the water's edge to the hatchery fence. In February 1971, the fence was removed allowing mowing to occur to within an average of 70 cm of the water's edge. Dominant east bank vegetation prior to removal was Johnson grass, beggar lice, peppervine (Ampelopsis arboria), wild lettuce (Latuca canadensis), and foxtail (Setaria geniculata) with poison ivy (Rhus toxicodendron), trumpet creeper (Campsis radicans) and Japanese honeysuckle (Lonicera japonica) dominating the fence row. In January 1971, this area was burned twice, three weeks apart, resulting in an estimated cover destruction of 80%. Following removal of the fence and subsequent bank mowing the narrow cover band on the east bank was dominated by the same species of sedges and the rush mentioned for region 1.

The west bank, apparently due to the openness of the area and the nearby mowing, changed very little during the study. At the very edge of the water and out into it in several places cut grass was abundant, also with several species of sedges and <u>Juncus</u> being present. Away from the

water's edge on the bank Bermuda grass (<u>Cynoden dactylon</u>), white clover (<u>Trifolium repens</u>) and paspalum (<u>Paspalum plicatulum</u>) dominated the area up to the mowed margin.

The aquatic plants in the 3.0 m wide ditch changed little during the study, except that cat-tails became much more common. In 1969, only 3 clumps, averaging 40 m long each, occurred at the north and south ends and in the middle. At the end of the study, only a few areas lacked cat-tails. Due to the shallow nature of the ditch, average depth 27 cm, little open water occurred in the non-cat-tail areas. These regions were typically dominated by smartweed (<u>Polygonum setaceum</u>), lizard's tail (<u>Saururus</u> <u>certuus</u>), alligator weed (<u>Alternanthera philoxeroides</u>) and small amounts of arrowhead (<u>Sagittaria graminae</u>) and pennyworts at the ditch margins.

<u>Region 3</u>. This 122 m long region was essentially unchanged during the sampling period and had an average width of 2.2 m of protective vegetation on the highway bank and 2 m on the other bank. Vegetation on the highway bank was essentially the same as that found in region 1 with the other bank dominated by dewberry, Johnson grass, broomsedge, and yellow dock (<u>Rumex crispus</u>). Water depth in the ditch averaged 30 cm. Cat-tails were abundant at the north and south ends, but in the central portion aquatic vegetation was restricted to alligator weed, smartweed and pennyworts.

<u>Region 4</u>. This 183 m long region changed only in the width of the cover on the north side during the study. This region, like region 1, was first tractor mown the spring of 1972. Prior to this the mean cover vegetation on the north was 6 m wide and on the south essentially 5 m, but the south bank was bordered by a sparsely vegetated abandoned cotton field. Mean width of cover on the north side, following mowing was 30 cm,

but most stations lacked vegetation. Black willows, spaced an average of 4 m apart, grew on the south bank. On both banks, Johnson grass and cut grass constituted the main understory vegetation with large amounts of the later tangled in the ditch. Small amounts of <u>Scirpus</u> and <u>Carex</u> sedges were also found along the edges in the relatively open areas. Aquatic vegetation was very limited, due in part to the matted cut grass, and consisted of only very sparsely scattered cat-tails. The average depth of the water was 26 cm with the ditch width averaging 2.9 m.

Mathematical Analysis of Distribution in Study Area

In an attempt to correlate certain environmental variables with trap results for January 1972 and 1973, eight physical factors and eight biotic related factors were recorded and measured for each station (Table 1). Variables for each station, each time it was trapped, were punched on a computer card and categorized as producing a rice rat, house mouse or no catch. January was chosen due to higher expected trapping success.

Variables 1, 2, and 3 were recorded the night of trapping. The other variables were determined only after trapping was completed for an area to avoid disturbing the habitat.

Variables 4, 5 and 6 were the same for both years with all others determined for both years. Each bank height (#4) was measured from the highest level point of the bank crest to the middle of the ditch using a calibrated pole placed in the center of the ditch on the mud bottom. Marks on the pole were sighted with a sighting tube mounted on a tripod equipped with levels (figure 4, A). Water depths and widths (variables 7 and 8) were also determined at this time and were measured only if no measurable rain had fallen in 48 hours. Bank angle was determined with the instrument shown (figure 4, C made from a protractor and a free

SIXTEEN ENVIRONMENTAL VARIABLES AND SPECIFICATION OF NUMERICAL VALUES FOR VARIABLES USED IN CORRELATION WITH TRAP RESULT FOR JANUARY 1972 AND 1973.

- 1. Cloud Cover 0=none, 1=haze, 2=light, 3=heavy.
- Airborne Precipitation O=none, 1-mist, 2=infrequent light showers, 3=rain, 4=snow.
- 3. Temperature lowest temp. in C⁰ on trap night.
- 4. Bank Height centimeters.
- 5. Bank Length centimeters.
- 6. Bank Angle degrees (0°-90°).
- 7. Water Depth centimeters.
- 8. Water Width centimeters.
- 9. Height of Dominant Vegetation centimeters.
- 10. Amount of Ground Cover 1=0-10%, 2=10-30%, 3=30-50%, 4=50-70%, 5=70-90%, 6=90-100%.
- 11. Width of Cover centimeters.
- 12. Dominant Vegetation in Water O=water clear or no water, l=submergent, 2=floating, 3=emergent, 4=supportive emergent.
- 13. Amount of Surface Water Covered 0=no water at station, 1=0-10%, 2=10-30%, 3=30-50%, 4=50-70%, 5=70-90%, 6=90-100%.
- 14. Terrestrial Stage of Succession 1=clear (all vegetation removed), 2=rag weed, sump weed, goldenrod, 3=sedges, cut grass, paspalum, 4=dewberry, elderberry, Johnson grass, 5=black willow and associated sparce cover.
- 15. Aquatic Stage Of Succession 0=no water in ditch, l=clear (no visible vegetation), 2=unattached submergent (green algae), 3=attached submergent (coontail, hydrilla), 4=smart weed, pennywort, alligator weed, arrowhead, 5=cattails, or cut grass hanging down into water.
- 16. Level of Nutria Activity 0=no evidence of nutria activity, l=slight vegetational damage by nutria, 2=great damage to vegetation (bare trails, tunnels, feeding sites) feces noted several times.

TABLE 1

Figure 4. Equipment used in collecting habitat data: (A) signting tube and calibrated pole; (B) 1 m banded dowel rod; and (C) bank angle apparatus.



swinging looped wire. Instrument placement on the bank caused the wire to seek a vertical position and thus indicate bank angle.

The remaining variables (9-16) were biotically related. Dominant vegetation was determined by subjective observation of plants 1/2 meter from the water's edge at each station. An average height for the plants was then determined using the calibrated pole. Variable 10 (amount of ground cover) was estimated using a 1 meter dowel rod (figure 4, B) which had been painted with alternating 10 cm wide red and white stripes. It was shoved, at ground level, under the lowest vegetation penetrating the vegetation 1 meter from the waters edge. The vegetation was entered to the left of the station, while facing the water and the dowel run to the waters edge. After placement of the entire rod under the vegetation, visual estimation of what percentage was still visible from a standing position was recorded. Sightings were taken between 1000 and 1400 hours to insure maximum light.

Variable 11, width of cover, was the width of the unmowed or unfarmed vegetation on the banks down to the waters edge. Variable 12 was determined by visual inspection of the aquatic vegetation in the ditch at the station in question. Supportive emergent vegetation was defined as the type, such as cat-tails, that would support a climbing rice rat. Variable 13, amount of surface water covered, gave an index of the emergent plant density and was visually determined using a procedure similar to that for variable 10 with the stripped dowel floating in the water in the center of the ditch parallel to the banks. Percentage of dowel visible from the bank was then recorded.

The terrestrial stage of succession, variable 14, and the aquatic stage of succession, variable 15, were determined by identification of

dominant species present and then recording the appropriate category for each as indicated in Table 1.

The level of nutria activity in an area, variable 16, as indicated in Table 1, was recorded at only 3 levels as to evidence of damaged vegetation, presence of trails, and droppings in the region of a station.

For purposes of analysis and due to the small number of stations in region 3 - regions 2 and 3 were lumped into a region B, with regions 1 and 4 referred to as regions A and C, respectively.

Initial statistical tests consisted of two sets of t-tests to compare males to females in both species for all variables. The second set of tests were to compare variables for each trap result for the two years. From the relatively few statistical differences noted here, it was felt that for other statistical tests, pooling of sexes and pooling of years was permissible. The next set of statistical tests consisted of analysis of variance, model II followed by a Newman-Keuls multiple range test when a significant F value was obtained. The last test was used to indicate specific equalities and inequalities. Such tests were run on: 1) the 2 years of collective data from the entire area comparing the three trap results, 2) the 2 years of collective data for each region comparing the three trap results, and 3) the 2 years collective data for the three trap results comparing the 3 regions. The descriptive statistics from computer print-outs were utilized in these tests. The computer, an UNIVAC 90/60, was also used to obtain intercorrelation coefficients on pairs of variables for each of the three trap results for the collective 2 years. These correlation values were then compared for each pair of variables, for the three trap conditions, using a t-test with Fisher's z transformation.

Oklahoma Outdoor Penned Population

The 13.7 x 18.3 m pen, utilized in this study, was originally constructed for lizard observation work at the University of Oklahoma's Animal Behavior Laboratory and was greatly modified for my work. The rat population was maintained for behavioral observations and to observe the effects of available food on trapping success in late summer-early fall.

Vegetation in the pen was a natural mixed growth of western ragweed (<u>Ambrosia psilostachya</u>), goldenrod (<u>Solidago altissima</u>), Indian grass (<u>Sorghastrum nutans</u>), and Japanese chess (<u>Bromus japonicus</u>). During the growing season, a 54 cm wide swath was mowed around the inside of the pen to discourage tunneling and also as a pathway for pen maintenance duties.

The sides of the pen were constructed of 1.8 m high corrugated roofing tin sunk 0.3 m below soil level. Several free roaming domestic cats were known to be present in the area so added above these sides was a 1.2 m wide tier of poultry wire with the top 0.3 m held at a right angle to the sides with the aid of wooden strips tacked to the post tops. Sheet metal strips were tacked to the outside supporting posts to further discourage climbing.

A 0.4 m deep pool 1 x 1.6 m in size was dug in the center of the pen and was maintained at a constant level by an enclosed float valve connected by underground hose to an outside reservoir. Transplanted around the pool, to give cover, were eight clumps of vegetation which included narrow-leaved cat-tail (Typha angustifolia), arrowhead (Sagittaria lancifolia) and the three-square bulrush (Scirpus americanus). None of the resident or added plant species were felt to be of any significant importance as a food source for this species.

An observation deck, used in behavioral work, was also built immediately north of the pool with access provided by an elevated walkway. Two sheltered hardware cloth food trays, held 1 cm off the ground, were placed 1 m from the pool sides on opposite sides. Food, in the form of 10 gms Purina Lab Chow and 10 gms Purina Dog Chow were placed in the trays on the initial night and were checked every day with every food addition recorded. If over half the food was missing from a tray, it was supplemented with 10 grams of each type. This quantity was later (3, September) changed to 15 grams and still later (6, October) to 20 grams due to decreasing insect availability, more rats due to reproduction, and to attempt to stimulate hoarding.

To separate the pen into trapping quadrats, verticle painted bars on the galvanized sides were used to divide the pen's length into 6-3.0 m sections (A-F) and the ends into 5-2.7 m sections (1-5). Each of the 30 resulting quadrats, therefore, was coded with a letter and a number which were used for recording capture sites. Baited Sherman live traps were employed for trapping and they were placed in the center of each quadrat on nights used.

On 19 July, at 2200 hours, three adult males and three adult nonpregnant females, captured in Louisiana eight weeks earlier, were released in the pen. These animals were randomly selected from those available with the aid of a random number table (Rohlf and Sokal, 1969). Prior to release, all animals were toe clipped and coats marked with black Nyanzol D amino dye. Trapping of animals to elucidate the effect of food availability (commercial in this case) was carried out a total of four times -26 July, 29 August, 20 September and 16 October for these single nights only. The first and third dates were used for food available sampling and

on the other dates no food was available. Food available conditions refers to when sufficient food was available; no food available conditions - no food in trays the afternoon preceeding the trap night, but a full complement received the preceeding night. Trapped animals were released before noon, following weighing and examination. Trapping and releasing were continued on subsequent nights, following the sample night, with no food available to ascertain if all original animals remained in the pen. Also I desired to determine if young produced were trappable. Only one additional night was necessary for the first two periods, but two additional ones were required for the last two periods.
RESULTS AND DISCUSSION

Post 1900 Distribution

Results of the literature and correspondence survey are shown in figure 5. Individual dots represent one to several animals and may indicate one or more trapping areas if areas were less than 15 miles apart. Darkened county lines aid in finding general locations.

Comparison of the United States distribution in Figs. 1 and 5 show several differences, notably in NE Texas, the SE Kansas - NE Oklahoma area, the area of Central Tennessee-Kentucky, and in North Central South Carolina. All of these distribution errors by Hall and Kelson (1959), except the second, apparently represent "rounding" errors between trap records known at that time. The Kansas extension (Fig. 1) was mapped due to a single questionable 1859 trap record near the town of Neosho Falls on the Neosho River by Goss (Lantz, 1907) and thus I excluded it. Stalling (1977a) discusses questionable and pre-1900 trap records, Indian midden and fossil records all indicating considerable distributional retreat even within recorded history.

Figure 6 shows post 1900 distribution in relation to 180 and 200 average days without killing frost. The 200 day line follows quite closely this species NE as well as its NW United States distribution. Nowhere is the 180 day line crossed. Possibly the predatory nature of this species accounts for this. Goodpaster and Hoffmeister (1952), Negus <u>et al</u>. (1961), Sharp (1969) and others have noted the abundance of exotherms in the rice

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Figure 5. Post 1900 distribution of <u>Oryzomys palustris</u>, by counties, as determined by literature and inquiry surveys.



Figure 6. Post 1900 distribution of <u>Oryzomys palustris</u>, previously noted, in relation to 180 and 200 frost free days. Weather data based on 1941 Yearbook of Agriculture.



rat diet. Sharp (1962) noted that young rice rats do not gain weight on only a seed diet, but need a diet higher in protein content. Shaw (1969) indicated that Purina Lab chow did not support optimal reproduction in lab rice rats, but was successful in white rats. I suggest that the prolonged cold periods north of 180-200 day lines decreases access to terrestrial and semi-aquatic exotherms by young animals sufficiently to significantly affect yearly population production. Low protein diets, 10%, have been shown to affect reproduction in female white rats (Richardson, <u>et al.</u>, 1964), thus, probably, this level of dietary protein, or even higher levels also adversely affects natality in rice rats.

Figure 7 indicates post 1900 distribution plotted in relationship to mean annual precipitation for every 10 inch increase from 24 to 64 inches. As can be seen, with the exception of: the Red River Valley between Texas and Oklahoma, the Texas coastal plain, and the Chesapeake and Delaware Bay areas, "no" trap records are found in areas where mean annual precipitation is lower than 44 inches. High water turnover rates under ad libitum conditions as well as in dehydrated animals was noted by Stalling (1977b). Liberal amounts of readily available surface water are undoubtedly necessary for survival. The aforementioned exceptions to the 44 inch line can perhaps best be discussed in light of elevations (Fig. 8). The last three distributional exceptions lie at elevations below 100 ft. The Red River extension also shows low elevation, compared to surrounding areas. These low elevations result in delayed surface water rum off, elevated water tables and thus increased probabilities for formation of the marshy areas favored by rice rats. Notice should also be made that the northern most distribution records occur along the NE coastal plains where free water is readily accessible, it also serves to ameliorate

Figure 7. Post 1900 distribution of <u>Oryzomys palustris</u>, previously noted, in relation to 24, 34, 44, 54, and 64 mean annual inches of precipitation. Weather data based on 1941 Yearbook of Agriculture.



Figure 8. Post 1900 distribution of <u>Oryzomys palustris</u>, previously noted, in relation to six ranges of elevations. Elevations pantograph transferred from Marschner, 1936.



winter temperatures both of which aid survival of extensive exotherm populations.

The absence of rats at higher elevations in the Ozarks, Ouachitas and Appalachians is probably due to numerous environmental factors. Those that seem most obvious include decreased availability of free water, lower temperatures and the associated fewer prey species.

Distribution of rats along main rivers and associated tributaries has been noted for pre-1900 records (Stalling 1977a). In post 1900 records, tributary access to elevations above 500 ft. is shown in the midwest along the Red and Arkansas rivers, but is best exemplified in E and W Tennessee and Kentucky, and N Alabama along the Tennessee River.

Weather Data

Found in Appendix I is weather data, by months, for Natchitoches, Louisiana from January 1968 to March 1973, prepared from monthly climatological data published by the U. S. Department of Commerce. Yearly graphs show mean monthly temperature minimums and maximums as well as the range and standard deviations with Dice-Leraas graphs. Precipitation graphs indicate monthly totals and also show numbers of days with rainfall greater than 2 cms and greater than 6 cms. As can be noted, April and May rainfall has varied considerably over the years. This weather data and that from Norman, Oklahoma, Appendix II, will be referred to in subsequent discussion.

Results of Trapping Study

The species composition of trapped animals for the entire study area is presented in Table 2. As can be noted, over 96% of the animals captured were either rice rats or house mice. No species, other than the first two, were recaptured. This high catch percentage of only two species is attributed to the relative habitat homogeneity of the area, limited access to this narrow area from suitable higher land and the susceptibility to flooding.

Statistically there was no difference in the number of male and female rice rats obtained either as individuals or as captures. Other studies involving field populations of <u>O</u>. <u>palustris</u> have also noted slightly more trapped males than females, but none indicated a significant difference. Park and Nowosielski-Slepowron (1972) noted that in 317 lab births of <u>O</u>. <u>palustris</u>, sex distribution did not deviate significantly from 50:50.

Significantly higher ratios of males in feral <u>Mus</u> populations have been noted by Baker (1946), Evans (1959), and Howell (1954). All of these were short term studies, involving limited sampling during the year. Brown (1953) in his indoor farm population found 60% of the animals were males (P < 0.01), but felt the larger home range in males was responsible for this difference. Smith (1954) in monthly indoor live trapping for <u>Mus</u> in Mississippi noted, over the one year period, a 1:1 sex ratio. He noted, however, that monthly data treatment showed significantly higher numbers of males from October-December and in April. In other months sexes were essentially equal or slightly more females were caught. A similar monthly trend was seen by Lidicker (1966) and De Long (1967) in their feral San Francisco Bay populations. House mice in the present

Species composition of small mammals from study area for April 1969 - January 1973. Total number of individuals and captures per species (including recaptures) and the percent abundance of each are given.

Species	Indi	viduals	Percent	Captures	Percent
<u>Oryzomys palustris</u>	ଂ ଦୁ	93 78	33.4 28.1	138 125	35.7 32.3
<u>Mus</u> musculus	ି ଦୁ	60 34	21.6 12.2	72 39	18.6 10.1
Sigmodon hispidus		6	2.2	6	1.6
Rattus rattus		3	1.1	3	0.8
Reithrodontomys fulvescens		3	1.1	3	0.8
<u>Didelphis virginiana²</u>		1	.4	1	0.3
Total		278		387	

Total number of captures, including recaptures.
Immature, 160 grams.

......

study, did show a difference in numbers of males and females for both conditions, with P < 0.01 for individuals, and P < 0.005 for captures. This difference is felt to be due to the very restricted part of the year sampled and larger home ranges in males (Table 9) also probably contributed to the results, particularly the capture difference noted.

Table 3 indicates trapping success, with seasonal categorizations, for each region of the study area. Trap night success can be noted to be seasonally quite variable. The poor trapping success in warm climates during the growing season has been seen by mammalogists for years. As noted previously, rice rats consume sizable quantities of exotherms when available. Crayfish, insects and immature anurans were abundant during much of the growing season in the study area and probably were prime food items. Negus, et al. (1961) felt that equal susceptibility to trapping existed in their Brenton Island rice rat population and that summer trapping gave an accurate picture of population density. This assumption is definitely invalid for the Natchitoches population. The Brenton Island population's April to September trap night success values ranged from 0.006 - 0.40 which I feel is too great a range to uniformly truly represent population estimates. Negus, et al. (1961) did not discuss vegetational changes nor invertebrate populations during their three year study. Based on my experience with the present study and my supply regions, I feel that summer trapping success tends to be directly related to food availability. This idea tends to be strengthened by the trapping results obtained in the Oklahoma penned outdoor population discussed later.

Lidicker (1966) noted that knowledge of the wild house mouse diet is very limited and that no doubt it changed in response to season, food availability, age and numerous other factors. Linduska (1942) and

Trapping success in four study area regions, captures and recaptures, of <u>Oryzomys palustris</u> and other small mammals.

	-1* *T-N	IS≃trap	night	success			D.	(othe	er small	l mammals)))	i		
	*1 *1	Y=trap	yield				a. r	umber	of are	a trap si	ites			
Totals	76(44)	1685	.071	151(57)	2552	.081	14(1)	224	.067	22(21)	384	.111	.080	
<u>1973</u> Jan	11(25)	264	.136	23(12)	174	.201	2(0)	48	.042	7(9)	72	.222	.159	
Aug	0(0)	176	0	0(0)	116	0	0(0)	32	0	0(2)	48	.042	.005	
May	0(0)	176	0	4(0)	116	.034	0(0)	32	0	1(1)	48	.042	.016	
<u>1972</u> Jan	35(13)	176	.272	31(6)	174	.213	5(1)	48	.125	14(7)	48	.438	.251	
Aug	2(0)	176	.011	0(0)	116	0	5(0)	32	.156	0(1)	48	.021	.021	
Jan May	7(0) 9(0)	88 176	.079	15(7) 7(5)	116	.189	2(0)	32	.063	U(0) 0(1)	48	0 .014	.115	
<u>1971</u>	7(0)	00	070	15 (7)	11/	100				0.403				ω
June, July	by loca board c	l leve rews.	e	2(0)	464	.004							.004	7
Apr,May	area Ja	.n. 197	0	3(3)	232	.026							.026	
<u>1970</u> Jan,Feb,Mar	Not tra to denu	pped d ding o	ue f	11(4)	290	.052							.052	
Dec				7(0)	58	.121							.121	
<u>1969</u> Apr,May June	12(6) ^b	453	.040	41(20)	464 116	.131							<u>Succe</u> .086	SS
Date	<u>REGI(</u> TY*	<u>N 1 (8</u> <u>T-N*</u>	8) ^a <u>T-NS*</u>	<u>regi</u> Ty	<u>ON 2 (5</u> T-N	<u>8)</u> T-NS	<u>REG</u> TY	<u>ton 3</u> T-N	<u>(16)</u> <u>T-NS</u>	REGIO	<u>) 4 (</u> T-N	<u>24)</u> T-NS	Mean Trap	night

Whitaker (1966) noted several arthropods and earthworms in the house mouse diet and Golley (1963) noted that anatomically the house mouse digestive tract is that of an omnivore. Apparently they are an opportunistic species, finding numerous substances edible under natural conditions in Louisiana, and like the rice rat, summer capture is difficult with ample food items available.

Diverging from strict discussion of the study area momentarily, Table 4 was prepared for comparative purposes showing trapping success in areas known to have rice rats in Louisiana and Oklahoma. Rice rats from these sites were used in the outdoor pen and for lab work. The overall trapping success for the entire study area (8.0%), with recaptures included, compares quite favorably to the 7.7% and 7.5% overall success for the Louisiana and Oklahoma supply areas respectively.

Regional Comparison of Populations

Negus, <u>et al</u>. (1961) in his isolated Brentom Island rice rat population, found that densities varied widely during the three year study and he attributed declines to the severity and duration of winter. These environmental factors he felt were enhanced in their adverse effect due to the unsheltered nature of this desert island's habitat. Although no plant data were available he felt that climatic factors affected plant nutrition, including plant estrogens, which in turn affected ovulatory rates in rats consuming them. Lidicker (1965) in captive lab populations of <u>O</u>. <u>palustris</u> felt that population control in this species, under these artifically high densities, was controlled primarily by fighting and nestling mortality.

Table 5 was prepared for the four regions of the study area to compare yearly capture success. Arcsine conversion on the trapping success values were carried out before Student t tests were run. Due to small

Trapping success in thirty-five animal supply areas, twenty-five in Louisiana and ten in Oklahoma.

LOUIS	IANA AREAS	5			LOUISIANA	AREAS	
<u>Date</u> 1968	TY	T-N	T-NS	<u>Date</u> 1972	<u>TY</u>	T-N	T-NS
Mar,Apr,M ay	27(12) ^a	318	.123	Jan	5(6)	79	.139
Sept,Oct,Nov	13(19)	290	.110	May	18(1)	250	.076
Dec	4(2)	18	.333	Aug	12(1)	296	.044
<u>1969</u> Feb	9(6)	225	.067	<u>1973</u> Jan	6(8)	116	.121
Apr,May	17(13)	479	.063	LA. 2	129(75)	2643	.077
Oct,Nov	8(5)	58	.224				
<u>1970</u> Mar,Apr	2(0)	82	.024	Date	OKLAHOMA	AREAS	
June, July, Aug	1(0)	280	.004	Apr,Ju	ne 0(7)	180	.039
<u>1971</u> Jan	4(1)	55	.091	<u>1969</u> July	0(0)	78	0
Мау	0(1)	36	.028	<u>Nov</u>	1(24)	230	.109
Aug	3(0)	61	.049	UKLA.	e 1(31)	488	.065
				GRAND 4	130(106)	3131	.075

TY= trap yield T-N= trap nights T-NS= trap night success a= #rice rats (other small mammals)

Comparison of yearly capture success of <u>Oryzomys palustris</u> and <u>Mus</u> <u>musculus</u> in four regions using capture success and total trap nights. Only significant values ≤ 0.05 are shown.

Years	Level of	Difference	Years	Level of Difference		
Region 1	Rice Rats	Nouse Mice	Region III	Rice Rats	house Mice	
$\frac{Jan}{71-72}$	0.01	0.001	<u>Jan</u>			
72-73	0.001	0.001	12-13			
71-73	01001	0.001	May			
		01001	71 - 72	0.05		
May						
71-72	0.001		Aug			
			71-72	0.002		
Aug						
71-72	0.05		Region IV			
			Jan			
Region II			71-72	0.001	0.001	
$\frac{Jan}{70-71}$	0.000	0.00	72-73	0.01		
70-71	0.002	0.02	/173	0.01	0.001	
72-73						
70-73	0.001	0.005	71-72			
71-73	0.001	0.005	/1-/2			
70-72	0.001		Aug			
–			71 - 72			
May						
69-70	0.001	0.02				
70-71	0.02					
71-72						
69-72	0.05	0.002				
70-72		0.05				
69-71		0.001				
A110						
71-72						

numbers trapped in May and August, the January values will be primarily discussed. Table 6 compares numbers and percentages of the three age categories of rice rats for each region of the study area. Figure 9 compares population weights regionally and periodically. These three sets of data will be discussed concurrently concentrating initially on Table 5.

The rice rats, in all regions except region 3, had a population high in 1972, thus accounting for the statistical differences when compared to other years. In region 1 this high is attributed to the ecologically more desirable conditions in 1972 than in 1971 when habitat recovery was occurring and in 1973 when considerable amounts of cover vegetation had been removed by mowing. In 1973 nutria (Myocastor coypus) activity was high at the south end of the region. This species' presence is felt to adversely affect rice rat populations in three ways: 1) production of wide, bare trails on the banks, 2) consumption of cattails that serve as rat nest supports (Stalling, 1977c), and 3) activity in the area, typically quite noisy, disturbs the shy and secretive rats. Lower population of the area in 1973 also is felt to be influenced by the increased abundance of Johnson grass which Carlton (1958) noted was poorly utilized by rice rats as a food source.

In region 2, a significant population low was also seen in 1971 compared with the other 3 years. This is attributed to the abundance of plants on the east bank such as wild lettuce, trumpet creeper and Johnson grass all of which are apparently poor rice rat food. Mowing on the west bank throughout the study helped to maintain Bermuda grass and white clover, both suspected of being important plant food items. The loss of vegetation by mowing, following the fence removal on the west bank, and the subsequent increase in Bermuda grass and sedges, apparently favorably

Total number and percentages of three age categories of <u>Oryzomys palustris</u> trapped in four regions of study area.

		REC	GION 1			REGION 2			REGIO	N 3		REGION 4	
<u>Date</u> 1969	#	J%*	SA%*	<u>A%*</u>	#	J% SA%	<u>A%</u>	#	J%	SAZ AZ	#	J% SA%	A%_
Apr, May	7		71.4	28.6	10	10.0	90.0						
June					6	33.3	66.7						
Dec					7	14.3 71.4	14.3						
1970													
Jan, Feb, Mar	Not	trap	ped due	to	8	100.0							
Apr,May	den	uding	of are	а	3	100.0							
June, July	Jan	ı. 1970	0 by lo	cal	1	100.0							
	lev	vee boa	ard cre	ws.									
1971													
Jan	7		71.4	28.6	13	76.9	23.1				0		
May	9		44.4	55.6	7	28.6	71.4	1		100.0	0		
Aug	2			100.0	0			4		75.0 25.0	0		
1972													
Jan	33	3.0	27.3	69.7	23	39.1	60.9	2	50.0	50.0	10	20.0 70.0	10.0
May	0				4		100.0	0			1		100.0
Aug	0				0			0			0		
1 <u>973</u>													
Jan	9		11.1	88.9	15	6.6 26.7	66.7	2		100.0	5	20.0	80.0
Totals	67	1.5	35.8	62.7	97	3.1 45.4	51.5	9	11.1	44.4 44.4	16	18.8 43.8	37.5
		*.	J%= % o	fjuveni	les								

*J%= % of juveniles *SA%= % of subadults *A%= % of adults 78

Figure 9. Mean weights of regional and area captures of <u>Oryzomys</u> <u>palustris</u> for trapping sessions 1969-1973. Numbers at top of histograms represent sample size.



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offset each other to allow this area to be the most uniformly productive region.

Region 3 was trapped only two Januarys and showed no significant differences in productivity for the two periods nor were any vegetational changes obvious.

Region 4 had no animals in 1971, increased significantly in 1972 (P < 0.001) and then decreased in 1973. This region, and region 3 to a limited extent, was felt to be an overflow area for immature animals displaced from regions 1 and 2. As noted (Table 6) in 1972, 90% of the rats in region 4 were sub adults or younger. In 1973, with lower population pressures, this percentage was down to only 20%.

The idea that food scarcity increases trapability of rice rats, in the growing season, is seen by noting May 1971 results for regions 1 and 2. These regions both had the most rats trapped at this time, compared to other years, yet both were in the state of habitat recovery-region 1 from complete denuding in Jan. 1970, and region 2 from an 80% burn, fence removal and mowing down the bank the spring of 1971.

In the age structure of the rat populations (Table 6), it is difficult to note changes in age groups during a year, due to the limited sampling periods used. Added to the difficulty is the fact that rats attain adult status approximately 150 days after birth (Negus, <u>et al</u>., 1961), as will be noted later, potential birth rates are quite high.

Statistical comparison of regional totals showed no significant differences in comparing sub-adult totals and comparing adult rice rats from one region to another. For the juveniles, however, two significant differences were seen - a difference of P<0.02 between regions 1 and 4 and P<0.05 for regions 2 and 4. With January 1972 as the central focus of

discussion, it can be noted that in January 1971 for combined regions 1 and 2 only 25% of the animals were adults. At the population peak, Jan. 1972, this adult percentage was 57%, but by Jan. 1973 this was up to 77%. This age distribution fits the well known axiom of population age distribution, perhaps best states by Odum (1971): "Usually a rapidly expanding population will contain a large proportion of young individuals, a stationary population, a more even distribution of age classes, and a declining population a large proportion of old individuals."

Population biomass changes, regional and area, are noted in Figure 9 and such changes have also been noted by Negus, <u>et al</u>. (1961) in the Brenton Island population. Negus felt that this change was influenced partially by the age structure of the population, but also that the severity of the weather caused population weight loss. Supportive data for this weather - body weight relationship theory can be noted from comparison of January population weights and the preceeding December's mean temperature (Append. I).

Mean Dec. Temp.	Mean Jan.	Pop. <u>Wt</u> .
1969 4.0°C	1970	37.00 gm
1970 7.5°C	1971	38.86 gm
1971 8.3°C	1972	42.26 gm

This relationship appears even more significant when considering that a higher percentage of the animals in the 1973 sample than the 1972 sample were adults.

Field (feral) population studies on the house mouse have been carried cut by several authors. Breakey (1963) in his study of five feral populations in California salt marshes, noted population cycles with associated age changes, but failed to speculate as to what causative factors might be involved. Pearson (1963) in two outbreaks in California noted densities of up to 300 mice per acre in one population he followed for 5 years and he attributed the outbreak to an unusually warm winter and spring preceeding the outbreak. Lidicker (1966) studied an island population that declined to extinction in 14 months from a population that originally contained about 300 animals per acre. This he attributed to several factors - reduced population viability, vole interference, relatively mean old age and most importantly a reduction in food supply. DeLong (1967) studied four populations of feral house mice in the San Francisco Bay area for two years, and all four underwent population declines. One decline was attributed to an epidemic disease, another to an insufficient food supply and the other two to "some intrinsic mechanism."

As with the rice rats, due to the small sample sizes, only the January populations of house mice will be discussed. In region 1 (Table 3), the absence of animals in January 1971 is attributed to the habitat destruction which had occurred the previous January. Briese and Smith (1973), in Georgia, noted heavy use of abandoned or even occupied <u>Peromyscus</u> <u>polionotus</u> burrows by <u>Mus</u>. They concluded from their and other's field work that the latter species, being a poorer burrower, depended at least to a certain extent on the former species for a place to live. Thus it is felt that the significant 1971 low was caused by the lack of old and new nests (burrows), of rice rats, for the mice to occupy. The high population level in 1973 for this region is attributed to the "minor" habitat

disturbances from bank mowing and nutria activity which adversely affected rice rats. Gentry (1966) noted rapid invasion of disturbed habitats by <u>Mus</u>. The region 2 population for January 1970 is felt to be attributable, in part, to the greater than normal December 1969 rainfall (\mathbb{Z} =16.5 cm) and lower temperatures ($\overline{x}=4.5^{\circ}$ C) (Append. I). The low <u>Mus</u> population's competition, the low December 1971 temperatures, and the above normal rainfall. No doubt these last two environmental factors contributed to the low in region 1 for 1971, also. In region 3, over the trapping period, no significant changes occurred in the two January populations. In region 4 the two significant values for population numbers, 72>71<73, are attributed to the three factor's mentioned for region 2. In 1972, this last region probably served as an overflow area for other regions with the 1973 population attributed in part also to the extensive mowing the previous spring in region 1 and this region's great increase in <u>Mus</u>.

In regional comparison of the age groups (Table 7), two statistically significant differences were seen for the adults and two for the immatures (for the adults, regionally 2>3 and 3<4). The relative absence of mice from region 3 can only be attributed to its small size, stability (no burning or mowing pattern change during the study) and adverse pressure from the rice rat population here. For the immatures, the same regional differences noted for the adults existed for them also. Age changes in the various regions were not as obvious as those previously noted for rice rats. The January adult populations in regions 2 and 4 all stayed well above 50Z apparently indicating relatively stable populations. The rapid population growth in region 1 from mid 1971 through mid 1972 is reflected in the 46Z adults in January 1972, but the 84Z in 1973 was perhaps in-

Total number and percentages of two age categories of <u>Mus musculus</u> trapped in four regions of study area.

	REGION 1	REGION	2	REGION 3	REGION 4	
Date	<u># 1% A%</u>	<u># 1%</u>	A%	# 1% <u>A%</u>	# 1%	А%
<u>1969</u>						
Apr,May	1 100.	0 9 22	.8 87.2			
June		0				
Dec		0				
<u>1970</u>						
Jan, Feb, Mar	Not trapped due	to 4 25	.0 75.0			
Apr, May	denuding of are	a 3	100.0			
June,July	Jan. 1970 by lo	cal 0				
1071	levee board cre	ws.				
19/1						
Jan	0	6 16	6.7 83.3	_	0	
May	0	4	100.0	0	1	100.0
Aug	0	0		0	1	100.0
1070						
1972	10 50 6	0 / OF		1 100 0		
Jan	13 33.8 40.	2 4 25	0.0 /5.0	1 100.0	6 33.3	66.7
мау	0	0		0	1	100.0
Aug	0	0		0	2	100.0
1072						
1973	10 15 0 0/	0 10 7		<u>^</u>		
Jan	19 15.8 84.	2 12 16	./ 83.3	0	7 42.9	57.1
Totolo	22 20 2 (0	7 40 14		1 100 0	10 47 5	
Totals	JJ JU.J 69.	/ 42 16	0.7 83.3	1 100.0	18 27.8	72.?

85

*I%≃ % of immatures *A%≂ % of adults 4 in January 1973 seems to indicate a rapid population growth.

Figure 10 shows weight changes for the <u>Mus</u> population. As with <u>Oryzomys</u> (Fig. 9) the changes noted are in part due to age changes as well as weather. The low in January 1972 is attributed primarily to the 46% immatures and the May 1971 high to a population containing all adults.

Using previously stated criteria for determining reproductive state, Table 8 was prepared to indicate percentages of trapped animals considered reproductively active for both species. Svihla (1931) felt that Louisiana females might produce as many as nine litters per year, if reproduction occurred all year and longevity of over one year existed. Hamilton (1949) also felt this to be true for Virginia rice rats. Negus, <u>et al</u>. (1961) showed this to be unrealistic, as average longevity of seven months was shown and nonbreeding periods of six months occurred during two "winters" of his study. In Table 8, reproductive activity in mid winter varied from 0 - 19% with the percentage seeming to be closely correlated with the desirable and undesirable modifications in the habitat previously mentioned.

Lidicker, W. Z. (1965), from lab population density studies, postulated that the house mouse is a opportunistic species that frequently has populations that reach high densities and thus has evolved the adaptation of temporary reproductive inhibition (mainly of females) to efficiently deal with this situation. The literature concerning the level of yearround reproductive activity in <u>Mus musculus</u> and the effects of various extrinsic and intrinsic factors on it has been adequately covered by DeLong (1967). He felt that basically two extrinsic factors caused cessation or reduction of breeding in adult females: "1) food supply, which is reduced by the germination of seeds after the fall or early winter rains, and 2) the cool, moist conditions of winter." The effects of various periods

Figure 10. Mean weights of regional and area captures of <u>Mus</u> <u>musculus</u> for trapping sessions 1969-1973. Numbers at top of histograms represent sample size.



Percentage of animals considered reproductively active and total sample size (N) of <u>Oryzomys palustris</u> and <u>Mus musculus</u> from study area

Date	<u>Oryzom</u> Palustri	7S LS	<u>Musculus</u>		
1969 Apr, May Jun	70.6 (12 33.3 (6	7) 5)	100.0	(10) (0)	
<u>1969, 1970</u> Dec, Jan, Feb Mr, Apr, May Jun, Jul	0.0 (14 100.0 (4 100.0 (1	() () ()	50.0 33.3	(4) (3) (0)	
<u>1971</u> Jan May Aug	15.0 (20 88.2 (17 100.0 (6		16.7 83.3 100.0	(6) (6) (1)	
<u>1972</u> Jan May Aug	19.1 (68 80.0 (5 (0)))))	62.5 100.0 100.0	(24) (1) (2)	
<u>1973</u> Jan	3.2 (31)	50.0	(38)	

of mowing and winter moisture have been discussed regionally in relationship to population size and will not be reiterated here. The elevated rates for January 1972 and January 1973 (Table 8) are felt to be truly indictive of a young vigorously growing population and the incidence of immatures reported in Table 7 lends weight to this assumption. As noted previously December 1971 was a wet and cold month, but apparently inadequately so to diminish the population's reproductive status.

Table 9 indicates minimal distances between the first and last captures for animals of both species captured twice, three times and for those captured four or more times. Using Student's t test no significant differences were noted between the male and female distance traveled for either species at the 0.05 level except in rice rats for = 4 captures (P<0.005). Summary comparison of the two species did not show a significant difference, but the small sample size of house mice may have contributed to the lack of a statistical difference.

In this study, since traps were not set out on a grid, but in two lines on either side of a ditch, home range area was impossible to compute in square feet,etc. Due to the observed frequency of rice rats crossing the ditch (Table 11) both sides were probably part of a rat's home range. Very limited work on rice rat movement (overnight movement) was reported by Svihla (1931) and Pournelli (1950). Pournille recaptured 6 of 19 animals and Harris (1952) recaptured 6 rice rats in a Florida marshy grassland. Negus, <u>et al</u>. (1961) found of the Brenton Island <u>Oryzomys</u> captured 3 or more times, the males had a mean home range of 0.81 acres, and the females 0.51 acres. Birkenholz (1963) reported an average home range of 0.62 acres for 12 animals. It is interesting to note that for both sexes in the current study, the longest distances between captures occurred in

Distance in meters between first and last capture,

Oryzomys palustris and Mus musculus.

NUMBER OF TIMES CAPTURED

Oryzo	omys palustris			
	2	3	≥4	Totals
ď	22* 111.5 <u>+</u> 40.76 (0-868.6)	5 70.1 <u>+</u> 14.93 (30.5-121.9)	4 289.5 <u>+</u> 54.59 (137.1-396.2)	31 127.8 <u>+</u> 31.70 (0-868.6)
Ŷ	12 142.2 <u>+</u> 83.05 (0-990.5)	6 71.6 <u>+</u> 29.9 (15.2-213.3)	9 71.1 <u>+</u> 19.5 (15.2-182.9)	27 102.8 <u>+</u> 37.7 (0-990.5)
°& 9	2 122.4 <u>+</u> 38.8 (0-990.5)	70.9 <u>+</u> 16.89 (15.2-121.9)	138. <u>+</u> 35.38 (15.2-396.2)	116.2 <u>+</u> 24.2 (0-990.5)
<u>Mus</u> o	nus <u>culus</u>			
්	5 33.5 + 13.97 (0-61.0)	2 137.1 <u>+</u> 76.20 (60.9-213.3)	1 152.4	8 74.3 <u>+</u> 25.99 (0-213.3)
ę	2 38.1 <u>+</u> 7.62 (30.5-45.7)	0	1 15.2	3 30.5 <u>+</u> 8.80 (15.2-45.7)
o" &	2 34.8 <u>+</u> 9.82 (0-61.0)		83.8 <u>+</u> 68.58 (15.2-152.4)	62.3 <u>+</u> 19.65 (0-213-3)

*N X<u>+</u>SE (Range)

92 animals captured only twice. The male moved from region 1 to 2 and the female in the opposite direction. Both presumably moved from region to region via region 4. More than a dozen animals that were recaptured were captured in region 4 from either region 1 or region 2, apparently indicating the importance of region 4 as an exchange route. No rats or mice marked in region 3 were ever recaptured in any of the other regions and visa versa. Apparently the 10 m long culvert pipe and the bare roadway were effective barriers to dispersal.

In house mice the distance between captures are shorter than rice rats, but not significantly so. Due strictly to size this is expected and perhaps the difference between species should be even greater since very few Mus crossed the ditch (Table 11) and thus undoubtedly only one bank side is of concern. Home ranges of Mus in buildings, particularly where a readily available food supply exists, are frequently very small - Young, et al. (1953) 12 ft. and Brown (1953) 17.2 ft. for average distances between captures. In feral Mus populations, published home range sizes are: in Guam, Baker (1946) 14.7 yards between captures; Howell (1954) 0.30 acres; and Lidicker (1966) 1,560 sq. feet but winter females only 710 sq. feet. Quadagno (1968) in two areas of San Francisco Bay found males mean home range to be 2132 and 4059 sq. feet and for females mean values were 1500 and 5663. These differences he attributed to the higher population levels for the second area.

In Table 10 are noted comparative sex and species values for time between first and last capture in recaptured animals. Due to the time between sample periods, this information is of very limited value in determining survival times. Recapture of house mice occurred only during a trapping session with no carry over between sessions. No statistically significant differences were seen within species, but interspecific comparison
TABLE 10

Days between first and last capture

of Oryzomys palustris and Mus musculus.

	Males	Females	Both Sexes
Oryzomys palustris	31*	27	58
	50.6 <u>+</u> 18.07 (1-367)	31.6 <u>+</u> 9.49 (1-139)	41.8 <u>+</u> 10.61 (1-367)
<u>Mus</u> <u>musculus</u>	8 3.7 <u>+</u> 0.86 (1-7)	3 4.0 <u>+</u> 1.00 (1-5)	$ \begin{array}{r} 11 \\ 3.8 \pm 0.66 \\ (1-7) \end{array} $

X<u>+</u>SE (Range)

was significant, P<0.001.

Negus, <u>et al</u>. (1951) on Brenton Island found average longevity for rice rats to be 7 months. No other workers specifically determined age, but Schwartz and Schwartz (1959) felt that few field rice rats in Missouri live past one year of age. In lab colonies, longevity records for males are 33 months and for females 24 months (Park and Nowasielski-Slepowron, 1971). During my work, several animals were maintained in the lab for over two years following their capture.

In <u>Mus musculus</u>, as indicated previously, several population studies have been conducted. In few studies, apparently due to rapid turnover, has there been an attempt to estimate average longevity. Evans (1949), Breakey (1963), Pearson (1963) and others have conducted age categorization tables for their populations, but due to lack of knowledge of birth rates have not been able to calculate average longevity. Brown (1953) noted a median disappearance of marked males in 40 days and females 76 days in a Maryland farm population. Baker (1946) in his monthly trapping of Guam grasslands, found that 70% of all mice trapped each period had not been trapped previously. On the basis of the preceeding information I expect that average longevity in <u>Mus</u> is under 3 months, but high reproductive rates usually more than offsets this short life spen.

Ditch as a barrier

Natural obstacles, such as water filled drainage ditches, boulders, and logs may play important roles in dispersal range extension and in home range for small mammals. No homing experiments were conducted with these two species, but Savidge (1973) noted a significant decrease in homing ability in the white footed mouse (<u>Peromyscus leucopus</u>) when a stream of a size comparable to the hatchery ditch occurred between the capture and

release points. An index of the importance of this barrier to movements of the rice rat and house mouse was felt to be the natural frequency of crossing in recaptured animals.

Numbers and percentages of the three categories of recaptured rodents of both species, that crossed the drainage ditch between captures, are shown in Table 11. Due to low incidence of crossings by house mice (18%), sexes were pooled. In the rice rats, over 53% crossed the ditch between captures. Males show little change regardless of capture times, whereas females show an increase with captures. Statistically, at the 0.05 level, no sex difference in ditch crossing is seen. Comparing species there is no significant difference for three captures, but there are for all other categories and for the sum of all captures. The ease with which rice rats take to the water for escape has been noted by most authors that have observed this species under natural conditions. Stalling (1977c) discusses aspects of their diving behavior. Both banks of narrow waterways, such as the hatchery ditches, are probably part of a rice rat's home range as well as the emergent vegetation in the ditch which will support an animal. In M. musculus, crossing apparently occurs, but infrequently. In a few areas of the ditches it is possible the house mice (mean weight 16 gms) could have crossed on inter-tangled vegetation.

TABLE 11

Numbers and percentages of

Oryzomys palustris and Mus musculus crossing drainage

ditches in study area between first and last capture.

Species		NUMBER OF TIMES CAPTURE								
			2		3		4	Tota	1	
Oryzomys palustris	ď	14/22	^a (64) ^b	2/5	(40)	2/4	(50)	18/31	(58)	
	ę	4/12	(33)	3/6	(50)	6/9	(67)	13/27	(48)	
	∞&?	18/34	(53)	5/11	(45)	8/13	(61)	31/58	(53)	
Mus musculus	₫&₽	1/7	(14)	1/2	(50)	0/2	(00)	2/11	(18)	

a= recaptured animals that have crossed ditch between first and last capture/total number of category recapture animals.

b= percent of recaptured animals crossing ditch
between first and last capture.

Mathematical Analysis of Distribution in Study Area

In the early 1960's G. E. Hutchinson defined MacArther's term, fundamental niche, stating that it was for a species an "N dimensional hypervolume" thus representing the totality of environmental parameters defining the conditions under which a species population could exist and reproduce (Boughey, 1973). These parameters can grossly be divided into three categories - physical, chemical and biological - realizing that spatial considerations also must exist. In my study I measured a combination of 16 selected physical and biotic variables in the chosen study area, hoping to be able to indicate variable characteristics that were most likely to produce rice rats, or house mouse or not produce either. I also desired to determine how these variables changed between the years, realizing that man made environmental changes were considerable during this period. As previously, only January 1972 and 1973 were analyzed due to insufficient sample sizes from other periods. It should be realized that scoring a station and its variables for a particular trap response did not imply that only that trap site was in the animal's home range. With traps only 15.25m apart on a ditch side, traps paired across the ditch (mean width 280.5 cm) and the very narrow nature of the study area, it was hoped that two or more traps were present in each animal's home range. Capture at a site obviously meant that the animal in question was in the area, enough "at ease" to enter the trap, but did not imply that this was the sole area of movement. No doubt interspecific and intraspecific home ranges overlapped, but in light of previously stated trap distances and the low levels of trap night success, even in January, the exclusion of animals from a trap already occupied was felt to be rare.

Selected studies which have shown mathematically a dependence of

certain small North American rodent's distributions on selected habitat variables follows: Raun (1966) noted a high correlation between the density of the gray woodrat (Neotoma micropus) and the prickly pear cactus (Opuntia lindeimeri) in southern Texas. He also observed rapid population declines following an unusually wet year which killed large quantitles of cactus. Rosenzweig and Winakur (1969) by correlation analysis showed association of two species of kangaroo rats (Dipodomys spp.) with sparseness of vegetation; two species of pocket mice (Perognathus spp.) with vegetation denseness; presence of bushes with two Perognathus spp.) three Peromyscus spp. and the fulvous harvest mouse (Reithrodontomys fulvescens); two other Perognathus spp. for grassy habitats; and the resistance of the soil to sheer stress appeared to correlate with distribution of the smallest and largest of the Heteromyidae. Brown, et al. (1927) also showed by correlation that 80% of the variability in the population density of the desert woodrat (Neotoma lepida) in southern California, was attributable to the variation in the density of cholla cactus (Opuntia bigelovii). M'Closkey and Fieldwick (1975) demonstrated ecological separation in sympatric populations of Peromyscus leucopus and Microtus pennsylvanicus in southern Ontario, in part by discriminant function analysis employing measurements of foliage height density, mat depth and tree basal area. M'Closkey and Lajoie (1975), in southern Ontario, showed that the density of a Peromyscus leucopus population is highly correlated (0.87) with the density of the foliage profile in the 0 - 7.6 cm layer above the soil.

Discussion of Data

The means and standard errors for all habitat variables for both species and the no catch stations are summarized in Table 12. Similar tables were prepared for the other ways of categorizing the data, but they were not included.

The initial statistical treatment (Table 13) employed analysis of variance (ANOVA) to compare the 3 trapping results for both 1972 and 1973. In 1972, as previously noted, the rice rat population was at its highest, the house mice population rapidly increasing, and the habitat in regions 1 and 4 had not yet been mowed. Only 4 differences for 1973, were noted when the Newman-Keuls Multiple Range Tests were used. The rice rats discriminate from no catch stations in water depth and water width choosing shallower and narrower areas than no catch stations. This I feel is advantageous due to their predation on crayfish that would seem to be more obtainable under these circumstances. The greater amount of water surface coverage preferred by rats compared to mice is due to the use of dense cattail stands by the former to build nests. Also the smaller mice are probably displaced by the rats into areas having less surface coverage. The significant preference of mice for less water surface coverage compared to no catch may be due strictly to displacement by rice rats from those regions that although they didn't "produce" rice rats may be frequently used by them.

For the 1973 comparison in Table 13, the greater catchability of house mice in wet weather is attributed to shelter seeking by these animals that are not as well adapted for these wet conditions as are the semiaquatic rice rats. Neither species hoards, thus both must forage "each" night to survive regardless of rain. The preference for greater bank

TABLE 12

Means and standard errors for January 1972 and 1973

habitat variables for entire study area

	<u>Rice Rats</u>		Hous	e Mice	No Catch		
	<u>1972 (78)</u> *	<u>1973(42)</u>	<u>1972(31)</u>	<u>1973(42)</u>	<u>1972(330)</u>	<u>1973(465)</u>	
Cloud Cover	1,14+0,10	1,64+0,13	1.10+0.16	2.05+0.14	0.98+0.05	1.79+0.04	
Precipitation	1,00+0,11	0.83+0.15	0.90+0.18	1.43+0.17	0.78+0.05	1.13+0.05	
Temperature	7.70+ 0.75	1.76+0.47	8,39+1,18	1,59+0,58	8.39+0.38	0.90+0.17	
Bank H eig ht	95,82+2.28	98.89 + 2.98	90,89+3.72	100.36+2.83	97.47+1.05	95.01+0.92	
Bank Length	219.73+9.54	223.85+12.33	201,52 +1 6,21	241.28+13.15	205.51+4.78	202.57+4.13	H
Bank Angle	31.24 + 0.86	31.19+1.12	29,52+1.61	29.55+1.25	32.66+0.50	31.83+0.41	ö
Water Depth	23.14 <u>+</u> 1.20	23.40+1.67	24.90+1.52	22.57+1.58	26.64+0.55	26.03+0.46	
Water Width	260.87+7.29	274.56+11.84	273,27+13.48	247.99+14.03	288,12+4.32	282.43+3.55	
Height Dom. Veg.	110.87+9.61	89.52+10.92	123.23+9.72	117.57+18.51	121.98+6.25	95.62+5.80	
Ground Cover	3.08+0.11	3.21+0.15	3,26+0.11	2.95+0.19	3.01+0.05	2.28+0.05	
Unmowed Veg.	315.31+29.62	180.21+37.98	346.68+46.55	299.36+51.28	291,71+15.55	213.01+12.59	
Dom. Veg. in Water	3.42+0.13	3.55+0.14	3.29+0.20	3.31+0.18	3.20+0.07	3.14+0.06	
Water Sur. Cov.	2.79+0.16	2.90+0.20	2.03+0.13	2,45+0,21	2.67+0.08	2.43+0.07	
Terrestrial St.	3.29+0.07	3.24+0.08	3.39+0.11	3.55+0.09	3.29+0.03	3.35+0.03	
Aquatic St.	4.49+0.14	4.67+0.15	4,19+0.26	4.45+0.22	4.18+0.08	4.08+0.07	
Nutria Activity	0.78 + 0.09	0.69+0.12	1.06+0.15	0.79+0.12	0.90 - 0.04	1.03+0.04	

* Sample size

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TABLE 13

Significance level of F values from ANOVA Model II test for separate January 1972 and January 1973

comparing the three possible trap results with separation at the 0.05 level using

	Signi. Level ANOVA test	Newman-Keuls Multiple R. test	Signi. Level ANOVA test	Newman-Keuls Multiple R. test	
	1972	1972	1973	1973	
Cloud Cover		1=2, 1=3, 2=3	0.05	1=2, 1=3, 2=3	
Temperature		1=2, 1=3, 2=3 1=2, 1=3, 2=3	0.05	$1\neq 2$, $1=3$, $2=3$ 1=2, $1=3$, $2=3$	
Bank Height Bank Length		1=2, 1=3, 2=3 1=2, 1=3, 2=3	0.05	1=2, 1=3, 2=3 $1=2, 1=3, 2\neq 3$	
Bank Angle Water Depth	0.05	1=2, 1=3, 2=3 $1=2, 1\neq 3, 2=3$		1=2, 1=3, 2=3 1=2, 1=3, 2=3	
Water Width Height Dom. Veg.	0.05	1=2, 1≠3, 2=3 1=2, 1=3, 2=3	0.05	1=2, 1=3, 2≠3 1=2, 1=3, 2=3	
Ground Cover Unmowed Veg.		1=2, 1⇒3, 2=3 1=2, 1=3, 2=3	<0.0005	1=2, 1#3, 2#3 1=2, 1=3, 2=3	
Dom. Veg. in Water Water Sur. Cov.	0,05	1=2, 1=3, 2=3 1≠2, 1=3, 2≠3		1=2, 1=3, 2=3 1=2, 1=3, 2=3	
Terrestrial St. Aquatic St.		1=2, 1=3, 2=3 1=2, 1=3, 2=3	0.05	1=2, 1=3, 2=3 1=2, 1≠3, 2=3	
Nutria Activity		1=2, 1=3, 2=3	0.01	1=2, 1≠3, 2=3	
Summary		15=, 14=, 1 5 =		15=, 13=, 13=	

Newman-Keuls multiple range test.

*l=Rice Rat 2=House Mouse 3=No Catch

length by house mice over those areas in which mice were not caught was probably due to the fact that no-catch stations were in areas subject to occasional flooding. Soil moisture near the bank crests probably was the determining factor. Water width "chosen" by house mice was narrower than that of the average (no catch) stations and was opposite 1971. This I feel is a quirk of the habitat destruction (mowing) which occurred the spring of 1972.

The two differences seen for ground cover comparison of no catch with rice rats and with house mice was obviously expected due to the massive mowing the spring of 1972. Here the two species shun the areas where vegetation is mowed down to the water's edge.

The significant difference in the aquatic stage of succession for rice rats and no catch occurs due to the selection by rice rats of the advanced successional stages which contain several supportive types of emergent vegetation for nests and protection.

The greatly increased nutria activity noted in the area the fall of 1973 was selected against by rice rats compared to the no catch situation. House mice did not select against the nutria presence, but the shy rat is unable to tolerate this.

Significance levels < 0.05 for t tests between males and females in both species for all variables are shown in Table 14. Only two significant differences, both 0.005, are noted: cloud cover in rice rats, and water width in house mice. The heavier cloud cover preferred by male rice rats may perhaps be explained on the basis of body size, male>female. It has been shown in several species of rodents that greatest activity occurs when cloudy conditions exist. The females with smaller body size, thus greater metabolism, perhaps can't be as selective as males as to sky

TABLE 14

Male vs. Female January 1972 vs. January 1973 Habitat Variable Oryzomys Mus Oryzomys Mus No palustris musculus palustris musculus Catch Cloud Cover 0.05 0.005 0.001 <0.001 Precipitation 0.05 <0.001 Temperature <0.001 0.001 <0.001 Bank Height 0.05 Bank Length Bank Angle Water Depth Water Width 0.05 Height Dom. Veg. Ground Cover Unnowed Veg. 0.01 <0.001 Dom. Veg. in Water Water Sur. Covered 0.05 Terrestrial St. Aquatic St. Nutria Activity 0.02

Student t test values to reject null hypothesis at 0.05 level for male vs. female and January 1972 vs. January 1973 for habitat variables in entire study area.

cover to obtain food. The preference of male mice for wider water width is difficult to explain, but may be associated merely with their larger territories and increased activity away from female nests and contact pressure with the rice rats, which as noted in Table 13, show a preference for the narrower water widths.

Also recorded in Table 14 are significance levels ≤ 0.05 for t tests between the two years for each of the trap results. In comparing years, the no catch t values should be considered as "control" values, thus significance values the "same" for the rice rats and/or the house mouse compared to the control should be disregarded as they merely represent an unselected change which has occurred from 1972 to 1973 in the hatchery area. On the basis of this, the differences between years should be disregarded for cloud cover and temperature. While discussing Table 14, Table 12 should be referred to since the latter's means and standard errors apply to Table 14. A significantly greater amount of precipitation occurred in the 1973 trapping session than the 1972 (P < 0.001), but house mice populations in the two years are different only at the 0.05 level and rice rats showed no difference. In both cases this would seem to indicate an active choice of not foraging in the rain, but a greater selection against this by rice rats. Once again the smaller size, in the house mice, metabolically dictates that less selectivity as to foraging times can exist. The significantly higher bank heights chosen by mice in 1973 may be associated with the higher average rainfall for 1972 from June through November (Append. I). The higher banks afford drier soil at the crest and better drainage. December 1971 rainfall is higher than December 1972, but as noted none of this month's rains came as 6 cm/24 hrs. The unmowed vegetation zones widths changed greatly from 1972 to 1973, but these values

for <u>Mus</u> did not. This indicates a great selection by this species for "constant" widths regardless of "average" choices. The rice rat, it is noted, does differ between years, but less significantly than the no catch (0.01 vs <0.001). This reduced discrimination when compared to the house mouse should be expected due to their heavy utilization of the "aquatic" environment, in particular the supportive emergent vegetation. The last two significant differences, noted in the no catch, are related since cattails (the prime reducer of water surface exposure) are one of the primary foods of nutria, and their consumption decreases water surface coverage. As seen, house mice and rice rats avoid these areas, but avoidance is strongest by rice rats (Table 13).

Table 15 shows significance levels for each of the three types of trap results for the pooled years, comparing the three regions of the study area. It was hoped that this approach, plus the use of correlation values for pooled years (Fig. 11, Append. III-VI), would help point out species differences regionally and that the inter-correlations would show variable relationships. The numerous sets of values in Table 15 tend to, when individually approached, discourage interpretation. Simply approached, comparison of the number of regional equalities for each of the 3 trap results, should be informative. For the rice rats 23/48 or (48%) equalities existed, for the house mice 20/48 (41%) and for the no catch stations only 11/48 (23%). This indicates a great deal of selectivity by the rice rats, and also the house mice, as to the variable consistency regardless of where they were caught. Regionally water depth, water width and ground cover were equal for the rice rats. In the house mice temperature, aquatic stage of succession and nutria activity were all equal. Of these variables all I think have been previously mentioned and discussed except

TABLE 15

Significance level of F values from ANOVA model II tests for combined January 1972, 1973 comparing three regions in study area for three possible trap results with separation at the 0.05 level using Newman-Keuls multiple range test.

	<u>Rice R</u>	at Stations	House Mouse Stations		No Catch Stations		
Habitat Variable	Signi. Level ANOVA Test	Newman-Keuls Multiple R. Test	Signi. Level ANOVA Test	Newman-Keuls Multiple R. Test	Signi. Level ANOVA Test	Newman-Keuls Multiple R. Test	
Cloud Cover	<0.0005	*A≠B_A≠C_B=C	<0.0005	Δ≠B Δ≠C B⊯C	< 0. 0005		
Precipitation	<0.0005	A≠B A=C B=C	0.01	$\Delta \neq B$ $\Delta = C$ $B = C$		AFB AFC B-C	
Temperature	0.01	A≠B.A=C.B=C	0.01	A=B.A=C.B=C	0.05	$A=B$ $A\neq C$ $B=C$	
Bank Height	0.005	$A=B$ $A\neq C$ $B\neq C$	< 0. 0005	A=R A=C R=C		AdB Adr Bdr	
Bank Length	0.005	$A \neq B$ $A \neq C$ $B \neq C$	< 0.0005	AZR AZC RZC		$A=B$ $A\neq C$ $B\neq C$	
Bank Angle	0.005	AZB A=C BZC	0.05	A#B.A=C.B=C	< 0.0005	AZB. A=C. BZC	
Water Depth		A=B, A=C, B=C	< 0.0005	A=B.A=C.B=C	0.01	A≠B.A≠C.B=C	
Water Width		A=B.A=C.B=C	<0.0005	A≠B.A≠C.B=C	< 0.0005	AZB.AZC.B=C	
Height Dom, Veg,	<0.0005	A≠B.A=C.B≠C	< 0.0005	A≠B.A=C.B≠C	< 0.0005	A≠B.A≠C.B≠C	
Ground Cover		A=B,A=C,B=C	0.05	A=B.A≠C.B≠C	< 0.0005	A≠B.A=C.B≠C	
Unmowed Veg.	<0.0005	A≠B.A≠C.B≠C	< 0.0005	A#B.A#C.B#C	<0.0005	A#B.A#C.B#C	
Dom. Veg. in Water	0.05	A=B.A≠C.B=C	0.01	A≠B.A≠C.B=C	<0.0005	A#B.A#C.B#C	
Water Sur. Cov.	0.005	A≠B.A=C.B≠C	< 0.0005	A≠B.A≠C.B≠C	<0.0005	A≠B A=C B≠C	
Terrestrial St.	<0.0005	A≠B A≠C.B≠C	<0.0005	A≠B.A≠C.B≠C	< 0.0005	A≠B.A≠C.B≠C	
Aquatic St.	0.05	A=B A≠C B=C		A=B.A=C.B=C	20.0005	A=B,A≠C,B≠C	
Nutria Activity	0.01	A≠B,A≠C,B=C		A=B,A=C,B=C	<0.0005	A≠B,A≠C,B≠C	
Summary		6=, 8=, 9=		5=, 6=, 9=		3=, 3=, 5=	
	Regions						
	*A= East dit	ch					
	B= West dit	ch					
	C= South di	tch					
	≠ -Signific	antly different					

the aquatic stage selection by mice. This may be an artifact in part caused by displacement by the rats from the later stages of aquatic vegetation succession. Of added interest is the fact that in the no catch, none of the variables were constant for all three regions.

The results of the intercorrelation analysis for the three trap results for the pooled two years are shown in Appendix III-V. As in all correlation matrices of this type, the top portion is a mirror image of the bottom part. A wide range of correlation values was obtained including both positive and negative values. A series of t tests, using Fisher's z transformation, were used to compare these intercorrelation values for the trap results. Appendix VI indicates the statistically significant differences at $P \leq 0.05$ level for these tests. These results are shown diagramatically in Figure 11, where the three pairs of comparison figures contain numbered rings representing the various variables. Interconnecting lines between variables indicate a significant difference in these two variables' correlations for the two trap conditions compared. Obviously variables having the largest number of lines radiating from them are the most important variables for separating the two trap responses examined. Rice rats when compared to no catch stations show the largest number of significant differences further indicating the rats high selectivity level. From Fig. 11 it can be noted that the four most important variables, in descending order of importance (= represents ties), for separating rice rat stations from no catch stations are: water width, bank height, height of dominant vegetation = temperature. For separating house mouse and no catch stations, the three most important variables are height of dominant vegetation, dominant vegetation in water = water depth. In all of these differentiating variables, except height of

Figure 11. Lines represent a significant difference, ≤0.05, in two habitat variables when comparing correlation values of the trap responses. Significance values determined using a t-test with a Fisher's transformation (See appendix 6).

Habitat Variable Codes

1.	Cloud Cover	6.	Bank Angle	12.	Com. Veg. in water
2.	Precip.	7.	Water Depth	13.	Water Sur. Cover
3.	Temp.	8.	Water Width	14.	Terrestrial St.
4.	Bank Ht.	9.	Ht. Dom. Veg.	15.	Aquatic St.
5.	Bank L5.	10.	Ground Cover	16.	Nutria Activity
		11.	Unmowed Veg.		





HOUSE MOUSE VS NO CATCH



RICE RAT VS NO CATCH



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dominant vegetation, no surprises are noted. This terrestial variable, as seen in Table 12, does vary quite widely between the two years for the rice rats and no catch, but house mice vary little. Rice rats are always the lowest for the year considered. The abundance of Johnson grass around the hatchery undoubtedly accounts for this selection, as has been indicated, this tall grass is very poorly used by rice rats as a source of food. Thus, perhaps due to variance, and sample size this variable appears significant only under conditions of pooling.

Oklahoma Outdoor Penned Population

In the July and September food available trapping, two of six (33%) and one of five (20%) of the animals respectively were trapped the first night. In the no food available trapping, in August and October, trapping results of four of five (80%) and four of eight (50%) respectively were obtained on the first night. Using a t-test with arcsine transformation, and testing at the 0.05 level, only the September (food available) and the August (no food) are statistically different from each other. This limited experiment I feel lends credulity to the idea that the trapability of rice rats is directly related to the available food. This is obviously of greater trapping significance when preferred foods - several exotherms, are available.

The nest survey in the pen produced four nests that were accessible for examination an average of five times each. At no time were any stored food articles present in the nests. Food hoarding by rice rats was studied under lab conditions by Dewsbury (1970) and Lanier, <u>et al</u>. (1974). In the former experiment rats would move food pellets from large cages into small nest jars. In the second experiment using seeds (corn and sunflower and a feeding runway for food placement) essentially no hoarding was

observed. The artificial nature of the 1st setup and the food, I feel negates the hoarding supposition for rice rats.

ACKNOWLEDGEMENTS

I wish to thank Dr. Charles C. Carpenter, my major professor and other committee members Drs. Keever Greer, Loren Hill and Victor Hutchinson for critically reviewing the manuscript. Thanks also go to my family (Emmalea, Richard, Marcia) for help in taking several of the field measurements and for animal care during my many trips necessitated by this research. Special thanks to my wife, Emmalea, for the many hours spent in typing and retyping this manuscript. Thanks also should go to the nearly 100 zoologists who responded to my questionaries concerning rice rat trapping records.

I wish to extend thanks also to Drs. Holmes, Noble, Sanders and Viers for help in field survey and plant identification work. Also to two students who helped with the illustrative work Cindy Cook and Robin Verett. Lastly thanks to Dr. Tom Burns for help in statistical work and especially to Dr. Gary Tubbs for help with the computer programs utilized. This study initially was made possible by a NSF Academic Year Extension Grant and aided by a 1972 Baldwin Study-Travel Award received from the University of Oklahoma.

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PAPER III

ASPECTS OF THE ETHOLOGY OF THE MARSH RICE RAT, ORYZOMYS PALUSTRIS TEXENSIS

ABSTRACT

Wild trapped rice rats (<u>Oryzomys palustris texensis</u>) were used in a study concerning aspects of social, ingestive, diving-swimming and shelter seeking behaviors with filming of selected parts of the first three categories. Males, in captivity, showed a straight line dominance hierarchy also noted among the females. Intersexual agonistic behavior varied as to the female's reproductive status from avoidance of all males to domination of all but the top male. No stationary submissive postures were observed. This solitary species, except for a short period in the winter, vanquish subordinant animals from their territories. Several foods, not previously noted for rice rats, were readily accepted by lab animals and several predatory bouts with crayfish were filmed. Diving and swimming behavior was recorded with entry angle and swimming form noted. Nest and burrow production was studied with five general categories of shelters observed in nature. Maintenance of ice holes for diving escape was noted in an outdoor penned population.

ASPECTS OF THE ETHOLOGY OF THE MARSH RICE RAT, ORYZOMYS PALUSTRIS TEXENSIS

DICK T. STALLING

Much of the early behavioral work with rodents involved select representatives of the lab reared Muridae and the diurnal Sciuridae. In recent years, increasing amounts of behavioral work on small nocturnal rodents has been published. A few outstanding examples include John King and his student's numerous publications on various species of the genus <u>Peromyscus</u>, John Eisenberg's work with <u>Peromyscus sp</u>. and heteromyid rodents, and Donald Dewberry's descriptions of reproductive beh**avior** in small rodents.

Behavioral work on <u>Oryzomys palustris</u>, with few exceptions, is nonexistent probably in part due to its geographic distribution, and trapping difficulties during large portions of the year (Stalling, 1977a). Harper (1927), and Hamilton (1946) discussed in very general terms the animal's field behavior. Svihla (1931), and Worth (1950) briefly discussed aspects of the life history and cage behavior, the latter, stating on the basis of observed behavior, that this species was not suitable as an all-purpose laboratory animal. Shaw (1969), however, by monogamous mating at time of weaning, overcame many of Worth's objections to the species' behavior and rice rats are now used by several schools in research on periodontal diseases (Rosen <u>et al.</u>, 1973).

Harris (1953), Negus, <u>et al</u>. (1961) and Sharp (1967) mentioned having made certain behavioral observations noted incidental to their studies. Dewsbury (1970) discussed copulatory behavior in which estrogen primed females were used.

My behavioral study on this species concentrated on aspects of three main behavioral categories: 1) shelter seeking and escape, 2) social interactions, and 3) predatory - ingestive behavior. Due to their nocturnal nature and the density of the vegetation in the natural habitat, most observations were limited to lab observation cages and pens. Some information, however, was obtained from a large "natural" outdoor pen and from field observations.

METHODS AND MATERIALS

All animals used in this study were trapped in Natchitoches Parish, Louisiana between January 1968 - January 1973, using Sherman live traps. Rats were numbered by toe clipping following Baumgartner (1940), removing no more than one front and one back toe per animal. Captured animals were housed individually during holding periods, in cages no smaller than 9 cubic cm. Hardware cloth cage bottoms facilitated cleaning, with paper toweling serving as nesting material. Only adult wild trapped animals were used that had been in captivity at least 4 weeks. Lab raised juveniles were used only to test adult aggressive response to immature animals. The <u>ad lib</u>. diet consisted of equal portions of Purina Lab Chow and Purina Dog Chow, supplemented on an irregular basis with vegetable and fruit peelings as well as dead fish and crayfish. Each cage was provided with a nozzled water bottle. For purposes of identification, animals were fur dye marked using Nyanzol D amino dye.

Observations of individual and social behavior of lab animals were made initially using 40 X 100 X 70 cm glass fronted observation boxes. The boxes contained a 10 cm deep layer of soil and a 30 cm diameter water filled plastic face pan buried to its brim. Another variety of observation container, available for only one month, was a hardware cloth cage 96 X 108 X 120 cm with a 21 cm deep soil substrate and a 110 X 45 X 19 cm pool. Living cattails, containing 2 nests of red-winged blackbird (<u>Angelaius</u>

phoeniceus), were placed in the pool to encourage nest building activity.

Three varieties of indoor pens, with sheet metal sides, a 15 cm deep soil substrate and both approximately 20 m² in size, were used for observation of social behavior where more than two animals were involved. These pens contained a pool (45 X 90 cm) with a water depth of 10 cm and the pool was stocked with 15 shiners (Notropis sp.) twice during the study.

A naturally vegetated outdoor pen 13.7 X 18.3 m with 1.8 m high galvanized metal sides was utilized in 1972 during the late summer, fall and early winter at the University of Oklahoma's Animal Behavior Lab in Norman, Oklahoma. The sides were sunk 0.3 m below the surface to block tunneling and a 0.5 m wide mowed swath inside the pen was maintained to further discourage escape attempts. A 1.2 m wide tier of poultry wire was added to the top of the sides to inhibit pen access by cats. A 0.4 m deep pool 1 X 1.6 m was dug at the pen center and was maintained at a constant level by an enclosed float valve connected by underground hose to an outside reservoir. Soil from pool site formed 2 banks at opposite pool ends both 0.3 m high, 1.6 m long and 0.5 m wide.

Vegetation in the pen was a natural mixed growth of western ragweed, goldenrod, Indian grass and Japanese chess. Transplanted around the pool were eight clumps of vegetation including cat-tails, arrowhead and threesquare bulrush. A 4.3 X 3.7 m poultry wire covered frame was supported on 2.4 m high posts, over the pool to protect animals from aerial predators. Commercial food, the same as the lab population received, was provided in 2 sheltered food trays placed on opposite sides of the pool 1 m from the water's edge. An observation walkway 2 m high was built immediately north of the pool and was mounted via a ladder outside the pen. On 19 July 1972, 3 adult males and 3 adult non-pregnant females, captured in Louisiana 8

weeks earlier and randomly selected, were released at 2200 hours. Prior to release, and every two months thereafter, the animal's fur was dye marked. The pen was surveyed every two weeks during the day to locate and describe nests and burrows. Occupancy of burrows was determined twice during December using a Barnes Infra-Red Field Thermometer.

Illumination for initial work employed red bulbs, with diving and predatory work lighted by low wattage white bulbs. No attempt was made to change the animals' natural rhythm, thus all observations were made at night. Selected behavioral sequences were filmed in the lab using either a 16 nm Bolex H-16 reflex movie camera equipped with a Pan Cinor 85 nm zoom lens or the Animal Behavior Lab's closed circuit television camera with video tape recorder. Film used in the initial work was black and white infra-red, but in later work Plus-X was used. Film and tape analysis procedures varied with data recorded and methods are indicated when recorded behavior is discussed. During the study several types of canvas and cardboard blinds were used.

For the diving experiments a fifty gallon aquarium was used in which water was maintained at a depth of 22 cm. The top of the aquarium was fitted with a hardware cloth skirt 27 cm high and it in turn had a fitted hardware cloth top. Unpainted wooden diving platforms 14 X 46 cm were attached at both ends of the aquarium top. Access to these platforms by swimming animals, was possible only via a four cm wide hardware cloth ladder which entered the water. Solitary animals were placed in the apparatus, via side doors, five minutes before they were used. Following this "adjustment" period animals were encouraged to dive by noise or by blowing on them. Dives were recorded on 16 mm Plus X film or on video tape.

The 50-gallon aquarium used for the crayfish predation studies were covered with a framed hardware cloth top and contained a sand substrate, 1-2 inches deep, which sloped from the back to the front. Single rice rats were placed in the aquaria 24 hours before use and were given access to only a petri dish of water. The adult rats, five males and five females, were used for a total of 30 crayfish encounters. The crayfish, (Procambarus acutus) and (Orconectes palmeri), ranged in size from 7.5 -48.3 grams and were obtained from the South Canadian River shortly before initial use. The approximately 60 animals were held in the lab in a concrete stock tank with a sand bottom and regularly fed pieces of frozen frog. The selected crayfish was removed from the tank, weighed and placed in the rat's aquarium. If after 20 minutes no attempt to attack occurred it was visually recorded and following the death of the crayfish the rat was allowed to consume the crustacean if no more bouts were desired. If more bouts were desired the crayfish was removed, the rat allowed a 10 minute rest, and then was run again. Observation of crayfish consumption to the rat's satiation was observed on four occasions.

RESULTS AND DISCUSSION

Nest and Burrow Types -

In rodents numerous environmental as well as physiological and genetic factors influence nest size and consistency. These factors may also influence burrowing with its various features. Kinder (1927) and others have shown that nest size in lab rats varies in response to experimentally induced ambient temperature changes. Richter (1941) and Lehrman (1961) have shown effects on nest size in relation to hormonal changes. King, et al. (1964) showed that experimentally, within a species group of Peromyscus, under constant temperatures, the northern forms used more nesting material than the southern forms thus noting the effect of genetic variation on nest building. Similar results were shown by Layne (1969) for three species of Peromyscus. Limited burrowing occurs in Hesperomyini tribe of the Cricetidae rodents, of which Oryzomys is a member genus with 51 other New World genera (Arata, 1967). Exceptions to this include some woodrats (Neotoma sp.) and a few species like the oldfield mouse (Peromyscus polionotus) which regularly excavates burrows and nest chambers in the sandy soils of southeastern U. S. (Hayne, 1936). King, et al. (1968) in lab tests on seven species of Peromyscus suggested that the propensity to dig sand is related to the habitat occupied by the species.

Cahalane (1947) felt that <u>O. palustris</u>, if the ground was dry, the animals built a ground nest or used a shallow burrow, but in a marsh

or on a tidal flat their nests were suspended up in some type of vegetation. The nests of O. palustris have been observed by several authors under several different natural situations, but they can be lumped into five basic categories: surface nests; independently woven nests suspended in vegetation; as modifications of, or adjuncts to, other species' abandoned nests (houses); nests in shallow burrows in a bank. Surface nests on the soil have been reported by Goldman (1918), Svihla (1931), Cahalane (1947), Hoffmeister and Mohr (1957), Schwartz and Schwartz (1959), Davis (1966), Lowery (1974), and in logs or the top of covered fence posts - Hoffmeister and Mohr (1957). Independently woven nests suspended in vegetation have been noted by: Audubon and Bachman (1851-4), Goldman (1918), Harper (1927), Svihla (1931), Moore (1946), Hamilton (1946), Cahalane (1947), Goodpaster and Hoffmeister (1952), Ivey (1959), Kale (1961), Sharp (1967) and Lowery (1974). Other animals' abandoned nests (houses) used by O. palustris have been noted for: marsh wren - Kale (1961), Sharp (1967); Virginia rail -Ulmer (1951); blackbirds - Davis (1966); the round-tailed muskrat - Harper (1920), Schwartz (1952), Porter (1953), Birkenholz (1963); and the muskrat -Stone (1898), Rhodes (1902), Ulmer (1944) and Harris (1953). Nests in shallow burrows under surface objects have been noted for several materials: under massed vegetation - Goldman (1918), Goodpaster and Hoffmeister (1952); Schwartz and Schwartz (1959) and Ivey (1959). Nests at the end of short tunnels in banks have been reported by Audubon and Bachman (1851-4), Cahalane (1947), and Davis (1966).

Searching for rice rat nests and burrows in the field occurred several times in the animal supply areas, but the areas used for an ecology study (Stalling 1977a) were intentionally not disturbed. However, several nests up in vegetation were incidentally seen and visually examined in this

last area. Of the five basic types of nests, seven surface nests, five independently woven suspended nests, nine remodeled nests of other species (one long-billed marsh wren (<u>Telmatodytes palustris</u>) and eight red-winged blackbird nests) and, 14 shallow surface burrows with no organized nest at their ends were found by the author in the field. Nests not occupied by a rat when initially examined, were checked for hair to verify occupancy by rice rats and the hair identified with acetate peels.

All surface nests found were constructed from the dominant vegetation in the area, typically sedges i.e. (Fig 1-A3) square-stem spikerush (Eleocharis quadrangulata) or a grass i.e. (Fig. 1-A2) Bermuda grass (Cynodon dactylon) and externally averaged 12 cm long and 10 cm in width. The main entrance usually was obvious at the initial sighting of the nest, but in occupied nests it was partially closed. Typically an obvious trail ran to this entrance with an indistinct one running to the rear entrance on the opposite side of the nest. This nest size is considerably smaller than the 12-18 inch diameter nests mentioned by Schwartz and Schwartz (1959), but perhaps is attributable to the more northern climate in Missouri. An internal cavity, averaging 8 x 6 cm in size, was lined with finely shredded leaves and stems of the same plant species used in the external construction. These nests were typically set in a shallow depression (pit) which had an average diameter of 8 cm and depth of 3 cm also with slight depressions at the afore mentioned entrances. In the literature, this nest pit has been mentioned only by Lowery (1974). In captive animals this "pit nest" was the type constructed when no cattails or redwing nests were available and loose nesting material was relatively abundant. No observable differences were noted between lab and wild constructed nests of this type.

Figure 1. Rice rat nests and feeding platform found in nature:

- A. 1. suspended nest of cat-tails.
 - 2. pit nest of Bermuda grass.
 - 3. pit nest of square-stem spikerush.
- B. feeding platform in and consisting of barn-yard grass.
- C. suspended nest in and consisting of barn-yard grass.

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Independently woven and suspended nests were only found in barnyard grass (Echinochloa crusgalli) (Fig 1-C), cat-tail (Typha latifolia) (Fig 1-A) and in the sedge Scirpus cyperinus. All nests were constructed from the supporting vegetation. These nests were basically the same size as the "pit nests" if the loosely woven outer restraining strands were removed with the leaves they were woven around. Internal size and the shredded nature of the nest lining was essentially the same as previously noted for the "pit nests". The size of this type of nest, mentioned in the literature, varies considerably with Audubon and Bachman (1851-4) 1-3 inches (2.5-7.6 cm) by 5-6 inches (12.7-15.2 cm), Harper (1927) 6 inches (15.2 cm) by 12-18 inches (30.5-45.7 cm), Hamilton (1946) "grapefruit sized", Ivey (1959) 4-5 inches, (10.2-12.7 cm) and Schwartz and Schwartz (1959) 12-18 inches. Latitude and the size of the builder were felt to be the prime contributing factors. Height of the nests above water when they were found by the author varied from 0.5 to 1.8 m. Height of these nests noted in the literature included: Harper (1927) 6-12 inches (15.2-30.5 cm), Ivey (1959) 2 feet (61 cm), Sharp (1967) 1 meter or more and Lowery (1975) a few feet. Height of nest apparently depends partly on vegetation type, but primarily on susceptability of the area to flooding. The highest nests the author found were in cat-tails in a drainage ditch subject to great fluctuations in water depth. This type of nest was produced only once under lab conditions following the only use of live cattails in a behavior pen and was also noted once in the outdoor pen stocked with cat-tails.

All but one of the modified nests were of red-winged blackbirds. The exception was that of a marsh wren, (Fig 2B). Its occupancy by $\underline{0}$.

Figure 2. Modified rice rat nests found in nature:

- A. in red-wing nest, suspended in cat-tails and rat nest of shredded cat-tails.
- B. an unmodified long-billed marsh wren nest in cat-tails.
- C. in an old red-wing nest, suspended in baccharis.



palustris had apparently been recent due to the excellent condition of the nest and the green cat-tails into which the nest was woven. Inside the nest no modification was apparent and hair was the only evidence that rice rats had been present. Perhaps the birds were victims of rat predation as Kale (1965) had shown rice rats to be significant predators on the long-billed marsh wren nestlings. Of the red-wing nests modified, two were in woody plants, one each in elderberry (Sambucus canadensis) and baccharis (Baccharis salicina) (Fig 2C). The latter red-wing nest appeared to be from the previous season and in its disintegration dropped away from the rat's nest. Nests that were attached to living cat-tail leaves (Fig 2A) obviously were nests that the birds had made during the same season and brood predation by rats was strongly suspected. The only other herbaceous plant found with this nest type in it was the goldenrod (Solidago altissima) where plants were woven into the red-wing nest. The rat produced portion of these nests, in size and appearance, looked identical to the pit nests except that only one entrance was used and they were essentially spherical. Red-wing nests were, on three occasions, placed in a pen with rice rats and both times they were modified for their occupancy. Similarly modified bird nests have also been reported for the deer mouse, Peromyscus maniculatus (Schwartz and Schwartz, 1959) and for the golden mouse Ochrotomys nuttalli (Goodpaster and Hoffmeister, 1954).

It isn't known how many nests an individual rat naturally has in its territory. An adult male rat left for 10 days alone in the hardware cloth behavior pen with living cattails, loose dry bermuda grass and two red-winged blackbird nests produced three "pit nests", one self woven suspended nest, and modified both red-wing nests for occupancy during this period.

Feeding platforms constructed by rats consisted of criss crossed leaf blades and stems stacked on the floor of a marshy area, and have been noted in Hamilton (1946), Goodpaster and Hoffmeister (1952), Hoffmeister and Mohr (1957), Schwartz and Schwartz (1959) and Paradiso (1969). These platforms allow feeding to occur out of the water and remains of food items have commonly been found littering them. Only four feeding platforms (Fig 1-B) were found during this study, with mean width 18 cm. The scarcity was believed due to the narrow width of the water in most areas trapped, thus banks were usually readily accessible. All four platforms were found in areas where ditches surveyed were wide, shallow and choked with vegetation or were found on the shore of a pond that had considerable fluctuations in water level. No platforms were constructed by captive animals.

In the lab, removal of all or nearly all nesting material from the behavior cage initiated construction of protective burrows. These Ushaped burrows consisted of two 3 cm diameter holes, 17 cm apart which dropped nearly vertically to a depth of 6 cm where they were joined by a horizontal tunnel. Burrows were also dug under corners of bricks, boards or similar objects lying on the soil surface of the pen. Burrows produced, when the animal had sufficient nesting materials, were typically 3 cm in diameter and usually consisted of a hole dug straight down or at a slight angle for 3-12 cm. Burrows of this type were frequently constructed with one side against the side of the pool or against the side of the cage. Tunnel construction into nests was noted on four occasions. The tunnel entrance was placed an average of 14 cm from the pit nest and went down at an 80° angle to a depth of 8 cm, then slightly upwards towards the nest, entering it at the bottom. Trenching, which may have

represented collapsed burrows in solitary caged animals, was noted to occur on several occasions. Trenches averaged 3 cm wide and were 3-6 cm deep. Trench length varied from 10-40 cm being highly variable.

In the field, several burrows were found in the banks and five casts were taken with plaster of Paris. Some were quite short (Fig. 3A), yet the longest was over 25 cm in length. All lacked an organized nest at their terminus.

Burrow production in the outdoor Oklahoma pen was first noted in mid October. Some burrows were quite shallow, similar to those noted previously in the field, but others were probed to a depth of 10 cm. The deeper burrows had well worn paths to them. Access to an infrared gun the last of December for 2 days showed occupancy of only 2 burrows at this time with the majority of rats in nests. Prior to this time, weather had been relatively mild with little snow. Starting January 5th temperatures didn't rise above freezing for 8 days and over 6 inches of snow fell during this period. This cold weather is felt to have caused increased burrow enlarging and an infrared survey at the end of January showed no nest occupancy. Three burrows were occupied with two showing considerable heat loss to the extent of melting the snow at their entrances. February 8th the rats were removed from the pen, due to flooding, and not returned. All burrows were poured with plaster of Paris, dug up when hardened with the largest and most complex one seen in Fig. 3B. It was located near the top of the north bank with the two entrances on the right on the south side and the single opening near the ridge of the bank. This burrow is thought to have been occupied by three or four animals while two were the maximum in the other two occupied burrows. One occupied burrow was U-shaped with both south facing entrances 4 cm apart

Figure 3. Rice rat burrows from outdoor behavior pen:

A. simple one rat burrows.

B. communal burrow complex.



and had a maximum depth of 12 cm. The other burrow, north facing, was essentially straight (19 cm), but angled upward from the middle, off 15⁰ from the horizontal. This upward angle, as well as high spots noted in other tunnels poured here, may serve as heat traps. No organized nest was found in any of the burrow casts poured, but pieces of cut grass were present in the casts and apparently formed a thin floor covering.

The thermal advantage of winter communal nesting is obvious, especially then insulating nesting material is used to only a very limited extent and burrows are not plugged. Winter occupation of nests by more than one rice rat has been reported by Birkenholz (1963) and Cahalane (1967). Under lab conditions, increased tolerance between dominant and subordinant animals has been noted during the non-breeding seasons as well as decreased resistance to handling. This diminished aggression is obviously essential if, thermally, communal nesting is to be successful.

Diving and Swimming

The ability of most terrestrial mammals to swim has been noted for years, but most are hesitant to enter the water. Field records of observed entrance of North American cricetid rodents into water is quite sparce, but has been noted by Orr (1933) for the deer mouse (<u>Peromyscus maniculatus</u>), Teeters (1946) the white-footed mouse (<u>P. leucopus</u>), and Blair (1939) the meadow vole (<u>Microtus pennsylvanicus</u>) when pursued by predators or other mice. Sheppe (1965) showed, from trapping and experimental work, the dispersal of <u>P. leucopus</u> over water spaces of nearly 800 feet width. King <u>et al.</u> (1968) experimentally compared ease of water entry from a wire platform for 7 species of <u>Peromyscus</u>. Numerous papers reporting field activity in rice rats have noted no hesitancy of this species to enter the water by diving and to escape by swimming under water. Stalling (1977a)

noted that over 55% of recaptured rice rats had crossed a 3 m wide water filled ditch between captures and that upon release the majority of the rats headed directly for the water.

Using the previously described diving setup 6 animals, all males, made several dives, 28 of which were properly recorded with 16 mm plus X-Kodak film and with a closed circuit TV camera on video tape. Angle of water entry, from the film, was determined with a Vanguard Motion Analyzer, and from the TV screen with a personally constructed inclinometer (Stalling 1977a). Mean angle of entry with standard error, from the horizontal was 51.1° + 1.1°. Several other dives were recorded, but discarded if the animal appeared to have slipped, was out of focus or the person initiating the dive, partially blocked the view. The body form and entry angle (Fig. 4) was drawn from 16 mm film frames. This form and engle is felt to be a compromise to assure ease of surface penetration, yet also attain a shallow dive. Most dives were initiated by a slight jump upward and out before the downward orientation preparatory to water entry. Time spent under water varied from 1 to 10 seconds with times longer than 2 seconds accompanied by vigorous underwater swimming. Submersion time seemed to vary inversely with the time the animal had been exposed to the experimental conditions.

Swimming propulsion was accomplished solely with the hind feet, the forefeet were tucked under the shoulders and the tail trailed limply behind in most cases. In a few instances the tail appeared to be used in a minor sculling fashion, similar to that reported for <u>Peromyscus sp</u>. by King (1968).

No attempts were made to determine maximal durations for dives or maximal distances for swimming under water. Several authors have noted this animal's swimming ability including Hamilton (1946) who stated that "rice rats are accomplished swimmers and when alarmed, they dive and swim

Figure 4. Body form and typical angle of entry for diving rice rat. drawn from 16 mm film.



under the water for a great distance". This distance underwater has been overestimated many times by the casual observer due to the animal coming up a short distance away from the entrance point, amid thick vegetation. The author has noted this "attraction to vegetation" on several occasions when trapped animals were released near water and they were carefully observed following their dive. During hand capturing of rats in the rain flooded outdoor pen, one pursued animal was noted to swim underwater for over 12 meters before it surfaced. In early December, 1972 the pool in the outdoor pen froze and remained frozen for approximately one week. During this time four ice holes, 4 cm in diameter were kept open by the animals. Three animals frightened out of their nests in the daytime dove in the holes, swam under the ice and surfaced on the other side through another hole. One animal was frightened from exiting immediately from under the ice and was twice noted to "nose up" into bubbles trapped under the ice apparently breathing there before diving again.

Ingestive Behavior

The natural diet of <u>0</u>. <u>palustris</u> has long been questioned with the extremes being: Davis (1966) indicating "chiefly green vegetation" and Sharp (1962) stating "almost exclusively on insects and small crabs". The extensive studies of Negus, <u>et al.</u> (1961) and Carlton (1958) have shown from kill trap studies that the diet varies widely throughout the year with high percentages of animal material in warmer months and replacement with plant material in cooler months. Negus, <u>et al.</u> (1961) indicated 76% animal material for August in his Brenton Island population, but only 14% in December. With more northern populations animal material in the winter diet would be expected to be even lower. Locally diets vary greatly as to

the most abundantly available foods, e.g. the rats in Carlton's Mississippi study had a yearly diet that was 74% rice in consistency.

Landry (1970) listed nine references which cited animal material in <u>0</u>. <u>palustris</u> diet. These included in part: insect larvae, snails, fish, crabs, spiders, adult insects, dead fish, mouse and muskrat careases and trap cannibalism. Food not mentioned above has been in other references as follows: five species of baby turtles (Goodpaster and Hoffmeister, 1952) and marsh wren nestlings and eggs (Kale, 1961). Vegetative foods reported in non-captive individuals include: marsh grass and sunflower seeds (Sharp, 1962), marsh grass and glasswort stems (Hamilton, 1946), rice seeds, gamma grass and wild rye (Audubon and Bachman, 1846), plant seeds, nuts and grain (Bailey, 1946), little barley, wild pea, Johnson grass, rescue-grass, vetch, yellow dock, cranesbill, and henbit (Carlton, 1958), seeds of sedges, marsh grasses, and rice (Davis, 1966).

No concerted effort to determine new types of foods that rice rats would consume was undertaken, but from personal observations additional plant and animal materials eaten included: live and dead crayfish, dead fish, live minnows, June beetles, live house mice, dead grass, frogs, earthworms, leaf hoppers, carrots, lettuce, cabbage, apple peelings, pecans, foxtail and corn seeds.

In the behavior cages, grass seeds or tiny flying insects that fell or were placed on the pool surface were obtained by the animals placing their forepaws in the water, at the surface, and agitating the water towards themselves in a gathering type movement. Several dozen live May beetles, genus <u>Phyllophaga</u>, were released singly to solitary rats with capture and consumption of the insects shortly following cage release. On other occasions rats were observed to capture these species and other

insects, attracted by the observation lights, that flew into their cages. Such insect sightings caused greatly increased activity and active pursuit. Insects dropped into the pool were obtained by swimming to them if they could not be reached from the side. Beetles were always captured by gresping them in the mouth, using the forepaws as an aid in pinning them. Beetles were eaten head first with the dorsal side pointing anteriorly. In two instances heads were observed to be cut off first, dropped and after consumption of the remaining insect, the head was then consumed. In the majority of the observations both sets of wings were discarded.

No inter-specific small mammal encounters were staged, but rice rats were kept in a room which was infested with a sizable house mouse (<u>Mus musculus</u>) population. On more than a dozen occasions, during the period of room use, mouse pelts with only the feet and leg bones attached were found in the rat cages. Apparently the mice had entered the cage from the refuse tray beneath the cages through the $\frac{1}{2}$ " mesh hardware cloth floor. Commercial rat food was available <u>ad lib</u>. to the rats, thus if the <u>Mus</u> killing was purely a territorial response one wouldn't expect complete consumption. Ruffer (1968) noted inter-specific killing and consumption of other small mammals by the northern grasshopper mouse <u>Onychomys</u> <u>leucogaster</u>).

The male rats used in the crayfish predation studies had an average weight of 72.3 g, the females 50.1 g. No female attacked or killed a crayfish over 16 g, while most males were hesitant at taking those over 30 g,but one male did after a ten minute bout kill a 48 g animal. The initial contact by rats with the smaller crayfish involved biting an extended cheleped while avoiding the other one. Typically the rat would pull vigorously and in two cases was able momentarily to flip the crayfish

over. Forceful pulls on the antennae using the forepaws were seen 3 times and filmed twice. In these crayfish, cheleped biting lasted only a few seconds with the rat moving in between them, holding them down with its forepaws, while viciously biting the rostrum area of the cephalothorax (Fig 5). The rat might stop biting to reorient the body, if the crayfish was thrashing or to make more bites at the chelepeds. Immobilization of the prey typically followed a few seconds of this head biting. In the large crayfish, the size and strength of the chelepeds kept the rats from holding them down, thus several minutes of the initial attack were solely directed towards dispatching these claws. Deep powerful bites were delivered to the heavy parts of the claw (Fig 6) in the encounter, bites were of short duration necessitated by the rat's rapid moves to avoid the other cheleped. As the minutes passed, the crayfish defense weakened and longer harder bites were possible. After an average of about 8 minutes the rat was able to dart in for a rostral bite and by 10 minutes the prey offered no resistance to the final rostral (brain?) bites. The smaller crayfish typically ended up on their backs and the rats usually entered the body cavity in the cephalathorax region. Entrance was made by removal of small pieces of exoskeleton after the walking legs had been disjointed at their base. Following consumption of the viscera, the ventral side of the abdomen was similary opened. If the crayfish were left with the rat for a day or more the various segments of the appendages were opened and their contents consumed. Upright dead crayfish fish were also opened initially in the cephalothorax.

The minnows stocked in the pools disappeared at a rate of 1 to 2 each night. Numerous attempts by rats to grasp fish from the pool with their front paws and teeth were observed, but no captures were seen. Prior

Figure 5. Rostral bite by rice rat to small crayfish while holding down its chelepeds. Drawn from 16 mm film.



Figure 6. Cheleped bites by rice rat in initial stage of large crayfish predation. Drawn from 16 mm film.



to their attempts, the rats solitarily sat on the pond edge for several minutes, looking down intently before making a lunge at a minnow the author was unable to see due to surface reflection.

Social Interactions

Over 240 hours of "rat watching", not including diving and crayfish predation, were logged using the behavior cages and pens previously described. Initially solitary males and females were observed, to become acquainted with this species' general behavior. The social interactions were divided up into four categories consisting of: a single male and a single female, two or more males, mother and young plus one or more adults and, more than two adults including at least one of each sex. These will be discussed as male-female, male-male, female-female and adult-juvenile interactions.

In the male and female interactions, the majority were carried out in the small behavior cages by temporarily placing the two animals together for periods of ½ to 1½ hours. Over 122 hours of these two animal interactions were observed. Various approaches to negate the natural antagonism included the introduction of a male to the cage of a resident female, visa versa, housing the female in small cage in the resident male's cage during the day and releasing for nightly observations, taking vaginal smears in an attempt to correlate introduction time with estrus, and placing animals together during pre-0600 hours. During these observations only one pair of animals was observed to copulate and they cycled three times within 30 minutes before the female stopped the series with her vegorous objection to further contact. The copulatory observations and termination of the session agrees with Dewberry's (1970) observations on this species using hormone primed females. The various pre-copulatory

behavioral categories of Dewberry, noted for both males and females, were seen numerous times by the author but only in the afore mentioned pair did it terminate in copulation. A courtship movement noted in most sequences observed, that was not noted by Dewberry, was "tail presentation" by the males. As the male's excitement grew he stopped his head-on feigning and bobbing at the female and turned his back to her and laid his tail in front of her. This typically caused the female to start sniffing the air in his direction, frequently stretching towards him. The male remained turned for only 1-2 seconds and then turned rapidly and renewed his face to free encounter with the female. Cornered females, in a sitting position, that were having gentalia, abdomen or flanks examined by the male were frequently noted to kick out at him with one or both feet. This kicking was not noted by Dewberry (1970), and is perhaps unique to non-receptive females.

Females introduced into a resident male's cage typically first entered the male's nest, and on four occasions while he was occupying it. The female's loud squeeking resulted in the male's leaving in 3-5 seconds. This pirated nest was a safe haven for about one hour; during this time she might leave and enter the nest at will, but was not forced from it by the male. As time passed the male increased his motor activity, running up to the nest to force his nose in, only to withdraw it upon hearing the female squeek or having her lunge at him. Following a few minutes of this activity most males charged the nest forcing the female out and usually severely damaging the nest. The male then typically, vigorously and aggressively chased the female, with my removal of her appearing desirable for her safety.

In all intersexual encounters observed, the female squeeked loudly

and frequently when pursued by the male, especially when physical contact was made. This was opposite to the silence noted in subordinate males, regardless of the intensity of pursuit by dominant animals. Tail "rattling" was also seen on four occasions in females that were cornered by males.

In one large indoor pen, a population of three adult males and one female was established on 4 March, 1969. Initially, as has been noted for the small behavioral cages, the female took a non-aggressive role, but chose the dominant male as a burrow mate. On 1 April the female became increasingly aggressive dominating both lower males and even attempting to dominate the top male with lunges that he returned and which put her to flight. The dominant male had been excluded from the burrow in late March and on 2 April the most subordinate male was found dead in the pen followed 2 days later by the other subordinate. The bodies both showed numerous back and tail bites with the first animal having much of the cranial contents, legs and thorax consumed. Quantity of food was not felt to be a prime factor as both varieties of commercial food were available.

Male-male interactions were observed under the last three interaction categories, with over 18 hours carried out involving males only in the arena. Initial contact between strange males always resulted in a very short 1-2 second fight with the winner, typically the resident animal chasing the intruder around the pen. The chase stopped when the intruder was temporarily lost to view or something momentarily caught the dominant animal's attention. On only one occasion were stationary dominant and subordinate body postures observed, when both the pursurer and pursued froze during a chase, when I clapped my hands. These positions were recorded on 16 mm film. On four occasions, introduced males became dominant over the

resident males following the initial contact and in all instances outweighed the resident animal.

Four male animals were introduced into an inside pen on 1 October, 1972, and a straight line hierarchy was established within ten minutes. Four concrete blocks placed on their sides in the pen served as nest areas, with blocks occupied by each animal determined every other morning. Ten hours following their introduction the most subordinate animal was found dead from numerous bites to the head, neck and back areas. No consumption of the body was evident. Fifteen days after the preceeding death, the most subordinate animal remaining was also found dying in the pen. Autopsy revealed several nearly healed bites on the back, but the lower small intestine was empty and a great deal of intestinal and mesenteric inflammation was noted. The two remaining animals continued to nest separately while frequent switching to other blocks and trading blocks between the recording days. On 21 Dec., 1972, these two were first found in the same nest and until the pen was cleaned out on 28 Feb., 1973, they were found in the same nest on every recording day but at least eight block changes occurred in this interval.

Female-female interactions were observed under the last two categories with only two hours of observations carried out involving females only in the arena. In general the females responded to each other, in a manner similar to the male-male aggressive interaction, but less violently, never-the-less establishing a dominant-subordinate relationship. One bout, observed and filmed for twelve minutes, involved an introduced female and the resident female. The introduced animal with young, became second only to the dominant male following her family introduction to a pen containing two adult males and the one adult female. Eighteen days later

the young were removed and five days following this, the bout occurred between the two females resulting in the resident female becoming dominant. Noted and filmed, during this contest, were numerous lateral confrontations exposing the lighter ventrum to the opponent (Fig 7). Contacts were typically made with both contestants on their rear legs lunging at each other and pulling the head back after initial contact. This resulted in movements somewhat resembling a bucking horse.

In the adult-juvenile interactions, no attempt to follow early maternal and young behavioral development was undertaken with the three litters born in captivity. Observations were made on relationships between half grown (+10 gms) young, the mother, and with other adults as part of a total population of animals. Between mother and young, nasonasal encounters were noted several times and apparently resulted in mutual recognition. Young were also noted to bite a food cube in their mother's mouth and "take" it away from her. Non-related adults, typically appeared to regard the young as objects of curosity and would follow them for short distances attempting to examine them. With contact the young typically squeeked strongly causing the adult to stop contact and frequently to jump back. As the animals matured adult aggression was noted to increase with increased flight activity by the young.

The majority of the social behavioral characteristics noted in $\underline{0}$. <u>palustris</u> have previously been reported in one or more species of <u>Peromyscus</u>. Examples include Nicholson (1941) and Eisenberg (1963) noting that in <u>P. leucopus and P. crinitus</u>, respectively, a dispersed social organization, high male-male antagonism and separate nesting of females with young existed. They also noted that adult social groupings were probably confined to brief intersexual pairings during the breeding season. The

Figure 7. Lateral and ventrum exposure by two fighting female rice rats.

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brief fights which typically occurred in the male-male rice rat encounters followed by a chase-flight sequence was also observed in these two <u>Peromyscus</u> species. More specifically Eisenberg (1962) noted in <u>P. californicus</u> and <u>P. eremicus</u> a fighting technique called the Jumping Avoidance which adequately describes the behavior seen in rice rats. He also noted in 4 species of <u>Peromyscus</u> that the chase frequently involved small leaps, with the pursuing animal delivering tail and rump bites to the subordinate as I observed in <u>O. palustris</u>. In populations of <u>P</u>. <u>maniculatus</u> and <u>P. crinitus</u>, confined for a week, Eisenberg (1963) noted persistent male-male aggression with rump and tail bites frequent enough that some males lost up to one-half their tails. This persistent initial aggression in confined populations of <u>O. palustris</u> also resulted in considerable tail and back injury. Sexual aggressive differences has been reported for <u>Peromyscus</u> with Eisenberg (1962) noting higher aggressiveness in males during breeding season than at other times.

Balph and Stokes, 1960, Sadleir, 1965 and Healey, 1967 reported for <u>Peromyscus</u>, as I have noted in <u>Oryzomys</u>, that individual recognition establishment among males results in a stable rank order establishment. In the non-parturient female <u>Peromyscus</u>, Eisenberg (1968) also noted that they are more prone to tolerate contact or show defensive patterns of behavior. King (1958) noted that the <u>Peromyscus</u> female nest defense increases strongly in the first week following birth, but wanes during the remainder of the rearing phase. The presexual grooming noted by Eisenberg (1968) in <u>Peromyscus</u> was also noted in <u>O. palustris</u>.

Eisenberg (1968) noted that <u>Peromyscus</u>, unlike the Microtine rodents, does not construct pathways, but seeks out routes among the relatively clear areas around stem bases and twigs. This was also noted for <u>O</u>. <u>palustris</u> and has been reported by others.

CONCLUSIONS

The behavioral repertoire of <u>Oryzomys palustris</u> basically resembles that of the genus <u>Peromyscus</u> with obvious modifications for a semipredator, semi-aquatic, and semi-arboreal type of existence. Hooper (1949) suggested that the genus <u>Oryzomys</u> originated in the tropics of North or South America and the lack of hoarding, high demand for water (Stalling, 1977b), utilization of large quantities of exotherms in the diet and the long heat losing appendages in <u>O. palustris</u> seems to reinforce this idea. Of the nearly 100 species in this genus (Martin and Guilday, 1967) only one entered the U. S. The plastic shelter constructing behavior of this species, along with semi-aquatic characteristics, allows a wide variety of wetland habitats to be inhabited that no other small mammals are capable of utilizing. This plasticity applies not only to the type of nests (burrows) constructed, but the type of plant material used, the specific site for shelter construction and production of a dry platform for feeding activities.

The aggressive, antagonistic nature of this rodent, during much of the year, is obviously advantageous to the dispersal of a carnivorous species. This behavior is apparently overcome in winter when sex hormone levels are lowered and cold weather thermally taxes this non-hoarder. Thermally induced shifts in preferred shelter types also appears to occur, along with diminished antagonism.

The ability to dive and swim underwater is obviously of considerable advantage to escape from most predators yet morphological specialization towards a semi-aquatic existence has been slight. This lack of overspecialization thus allows it to readily move in the terrestrial as well as the semi-arboreal realms making it truly capable of a three dimensional utilization of its habitat.

The wide variety of foods consumed by this species, appears distributionally advantageous allowing the rats to fill a herbivore, omnivore or carnivore niche as the habitat allows. The apparent prey assortment, on a size basis, would seem to reduce intraspecific competition, perhaps primarily along sexual lines. The high protein diet necessary for proper development in the young (Sharp, 1967) probably contributes to their wanderings and dispersal.

Behaviorally, the absence of body positions denoting submission in subordinate animals should perhaps be expected in this solitary animal. The vocalization by male pursued non-receptive females appears to deter male aggression as her flight takes her into another male's territory.

It is felt that lack of hoarding, high water turnover rates and high protein demand by young are the primary factors that have restricted distribution in this behaviorally plastic species.

ACKNOWLEDGEMENTS

Thanks is extended to my committee members Drs. Charles C. Carpenter, Keever Greer, Loren Hill and Victor Hutchinson for critically reviewing the manuscript. A special thanks to Dr. Carpenter for initial encouragement, aid in setting up behavior pens and advice on photographic procedures. Thanks also to Cindy Cook for the behavioral diagrams drawn from 16 mm frames and to Dr. Tom Burns for photographic assistance. I'm also grateful to my wife for typing this manuscript, and to her, Richard and Marcia for animal care during my many trips.

Film and equipment were purchased with the aid of a NSF Academic Year Extension Grant and travel cost covered in part by a Baldwin Study-Travel Award received from the University of Oklahoma.

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APPENDIX LEDGEND

Appendix I1 - 15

Monthly minimum and maximum temperature (C^0) data for Natchitoches, Louisiana, by years, with mean, standard deviation and range. Monthly total precipitation for Natchitoches, by years, with days per month when 24 hour total exceeded 2 and 6 cms.

Appendix II

Monthly minimum and maximum temperature (C^0) data for Norman, Oklahoma, for June 1972 - March 1973 with mean, standard deviation and range. Monthly total precipitation, same period, for Norman, with days per month when 24 hour total exceeded 2 and 6 cms.

Appendix III - V

Intercorrelation values of 16 environmental variables at study area trap sites for January 1972, 1973 for three trap responses.

Appendix VI

Comparison of intercorrelation values, following Fisher's z transformation, between three trap results for January 1972 and 1973. Values indicate significant comparisons and level of statistical difference.





































APPENDIX III

Intercorrelation values of 16 environméntal variables at study area trap sites for January 1972, 1973 producing 120 <u>Oryzomys palustris</u>.

		Cloud Cover	Precip- itation	Temper- ature	Bank Height	Bank Length	Bank Angle	Water Depth	Water Width	Height Dom. Veg.	Ground Cover	Unmowed Veget.	Dom. Veg. in Water	Water Sur. Covered	Terrest. Stage	Aqu. St.	Nutria Act.
	Cloud Cover	1.00	0.82	0.41	-0.02	0.11	-0.21	-0.09	-0.14	0.23	0.00	0.36	-0.16	-0.35	0.02	-0.12	0.14
	Precipitation	0.82	1.00	0.36	-0.12	-0.02	-0.10	-0.04	-0,12	0.13	-0.04	0.22	-0.14	-0.25	0.00	-0.11	0.13
	Temperature	0.41	0.36	1.00	-0.00	0.16	-0.13	-0.12	-0.20	0.21	-0.07	0.36	-0,15	-0.27	0.09	-0.14	0.05
	Bank Height	-0.02	-0.12	-0.00	1.00	0.67	-0.06	0.17	0.10	-0.14	0.16	0.05	-0.17	0.07	-0.31	-0.09	0.10
	Bank Length	0.11	-0.02	0.16	0.67	1.00	-0.37	-0.40	-0.35	0.05	0.24	0.22	0.02	0.11	-0.15	0.10	-0.17
	Bank Angle	-0.21	-0.10	-0.13	-0.06	-0.37	1.00	0.15	0.11	-0.23	-0.08	-0.41	-0.01	0.17	-0.20	-0.01	-0.06
172	Water Depth	-0.09	-0.04	-0.12	0.17	-0.40	0.15	1.00	0.78	-0.15	-0.33	-0.01	-0.35	-0.28	-0.08	-0.33	0.54
-	Water Width	-0.14	-0,12	-0.20	0.10	-0.35	0.11	0.78	1.00	-0.25	-0.31	-0.10	-0.23	-0.05	-0.12	-0.30	0.59
	lieight Dom. Veg.	0.23	0.13	0.21	-0.14	0.05	-0.23	-0,15	-0.25	1.00	0.02	0.59	-0.09	-0.28	0.52	-0.09	-0.10
	Ground Cover	0.00	-0.04	-0.07	0.16	0.24	-0.08	-0.33	-0.31	0.02	1.00	-0.02	0.40	0.32	-0.10	0.34	-0.32
	Unmowed Veg.	0.36	0.22	0.36	0.05	0.22	-0.41	-0.01	-0.10	0.59	-0.02	1.00	-0.11	-0.48	0.21	-0.14	0.32
	Dom. Veg. in Water	-0.16	-0.14	-0.15	<u>-</u> 0.17	0.02	-0.01	-0.35	-0.23	-0.09	0.40	-0.11	1.00	0.57	-0.11	0.93	-0.11
	Water Sur. Cov.	-0.35	-0.25	-0.27	0.07	0.11	0.17	-0.28	-0,05	-0.28	0.32	-0.48	0.57	1.00	-0.26	0.52	-0.30
	Terrestial St.	0.02	-0.00	0.09	-0.31	-0.15	-0.20	-0.08	-0.12	0.52	-0.10	0.21	-0.11	-0.26	1.00	-0.04	-0.22
	Aquatic St.	-0.12	-0.11	-0.14	-0.09	0.10	-0.01	-0.33	-0.30	-0.09	0.34	-0.14	0.93	0.52	-0.04	1.00	-0.17
	Nutria Activity	0.14	0.13	0.05	0.10	-0.17	-0.06	0.54	0.59	-0.10	-0.32	0.32	-0.11	-0.30	-0.22	-0.17	1.00

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APPENDIX IV

Intercorrelation values of 16 environmental variables at study area trap sites for January 1972, 1973 producing 73 <u>Mus</u> musculus.

	Cloud Cover	Precip- itation	Temper- ature	Bank Height	Bank Length	Bank Angle	Water Depth	Water Width	Height Dom. Veg.	Ground Cover	Unmowed Veget.	Dom. Veg. in Water	Water Sur. Cove <u>r</u> ed	Terrest. Stage	Aqu. Nutria St. <u>A</u> ct.
Cloud Cover	1.00	0.79	0.16	0.26	0.27	-0.06	-0.26	-0.32	0.30	-0.05	0.36	-0.20	-0.23	0.17	-0.10 -0.07
Precipitation	0.79	1.00	0.02	0.13	0.14	-0,08	-0.15	-0.20	0.24	-0.02	0.26	-0.19	-0.19	0.17	-0.08 -0.10
Temperature	0.16	0.02	1.00	-0.06	<u>-0.07</u>	0.03	0.05	0.08	0.06	0.05	0.19	0.04	-0.12	-0.07	-0.01 0.22
Bank Height	0.26	0.13	-0.06	1.00	0.68	-0.22	-0.09	-0.14	0.10	0.37	0.34	-0.15	0.03	-0.18	-0.01 -0.02
Bank Length	0.27	0.14	-0.07	0.68	1.00	-0.42	-0.60	-0.42	0.36	0.37	0.42	-0.19	-0.06	-0.04	-0.04 -0.15
Bank Angle	-0.06	-0.08	0.03	-0.22	-0.42	1.00	0.11	0.12	-0.23	-0.09	-0,38	0.09	0.15	-0.20	0.00 ~0.11
Water Depth	-0.26	-0.15	0.05	-0.09	-0.60	0.11	1.00	0.77	-0.45	-0.17	-0,28	0.04	0.08	-0.15	-0.05 0.40
Water Width	-0.32	-0.20	0.08	-0.14	-0.42	0.12	0.77	1.00	-0.53	0.00	-0,29	0.11	0.18	-0.40	-0.02 0.52
Height Dom, Veg.	0.30	0.24	0.06	0.10	0.36	-0.23	-0.45	-0.53	1.00	0.11	0.60	-0.47	-0.43	0.55	-0.36 -0.34
Ground Cover	-0.05	-0.02	0.05	0.37	0.37	-0.09	-0.17	0.00	0.11	1.00	0.20	0.11	0.22	-0.27	0.17 -0.24
Unmowed Veg.	0.36	0.26	0.19	0.34	0.42	-0.38	-0.28	-0.29	0.60	0.20	1.00	-0.34	-0.53	0.21	-0.31 0.09
Dom. Veg. in wate	er -0.20	-0.19	0.04	-0.15	-0.19	0.09	0.04	0.11	-0.47	0.11	-0.34	1.00	0.54	-0.17	0.94 0.08
Water Sur, Cover	-0.23	-0.19	-0.12	0.03	-0.06	0.15	0.08	0.18	-0.43	0.22	-0,53	0.54	1.00	-0.25	0.51 -0.12
Terrestial St.	0.17	0.17	-0.07	-0.18	-0.04	-0.20	-0.15	-0.40	0.55	-0.27	0.21	-0.17	-0.25	1.00	-0.03 -0.36
Aquatic St.	-0.10	-0.08	-0.01	-0.01	-0.04	0.00	-0.05	-0.03	-0.36	0.17	-0.31	0.94	0.51	-0.03	1.00 -0.09
Nutria Activity	-0.08	-0.10	0.22	-0.02	-0.15	-0.11	0.40	0.52	-0.34	-0.24	0.09	0.08	-0.12	-0.36	-0.09 1.000

APPENDIX V

Intercorrelation values of 16 environmental variables at study area trap sites for January 1972, 1973 not capturing animals, 795.

	Cloud Cover	Precip- itation	Temper- ature	Bank Height	Bank Length	Bank Angle	Water Depth	Water Width	Height Dom. Veg.	Ground Cover	Unmowed Veget.	Dom. Veg. in Water	Water Sur. Covered	Terrest. Stage	Aqu. St.	Nutria Act.
Cloud Cover	1.00	0.79	0.22	-0.03	0.05	-0.13	-0.05	-0.08	0.12	-0.22	0.23	-0.11		0.11	-0.13	0.21
Precipitation	0.79	1.00	0,10	0.01	0.05	-0.09	-0.04	-0.06	0.11	-0.12	0.17	-0.07	-0.11	0.07	-0.09	0.13
Temperature	0.22	0.10	1.00	0.02	0.01	<u>-</u> 0.01	0.02	0.01	0.12	0.18	0.20	-0.03	0.00	0.01	-0.03	0,01
Bank Height	-0.03	0.01	0.02	1.00	0.67	-0.04	-0.05	-0.11	0.18	0.12	0.11	-0.07	0.05	-0.02	-0.00	-0.09
Bank Length	0.05	0.05	0.01	0.67	1.00	-0.34	-0.49	-0.32	0.34	0,15	0.28	0.09	0.17	0.09	0.13	-0.18_
Bank Angle	-0.13	-0.09	-0.01	-0.04	-0.34	1.00	0.11	0.04	-0.27	-0.03	-0.36	-0.02	_0.08	-0.29_	-0.02	-0.13
Water Depth	-0.05	-0.04	0.02	-0.05	-().49	0.11	1.00	0.69	-0.39	-0.13	-0.08	-0.18	-0.20	-0.19	-0.16	0.43
Water Width	-0.08	-0.06	0.01	-0.11	-0.32	0.04	0.69	1.00	-0.45	0.05	-0.08	0.01	0.12	-0.23	-0.01	0.56
Height Dom. Veg.	0.12	0.11	0.12	0.18	0.34	-0.27	-0.39	-0,45	1.00	-0.01	0.56	-0.12	-0.15	0.60	-0.12	-0.22
Ground Cover	-0.22	-0.12	0.18	0.12	0.15	-0.03	-0.13	0.05	-0.01	1.00	0.08	0.31	0,32	-0.18	0.30	-0.16
Unmowed Veg.	0.23	0.17	0.20	0.11	0.28	-0.36	-0.08	-0.08	0.56	0.08	1.00	-0.13	-0,26	0.35	-0.13	0.24
Dom. Veg. in water	-0.11	-0.07	-0.03	-0.07	0.09	-0.02	-0.18	0.01	-0.12	0.31	-0.13	1.00	0.62	-0.04	0.96	0.01
Water Sur. Cover	-0.17	-0.11	0.00	0.05	0.17	0.08	-0.20	0.12	-0.15	0.32	-0.26	0.62	1.00	-0.17	0.59	-0.08
Terrestial St.	0.11	0.07	0.01	-0.02	0.09	-0,29	-0.19	-0.23	0.60	-0.18	0.35	-0.04	-0,17	1.00	-0.06	-0.12
Aquatic St.	-0.13	-0.09	-0.03	-0.00	0.13	-0.02	-0.16	-0.01	-0.12	0.30	-0.13	0.96	0.59	-0.02	1.00	0.00
Nutria Activity	0.21	0.13	0.01	-0.09	-0.18	-0.13	0,43	0.56	-0.22	-0.16	0.24	0.01	-0.08	-0.12	0.00	1.00

APPENDIX VI

Comparison of intercorrelation values, following Fisher's z transformation, between <u>Oryzomys palustris</u>, <u>Mus musculus</u> and no capture stations for entire area and January 1972, 1973. Table values indicate significant comparisons and statistical level for rejection of null hypothesis.

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	Cloud Cover	Precip- itation	Temper- ature	Bank Height	Bank Length	Bank Angle	Water Depth	Water Width	Height Dom.Veg.	Ground Cover	Unmowed Veget.	Dom.Veg. in Water	Water Sur. Covered	Terrest. Stage	Aqu. St.	Nutria Act.	
Cloud Cover		· ·	1-3*(.05)	2-3(.02)				2-3(.05)	1-2(.001)) 1-3(.0	5)						
Precipitation			1-2(.02) 1-3(.005)													
Temperature	1-3(.05)	1-2(.02))					1-3(.05)		1-3(.0	2)		1-3(.005)				
Bank Height	2-3(.02)						1-3(.0	<u>5)1-3(.(</u>	5)1-3(.00	1)2-3(.0	1-2(.05) 5)2-3(.05)			1-3(.005)		1-3(.05)	
Bank Length									1-2(.05) 5)		2-3(.05)		1-3(.02)			
Bank Angle	L													·		·	5
Water Depth				1-3(.05))			1-3(.05)	1-2(.05)) 1-3(.0	5)	1-2(.01)	<u>1-2(.02)</u> <u>2-3(.05)</u>		1-2(.)5)	
Water Width	2-3(.05)		1-3(.05)	1-3(.05))		1-3(,0	5)	1-2(.05) 1-2(.0) 1-3(.0	5) 01)	1-2(.05) 1-3(.02)		1-2(.05)	1-3(.	005)	
Height Dom. Veg.	1-2(.001	.)		1-3(.00)	1-2(.0	5) D5)	1-2(.0	$\frac{5}{1-3}$)5))2)			1-2(.01) 2-3(.005)	2-3(.02)		2-3(.)5)	
Ground Cover	1-3(.05)		1-3(.02)	2-3(.05)			1-3(,0	1-2(.(5)1-3(.()5))01)			1-2(.05)					
Unmowed Veg.				2-3(.05)) 								1-3(.01) 2-3(.01)				
Dom. Veg. in water					2-3(.0	5)	1-2(.0	1-2(.(1)1-3(.(05)1-2(.01)2)2-3(.00) 5)1-2(.0	5)				1-3(.	01)	
Water Sur, Cover			1-3(.005)			1-2(.0 2-3(.0	2) 5)	2-3(.02)	1-3(.01) 2-3(.01)					1-3(.02)	
Terrestial St.				1-3(.005)	<u>1-3(.0</u>	2)		1-2(.0)5)							2-3(.05)	
Aquatic St.					<u> </u>		1-2(.0	5)1-3(.(05)2-3(.0	5)		1-3(.01)					
Nutria Activity				1-3(.05)									1-3(.02)	2-3(.05)			

*Intercorrelation values compared 1= <u>Oryzomys palustris</u> 2= <u>Mus musculus</u> 3= no catch

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