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LABORATORY STUDY ON JUVENILE GROWTH OF THE COMMON RICEFIELD RAT (*RATTUS RATTUS MINDANENSIS* MEARNS)

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ABSTRACT

Ferrer, Lorenza Segui, University of the Philippines at Los Banos, October, 1973, Laboratory Study on Juvenile Growth of the Common Ricefield Rat (Rattus rattus mindanensis Mearns). Major Professor: Pablo J. Alfonso.

Growth and development were studied in the common ricefield rat, Rattus rattus mindanensis Mearns, in the laboratory from November, 1971 through February, 1973. Data were obtained from 87 young born in captivity, from 14 litters. The animals were apportioned into two groups: Group I, the litters from female rats bred in the field and born in the laboratory, and Group 2, the litters from females bred and born in the laboratory.

Litter size ranged from 3 to 8 and averaged 6.21, and sex ratio of the litter was equal. Initial average weight and total length of the rat was 3.71 grams and 59.53 millimeters, respectively. Growth in weight was most rapid in the sixth to the eleventh week while growth in linear dimensions was most rapid in the first 7 weeks. The young reached sexual maturity in approximately 6 weeks for the females and 8 weeks for the males.

The young rats consumed a daily average of 5 grams after weaning and consumption increased to an average of 8.5 grams during the first and second weeks. At 6 weeks there was further increase of 0.5 to 1.5 grams in daily feed consumption and finally leveled off to an average of 12.5 grams per day at the age of 7 to 9 weeks.

Sexual dimorphism in the two groups for weight and linear dimensions resulted from the continued growth of the rats until the ninety first day for the laboratory-bred group. Weights tended to attain maximum rate of increase when the rats were about 56 days for the laboratory-bred group and 70 days for the field-bred group. Increase in total, body plus head, and tail lengths for both groups were recorded during the first 7 weeks.

The time of occurrence of certain morphological and behavioral changes of nursing and weaned rats are summarized.

Correlation coefficients and regression lines calculated for the relationships between weight and age, between total, body plus head, tail, and hind foot lengths and age showed that there were highly significant differences at 1 per cent level.

INTRODUCTION

Information on growth and patterns of individual development are important in understanding the animal population dynamics of a species. These are best obtained by examination and by measuring the numerical as well as the developmental activities of the animals from birth to maturity. Since this is quite impossible when working under field conditions, raising this wild species in the laboratory is necessary to obtain the data from which the structure and status of the population can be estimated.

Details on the growth patterns of the common ricefield rat (Rattus rattus mindanensis Mearns) have not been reported previously and have remained largely unknown. In contrast, other species such as the roof rat (Rattus rattus Linneaus), the Norway or brown rat (Rattus norvegicus Erxleben) and the Polynesian or bush rat (Rattus exulans Peale) have been studied extensively in other parts of the world (Leslie et al, 1952; Jackson and Barbehenn, 1962; Calhoun, 1962; Bentley and Taylor, 1965; Spillet, 1966; Egoscue, 1970; and Wirtz, 1973).

Numerous investigators (Leslie et al, 1952; Jackson and Barbehenn, 1962; and Bentley and Taylor, 1965), are of the opinion that much remained to be learned and more gaps need to be filled about our basic knowledge on the biology and the related ecology of even among the most studied species of Rattus. It is for this reason that the following study on the growth, development and general behavior of the common ricefield rat (Rattus rattus mindanensis is presented.

REVIEW OF LITERATURE

Growth Rate in Relation to Litter Size

A study by the Rodent Research Center (Sanchez et al, 1971) has been conducted on the rate of physical growth of the rat (*Rattus rattus mindanensis*) in relation to litter size at weaning time. Five litters of rats raised in outdoor nest boxes produced 37 animals at weaning time (23 days after birth). Litter size varied from 2 to 11 and averaged 7.4. The two weanlings in the single litter were more than four times the weight of those in the set of 11 young at 23 days. The average weight of the young in each litter was significantly different from every other litter.

The litter containing 11 animals was not independent of their mother at 23 days and none survived after being removed from the mother. In contrast, another litter of 11 weanlings was independent of their parent in 23 days and nine of these survived after separation from the mother.

Birth Weights

The birth weights of rats and mice (Bentley and Taylor, 1965 and Reading, 1966) are found to be related to both the parity of their mothers and the size of their litters. Individuals born to mothers that have previously undergone pregnancy weighed significantly more at birth than those born to primiparous mothers. Independently of maternal parity, individuals from smaller litters weighed

significantly more at birth than those from larger litters. However, multiparous females generally have larger litters than do primiparous females. Likewise, multiparous females are usually older, larger and have a greater rearing ability.

The work of Bentley and Taylor (1965) on Rattus rattus reared in the laboratory shows that at birth males are slightly heavier on the average than females. Females gained weight more quickly during the first 2 weeks but, at 5 to 6 weeks of age, the males became significantly heavier and remained so.

Parturition

Farris (1950) observed that at birth the first young delivered is usually expelled by head presentation and the others follow either by breech or by head delivery. In most cases, the female licks the vulva preceding the delivery; failure of the rat to lick the vulva seems to be correlated with difficult delivery. Following parturition the mother licks the young rat and removes the amniotic sheath. The mother very seldom pays any attention to the young until the placenta has been eaten.

In the mice, parturition generally occurs between midnight and 4 a.m., but may occur at any time (Hugh, 1964). This will depend upon the age, litter size, and physical condition of the female. Delivery may take a few minutes and may be prolonged for many hours,

the usual litter being born within 1 to 2 hours. The female rats eat the placenta which promotes growth of substance for milk production.

Wirtz (1973) reports a detailed litter delivery of a female R. exulans from the time the gravid parent is settled in one corner of the cage preparatory to delivery up to eating the placenta of the third and fourth young immediately following birth. The entire process took only four minutes.

Reproduction

Sumangil and Rosell (1959), working on the reproductivity of some species of field rats, note a comparatively reduced breeding in the Rattus argentiventer Robinson and Kloss in cage condition. Mortality rate at weaning period was extremely high and they associated this to a high rate of cannibalism on the part of the parent rats, resulting in about 68 per cent of all the fatalities at lactation. Sumangil (personal communication) associates cannibalism in cages mainly to (i) human handling of the young and (ii) dietary deficiencies. He finds it apparent that under field conditions such mortality rates due to cannibalism may not be as high as in cage condition. Sumangil and Rosell (1959) further observe an abnormally hastened juvenileship and early physical, as well as sex maturity among young rats delivered at the early phase of the breeding cycle. Based on seasonal breeding, females belonging to the first generations are commonly pregnant in about 1 1/2 months to

two months from birth. Supplementary laboratory studies showed a similar early maturity trend wherein a 53-day old female gave birth to 3 young. Considering the gestation period of 21 days, the specimen was only 32 days old at fertilization.

Peculiarities of sexual precociousness were further subtantiated by Sumangil, et al, (1963) in the reproductive study of the R. argentiventer in ricefields of Buluan, Cotabato. I have noted similar sexual precociousness existing in R. r. mindanensis from field conditions in Central Luzon.

The presence of viable sperm in the male rat has proved to be correlated with macroscopically visible tubules in the cauda epididymis for several cricetids (Hamilton, 1941) and for a murid rodent (Davis and Hall, 1948). Jackson (1962) used this technique on Ponape; in doubtful cases where the testes were enlarged but the tubules were not readily discernible, separate smears of testis and epididymal tissue were examined microscopically for sperm.

Litter Size

Litter size at parturition of Rattus rattus mindanensis in Mindoro, based on Sumangil and Rosell report in 1959, varied from 1-6 young. There is no record on the average number of young weaned per litter. Sumangil, Ferrer and Macanas (unpublished) working on the same species in Buluan, Cotabato, found an average litter size of 7.6, ranging from 4 to 12 young. Medina et al (1972) however obtained a lower average litter size of 5 for the same species under cage condition.

Ragoscue (1970) observed that the litter size for some species of rodents varies within narrow limits apparently so fixed by heredity that it remains unchanged by selection through many generations. He exemplified the Polynesian rat (R. exulans) as having seemingly the best possibilities in this direction because the number of mammae (8) greatly exceed the average litter size, which is 3.8 from a range of one to 10 young in the species.

Rosell (1959), on his studies on the reproduction of Rattus argentiventer, states that the age of the mother is a factor that determines the number and size of litters. He observed that there was an increase in litter size as the mother grew older until the age of 7 to 8 months and from where a decrease in litter size was noted.

A study by Cameron (1973) probe into the effect of litter size on postnatal growth and development in the desert woodrat (Neotoma lepida). He stated that the proportion of young surviving to wean was also a function of litter size. There was no post-parturitional mortality in litters of one, two or three young. However, there was only a 75 per cent survival to weaning in litters of four young and a survival of 50 per cent in males and 34 per cent in females among litters of five young.

Sex Ratio

The primary sex ratio in mammalian population is considered to be about 60 per cent male (Asdell, 1964), but only a slight excess

of males is apparent at birth. This conforms with the finding of Sumangil and Rosell (1959) that Rattus rattus mindanensis has 1.23:1 sex ratio at birth but Medina et al (1972), who raised the same species in the laboratory, found that sex ratio was 1:1.1 indicating a very slight preponderance of the females over the males. According to Jackson (reported in Storer, 1946), the departure from equality was slight, but the numbers were too small to have significance and probably at birth up to the time of weaning, the sex ratio remains at equality.

It has been observed (Beer et al, 1958) that such factors as season of the year, age of the animals, and method of collecting may cause the observed sex ratios to deviate from the true sex ratio of the population. Sumangil, Ferrer and Macanas (unpublished) particularly note the preponderance of mature males during the breeding months of R. argentiventer in paddy fields of Cotabato. Sumangil (1971) relates this to burrowing behavior of ricefield rats for reproductive purposes.

OBJECTIVE

The objective of this study is to obtain information on postnatal growth and behavioral patterns in Rattus rattus mindanensis Mearns.

MATERIALS AND METHODS

The study was conducted in the Department of Entomology, the Department of Zoology and at the Rodent Research Center, College, Laguna from November, 1971 to February, 1973.

Data were obtained from 44 males and 43 females born in captivity from 14 litters from selected females that were pregnant when captured and from females that mated and became pregnant in the laboratory.

Capture

With the use of blanket system (Tormes and Morales, 1953) and live traps (28 by 18 by 14 centimeters), gravid and non-gravid females and males were collected in Siniloan, Laguna. The collection area was two kilometers from Laguna de Bay shoreline mostly covered with succulent grasses such as "bayakibok" (Echinocloa crusgalli), "tikiw" (Scirpus grossus), and para grass (Brachiaria mutica). A selective 10 m x 10 m quadrat was applied and 20 live traps were employed in separate but adjacent collection sites. A total of 70 rats were gathered and brought to the laboratory. Six collections were performed during the period of study.

Care and Feeding

Ten pregnant and 30 non-pregnant but mature females and 30 mature males were collected. Pregnant animals were maintained in individual wire cages measuring 27 by 22 by 18 centimeters. The non-pregnant females were caged in pairs with opposite sex in each of the 30 wire cages used. All individuals were provided with food and water given ad libitum. Mother and young were provided with ample amount of fresh green leaves and grasses which served both as food and nesting material. The leaves and grasses given

were: Oryza sativa, Epomea batatas, E. aquatica, Pennisetum polystachyon, Brachiaria distachya, and B. mutica. Commercial multi-purpose mash (creep pellets) of A-One Feeds, Inc., Pasig, Rizal was used as the main feed and paddy rice (palay) was given once a week as a supplement. The amount of feed consumed was recorded for both the gravid rats and for the subsequent litters that were weaned.

Reproduction

The mated females were examined two times a week for the placental sign (droplet of blood in the vaginal opening), or by marked increase in weight (approximately 25 to 30 grams) and by enlargement of the abdomen (fourteenth day of gestation), indicating pregnancy (Farris and Griffith, 1963). The male was removed whenever pregnancy was noticed or immediately after copulation has taken place.

Pregnancies were detected through daily visits and examinations and the animals were checked around the estimated time of parturition.

Measurement of Variable

1. Growth

Each young within a litter was weighed and measured on the day of its birth and every day up to day 21. Weighing and measurements were performed in the morning before the animals were given food. The weighings were read to the nearest 0.1 gram with a Harvard triple-beam balance (Ohaus). All measurements were taken to the nearest millimeter. Thereafter, the weaned animals were

individually weighed and total length, tail length, hind foot length, and ear notch length measured at weekly interval until the age of sexual maturity.

Perforate vaginal orifice in the female and fully descended testes in the male were considered to be the initial criteria for sexual maturity. However, the weekly growth measurements were continued for four more weeks after the indicated initial signs of sexual maturity. A few specimens from both sexes exhibiting these criteria of adult characteristic were sacrificed to determine whether or not perforate vagina and descended testes are reliable signs of sexual maturity. The presence of testicular and epididymal sperms were considered as adequate evidence of male sexual maturity, while vascularization of the reproductive tract would indicate similar maturity in females.

When weanlings were to be weighed, the mother was temporarily removed from the cage by inducing her to climb into an opaque sack placed over the mouth of the cage. The young were then individually picked with forceps, weighed, measured, and returned to their nest. The mother is then released back to her litter. All weaned rats were identified by toe clipping to indicate litter number and by ear punching to designate individual number. Likewise, parent animals were properly identified corresponding to their litter markings.

Animals that were difficult to handle were anesthetized with sulfuric ether prior to weighing and measurement.

Litters were separated form their parents on the twenty first day after birth which is the weaning period for R. rattus

mindanensis (Medina et al, 1972 and Sumangil, 1965). Age of weaning was determined on the bases of the young taking solid food, evidence of rejection by mother when the young attempted to nurse, and by whether or not milk could be expressed from the mammae of anesthetized mother. These criteria are similar to those used by Layne (1968). Litters were split into groups of two or three animals, primarily to avoid crowding in the cages.

2. Age determination

Observation on the suckling and weaned litters were made to relate physical and behavioral measurements to age. This included the basic measurements of total length, lengths of body plus head, tail, hind foot and ear length measured from the ear notch and the occurrence of certain morphological characteristics such as the appearance of vibrissae and hairs, teeth eruption, opening of ears and eyes, skull ossification, perforation of vaginal orifice for female and when testes became scrotal in position for the male.

Mortality

In order to obtain information on mortality, litter size was recorded at different periods: parturition, 2 weeks after parturition, weaning, and 2 weeks after weaning.

Proximate Analysis

The quality and nutritional composition of a feed indicate whether an animal utilizes a diet high in protein or carbohydrates, or whether some other component is important. Therefore, a proximate analysis was utilized to determine the per cent weight of moisture, ash, crude protein, crude fiber, crude fat and nitrogen-free extract. All analyses were performed, using the Association of Official Agricultural Chemists methods (Horwitz, 1965), at the Animal Nutrition Laboratory, Department of Animal Science.

Statistical Analyses of Data

The distribution of sexes between field-bred and laboratory-bred rats were compared using the binomial test (Siegel, 1956). Weight of the individual rats at zero age was tested for statistical significance by the use of analysis of variance (Snedecor, 1956).

The daily mensural data of each sex for Group I and Group 2 from birth to maturity were analyzed and relationship between variables was determined by correlation and regression analysis (Steel and Torrie, 1960).

The 50 per cent points of the ricefield rat at various stages of maturity with reference to weight and body plus head length were approximated by visually fitting data plotted on arithmetic probability paper (Davis, 1964).

RESULTS AND DISCUSSION

The data obtained on the common ricefield rat, *Rattus rattus mindanensis* during the course of this study were apportioned into two groups: Group I, the litters from female rats bred in the field and were born in the laboratory, and Group 2, the litters from female rats that were bred and born in the laboratory. In other words, the first group consists of young delivered by female rats pregnant when captured and the second group consists of young born by female rats that bred under laboratory conditions. This pattern had been similarly described by Wirtz (1973) on *Rattus exulans*.

Reproduction

All the 10 pregnant female rats collected from the field gave birth but only 8 litters, litters 1 to 6 and 13 to 14 (Table 1), were considered since one mother had devoured its entire litter a day after parturition while the other mother escaped out of the cage. The earliest delivery was a litter of 8 on November 20, 1971 while the latest was almost after a year, on November 10, 1972 composed of 6 young.

Out of the 30 pairs of breeding stock kept in the laboratory, only 6 females became pregnant and gave birth to litters 7 to 12 (Table 1). First delivery was on September 15, 1972 of 7 young and the last litter birth was on October 7, 1972, also of 7 rats.

Table 1. Date of birth, size of litter and number of males and females of the 14 litters of the ricefield rat.

Litter no.	Date of delivery	Litter size	No. of males	No. of females
	Group I (field-bred)			
1	November 20, 1971	8	3	5
2	November 21, 1971	6	3	3
3	November 22, 1971	6	2	4
4	December 11, 1971	7	3	4
5	February 26, 1972	5	3	2
6	September 15, 1972	7	4	3
13	November 6, 1972	6	2	4
14	November 10, 1972	6	3	3
	Group 2 (laboratory-bred)			
7	September 26, 1972	7	5	2
8	September 27, 1972	3	3	0
9	September 28, 1972	7	5	2
10	October 2, 1972	6	3	3
11	October 5, 1972	6	2	4
12	October 7, 1972	7	3	4
	Total	87	44	43

Feed Analysis

The proximate analysis of nutrient composition of the multi-purpose mash (creep pellet), which served as the main food of the rats is shown in Table 2. The creep pellets contained 14.08 per cent protein.

Table 2. Proximate nutrient composition of the multi-purpose mash (creep pellet) feed.

	Percentage
Dry matter	87.07
Ash	9.71
Crude protein	14.08
Crude fiber	11.79
Crude fat	9.89
Nitrogen-free extract	41.61

Crude protein analysis (Gerpacio and Castillo, 1973) of rough rice (palay) and green feedstuffs such as camote, kangkong, and para grass that were fed to the rats as supplements are 7.39, 2.04, 3.9, and 1.82 per cents, respectively. The study however did not run any digestibility trial of the feeds used to assess how much each of the nutrients analysed were taken in by the animals under investigation.

Feed Consumption

The average daily creep pellet consumption of the rats from weaning to sexual maturity are summarized in Table 3. The young rats consumed a daily average of 5 grams on the first 2 to 3 days. Consumption increased to an average of 8.5 grams (range, 8-12 grams) during the first and second week. As the rat approaches the age of sexual maturity (4-6 weeks) there was a further increase of 0.5 to 1.5 grams in daily feed consumption, which finally tended to level off to an average of 12.5 grams (range, 10-14 grams) per day when the animals reached the age of 7 to 9 weeks.

Litter Size

As shown in Table 4, the litter size in R. r. mindanensis had a mean of 6.21 young per litter (range, 3-8 youngs/litter). The litter sizes did not vary much from the average except for litter No. 8 which had only three. The present observation does not seem to reflect the contention of Asdell (1964) who stated that confinement reduces the litter size and that litter size of the wild female is larger than that of the laboratory or zoo female. Asdell reported that litter size in a small sample of rats in captivity is 5.6.

Sex Ratio

The proportion of males and females from the two groups taken together is 44 males and 43 females. This gives a ratio of 102.33 males to 100 females or a male percentage of 50.57 (Table 4).

Table 3. Average daily creep pellet consumption of the growing rats from weaning to sexual maturity.

Period after weaning	Amount (gms)
0 week	5
First week	8.5
Second week	8.5
Third week	10
Fourth week	10.5
Fifth week	11
Sixth week	11
Seventh week	12.5
Eighth week	12.5
Ninth week	12.5

Table 4. Totals and percentages of the sexes for the 14 litters of *Rattus rattus mindanensis*.

Litter no.	Total	Male	Female	Per cent male	Per cent female
		Group I (field-bred)			
1	8	3	5	37.50	62.50
2	6	3	3	50.00	50.00
3	6	2	4	33.33	66.67
4	7	3	4	42.86	57.14
5	5	3	2	60.00	40.00
6	7	4	3	57.14	42.86
13	6	2	4	33.33	66.67
14	6	3	3	50.00	50.00
		Group 2 (laboratory-bred)			
7	7	5	2	71.43	28.57
8	3	3	0	100.00	0
9	7	5	2	71.43	28.57
10	6	3	3	50.00	50.00
11	6	2	4	33.33	66.67
12	7	3	4	42.86	57.14
Total	87	44	43	50.57	49.43

Table 5. Percentage of sex ratio distribution of the ricefield rat separate for Group I and Group 2.

Group I (field-bred)				Group 2 (laboratory-bred)			
Litter no.	Male	Female	Per cent male	Litter no.	Male	Female	Per cent male
1	3	5	37.50	7	5	2	71.43
2	3	3	50.00	8	3	0	100.00
3	2	4	33.33	9	5	2	71.43
4	3	4	42.86	10	3	3	50.00
5	3	2	60.00	11	2	4	33.33
6	4	3	57.14	12	3	4	42.86
13	2	4	33.33				
14	3	3	50.00				
Total	23	28	45.10		21	15	58.33

This conforms with the findings of Wirtz (1973) and Rosell (1959) who claimed that the sex ratio in litters born in captivity are equal.

The distribution of the total number for the two groups is given in Table 3. The figures as a whole show a preponderance of females for Group I and of males for Group 2. The binomial test (Siegel, 1956) does not show any statistical significant difference (P = .05) in the distribution of the sexes between field-bred and laboratory-bred rats. Studies of the same rat species by Marges (1972) trapped from the field indicate that the over-all sex ratio of 51.83 per cent preponderance of males was not statistically different from the ratio indicating perfect equity between sexes.

Morphological and Behavioral Development

The rats are born without hair, with closed eyes and ears, undeveloped limbs, short tail, vibrissae absent, and pinkish in color. As Farris (1965) described, locomotion is affected by wriggling and paddling, the head is always searching, with quick response to olfactory and taste stimuli.

The time of occurrence of certain morphological and behavioral changes may prove useful in estimating the age of young *Rattus rattus* (Bentley and Taylor, 1964). Medina et al (1972) working on *R. r. mindanensis* noted some aspects of behavior of the species.

At birth, the mean weight of the ricefield rat reared in the laboratory was 3.71 grams and the average total length was 59.53 millimeters.

Age determination of the suckling litters and weaned rats by means of the time of occurrence of certain morphological and behavioral changes are summarized in part below:

Suckling young	Approximate no. of days	
	Range	Mean
Vibrissae appear	2	2
Hairs appear	5-7	6
Incisors erupt	8-10	9
Ears open	8-11	9
Young find way to mother	9-11	10
Eyes open	14-16	15
Hair obscures genitalia	14-17	15
Hair obscures nipples in female	14-17	15
First molar erupts	19-20	19
Second molar erupts	21-23	22
Weaned rats		
Third molar erupts	35-40	36
Ossification of skull	38-40	39
Vaginal orifice perforates	40-56	51
Testes scrotal in position	60-70	64

By the end of the first week the dorsal pelage was obvious, but the white ventral hairs were not yet noticeable to the unaided eye. Mystacial vibrissae were 11 millimeters long and the teats were visible on females. During the second week, white ventral pelage appeared, the grayish brown hairs of the dorsum developed into a solid coat, and the guard hairs were distinguishable among the finer body hairs. Once the ears opened the young find their way to the mother whenever the latter leaves the nest. Mystacial vibrissae reached 20 millimeters. Incisors erupted bet-

ween the eighth and tenth days, with lowers usually being slightly ahead of the uppers.

During the third week behavioral changes were more apparent than morphological ones. The movement of the young became well coordinated and the young jump in response to squeaking by the observer. The juveniles leave the nest and began climbing the cage walls if disturbed. Molars occasionally erupted as early as the nineteenth day, but usually not until the beginning of the fourth week. At this age the vibrissae was 31 millimeters.

Nursing ceased after the third week. The young weighing between 14 and 31 grams were roaming in the cage and started tasting solid food. Molting in the young rats was normally completed during the fourth week. Dark hairs continued to appear on the dorsum until the seventh week, giving it a dark cast. The vibrissae had grown to a maximum of 51 millimeters at this stage and reached a full length of 60 millimeters at approximately 10 weeks of age.

Sexual Development

There are many physiological criteria to determine chronological age in wild species but perhaps the easiest for live animals is the condition of the reproductive organs (Davis, 1964). The vaginal orifice of young females is sealed by a membrane, while the testes of young males are confined to the abdominal cavity. In rodents, the testes descend into the scrotum as the male becomes sexually mature and the vaginal orifice becomes perforate as the female ap-

proaches maturity. These two characters can thus be considered to be the first overt signs of approaching sexual maturity and are useful because they are so easy to observe and record. Not until after weaning did any members of either sex exhibited these criteria.

The conditions of the reproductive organs when Rattus rattus mindanensis reached sexual maturity in the laboratory were determined from the observations on 29 males and 20 females which were sacrificed at various weeks of maturity, usually until the fourth week after the testes have descended or the vaginal orifice perforated (Tables 6 and 7).

Captive females became perforate as early as 40 days and all females have perforated vaginas by 56 days of age. This result conforms with the findings of Southwick (1966) and Asdell (1964) on R. rattus who both claimed that puberty was reached on about the same day. Males did not attain a comparable state until 14 days older. Table 6 shows that at all weeks after perforation of vaginal orifice there was vascularity of the reproductive tract examined. This finding contradicts the statement of Marges (1972) on the same species that perforation was not indicative of sexual maturity since newly perforate females showed no development of reproductive tract.

Table 7 shows the individual males examined for the presence or absence of sperms in the cauda epididymis with the corresponding rat weight and testes weight. It could be seen that three weeks after the testes became scrotal, there were already sperms in the cauda epididymis but before this date there was no trace of sperms yet.

Table 6. Sexual development of the female ricefield rat.

Litter no.	Rat no.	Weight (gm)	Vaginal orifice perforates (nth day)	Vascularity of the reproductive tract: Wk. after vaginal orifice perforates 0	1st	2nd	3rd	4th
			Group I (field-bred)					
1	1	34.4	56	✓				
	4	35.1	56		✓			
2	4	44.5	45		✓			
3	1	33.2	53		✓			
	2	42.7	50			✓		
4	1	36.8	50	✓				
	2	45.0	40			✓		
	4	50.3	40				✓	
5	4	52.3	45			✓		
13	3	40.6	50		✓			
	4	41.2	52	✓				
			Group 2 (laboratory-bred)					
9	1	99.3	55					✓
10	4	79.7	55	✓				
	5	104.0	56					✓
	6	105.0	56					✓
11	3	72.6	50	✓				
	4	92.9	50				✓	
	5	82.0	50			✓		
12	4	120.6	56				✓	
	5	71.6	56	✓				

Table 7. Sexual development of the male ricefield rat.

Litter no.	Rat no.	Weight (gm)	Testes scrotal in position (nth day)	Testes weight (gm)	Presence (p) or absence (a) of sperm in cauda epididymis: Wk. after testes descended 0	1st	2nd	3rd	4th
			Group I (field-bred)						
1	5	55.0	70	0.5	a				
	6	63.9	70	0.5		a			
2	1	73.3	68	0.5		a			
	3	102.0	69	0.6			a		
3	3	50.0	62	0.3	a				
	4	83.9	63	0.6					p
4	3	89.4	60	0.9					p
	5	83.5	60	0.8					p
5	1	63.5	64	0.6	a				
	2	73.7	64	0.6			a		
13	1	77.4	63	0.5			a		
	2	56.3	63	0.5	a				
14	1	73.4	64	0.5				a	
	2	83.8	64	0.5				a	
	3	93.8	64	0.7					p
			Group 2 (laboratory-bred)						
7	1	113.9	65	0.7					p
	3	117.5	63	0.6				p	
	4	116.8	65	0.7				p	
8	1	97.3	60	0.6		a			
	2	112.7	60	0.8				p	
	3	89.2	60	0.6	a				
9	2	114.5	63	0.7					p
	6	119.4	64	1.0					p
10	1	104.3	63	0.6			a		
	2	112.0	64	0.8				p	
11	1	92.7	64	0.6		a			
	2	125.1	64	0.5	a				
12	1	106.2	65	0.5			a		
	3	129.2	65	0.7				p	

Previous work done on R. rattus and R. exulans by Jackson and Barbehenn (1962) showed that the testes descended in about 7 weeks but required 10 weeks to reach sexual maturity. This means that there was a period of 3 weeks between testes descent and the presence of active spermatozoa in the cauda epididymis which was the contention of the present study. The descent of testes then as applied to growing males is not a very good index of sexual maturity since at the stage of development the animal may still be on the sub-adult category (Sanchez et al, 1971).

The presence of viable sperms has proved to be correlated with macroscopically visible tubules in the cauda epididymis (Jackson, 1962) but not with the testes weight. A linear correlation was made on testes weight (fifth column of Table 7) with the presence of sperms at various weeks after testes descent and there was no significant difference at 5 per cent level ($r = 0.662$). The 29 pairs of values are plotted in figure 1.

Mortality

Infant mortality is one of the most changeable parameters of population dynamics. Study by Brown (1953) on confined rodent populations had shown that infant mortality is often the major controlling mechanism in crowded rodent populations with adequate food. The results of data on mortality from the present study was wholly on infant mortality.

$$Y = 0.4689 + 0.3466 \, [\log (X + 1)]$$

$$r = 0.66242$$

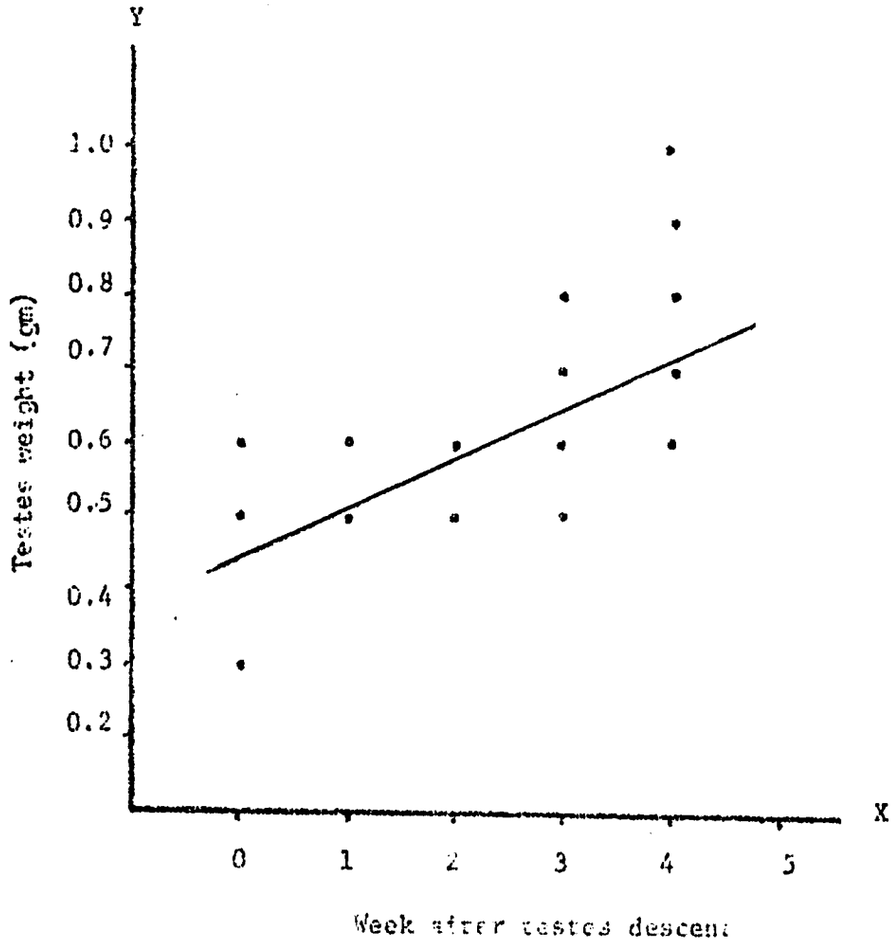

Figure 1. Regression of testes weight (Y) on week after descent of testes (X) for 29 male ricefield rats.

Table 8 presents the record of mortality from parturition to 2 weeks after weaning time and the number of rats that reached maturity. All 87 animals were born alive. At parturition eight animals (two males and six females) were killed either by accident or other misfortunes and two 'runts' (one male and one female) were eaten by the mother. A total of 77 individuals or 88.51 per cent of the population survived after this stage. There was no mortality rate at 2 weeks after parturition but at weaning a reduction in the total number by three animals was noted.

Again, there was no mortality at 2 weeks after weaning and the total number of individuals surviving this period reached sexual maturity giving a total of 74 rats. A mortality rate of 14.94 per cent was very low compared to 31.6 per cent noted by Wiesner and Sheard (1935) in their study of laboratory populations from birth to 31 days of age.

Surviving animals from birth to adulthood gave 85.06 per cent which was a comparable result to 87.5 per cent in Rattus argentiventer (Rosell, 1959). However, Medina et al (1972) got only 62.11 per cent of the offsprings living up to weaning and to maturity.

Growth Rate

Generally it is to be expected that male rats will tend to be larger and heavier than females of the same age which will become more apparent with time (Spillat, 1966; Calhoun, 1962).

Table 8. Mortality of the ricefield rat at parturition, 2 weeks after parturition, weaning, and 2 weeks after weaning.

Litter no.	Rats born	Mortality at: Parturition	2 weeks after parturition	Weaning	2 weeks after weaning	Rats attaining maturity
		Group I (field-bred)				
1	8	2				6
2	6			1		5
3	6					6
4	7	2				5
5	5					5
6	7	1				6
13	6	1				5
14	6			1		5
		Group 2 (laboratory-bred)				
7	7	1				6
8	3					3
9	7	1		1		5
10	6					6
11	6					6
12	7	2				5
Total	87	10		3		74

The data here presented are no exception. However, from birth to the ninety first day males and females of the Group 2 animals tended to grow faster than those of Group I. Although the observed rats for the two groups continued to increase gradually in size throughout the study, weights tended to attain maximum rate of increase by about 56 and 70 days for Group 2 and Group I, respectively, and then increased only very slowly. Increase in total, body plus head and tail lengths were recorded for both groups during the first 7 weeks.

Daily mensural data of each sex for Group I and Group 2 from birth to maturity are presented in Tables 9 and 10. Absolute mean growth curve in weight and linear dimensions plotted at weekly intervals from birth to 91 days are given in figures 2, 3, and 4. Since the study involved sacrificing few animals at various stages of maturity, the number of individuals contributing to the various means was not constant.

The different sizes of the suckling male and female ricefield rats taken on the sixth, fifteenth, and twentieth days before weaning time are shown in figures 5, 6, 7, and 8. At any one time, a rat may be heavier or lighter, bigger or smaller than another rat of same age. This militates against the use in the field of weight or size as a sole guide to age.

Suckling young

The average weight of 87 newborn young was 3.71 grams (range, 3.0 to 5.2 grams). The members of smaller and of laboratory-bred litters were generally heavier and larger in linear dimension than those from larger and field-bred litters. Analysis of variance

Table 9. Mean weight (grams) of male and female ricefield rats from birth to 91 days.

Day	Field-bred group		Laboratory-bred group	
	Male	Female	Male	Female
0	3.6	3.4	4.2	3.6
1	4.2	4.0	5.0	4.4
2	4.8	4.6	5.9	5.1
3	5.3	5.1	6.6	5.8
4	5.8	5.5	7.5	6.5
5	6.0	5.8	8.7	7.6
6	6.9	6.5	9.8	8.7
7	7.2	7.1	11.1	9.8
8	7.7	7.3	12.4	11.0
9	8.4	8.4	13.4	12.2
10	8.8	8.7	14.5	13.3
11	9.4	9.2	15.9	14.6
12	10.1	9.8	17.3	16.1
13	10.8	10.5	18.6	17.2
14	11.7	11.3	19.6	18.3
15	12.8	12.2	20.9	19.7
16	13.2	12.7	22.3	21.4
17	13.8	13.3	23.6	23.0
18	14.4	13.9	25.1	24.3
19	15.1	14.6	26.1	25.2
20	15.9	15.4	27.6	26.0
21	17.4	16.6	29.1	27.8
28	21.0	19.6	37.1	35.0
35	25.5	23.6	46.0	43.2
42	31.4	28.8	55.9	52.9
49	38.5	36.0	64.5	61.4
56	43.7	40.2	75.4	72.3
63	52.1	45.8	84.6	81.4
70	63.1	59.2	94.2	91.5
77	72.6	67.0	103.5	99.6
84	83.8	70.8	111.9	105.1
91	91.2	76.3	119.4	110.2

Table 10. Mean linear dimensions (millimeters) of male and female ricefield rats from birth to 91 days.

Day	Field-bred group				Laboratory-bred group			
	Total length		Tail length		Total length		Tail length	
	M	F	M	F	M	F	M	F
0	59	57	-	-	61	61	-	-
1	62	59	16	17	65	63	19	17
2	67	64	18	18	69	67	21	19
3	70	68	22	20	75	73	24	23
4	74	72	23	22	82	80	27	26
5	78	76	26	25	91	86	31	30
6	83	81	28	27	95	92	34	33
7	87	86	31	31	101	97	37	36
8	90	89	33	32	107	102	42	40
9	95	94	36	35	115	108	46	43
10	99	98	38	37	123	115	52	48
11	103	102	41	39	131	124	56	52
12	106	106	43	41	138	132	60	57
13	110	110	46	45	145	139	64	61
14	115	114	48	48	152	146	68	65
15	119	118	51	50	160	154	73	69
16	124	123	54	54	166	161	76	73
17	130	129	57	56	172	166	79	75
18	136	136	61	60	178	172	82	80
19	142	141	64	63	185	180	86	84
20	148	147	67	67	192	188	90	88
21	156	156	71	71	199	197	94	93
28	170	169	80	79	214	212	105	103
35	183	182	88	87	232	226	119	113
42	196	195	95	95	243	238	125	119
49	210	210	107	107	255	249	132	126
56	225	223	116	114	265	258	138	132
63	241	239	127	124	275	267	141	134
70	264	258	137	134	286	281	144	142
77	279	275	146	143	295	291	152	150
84	289	285	153	152	303	297	160	156
91	298	295	158	157	310	305	164	160

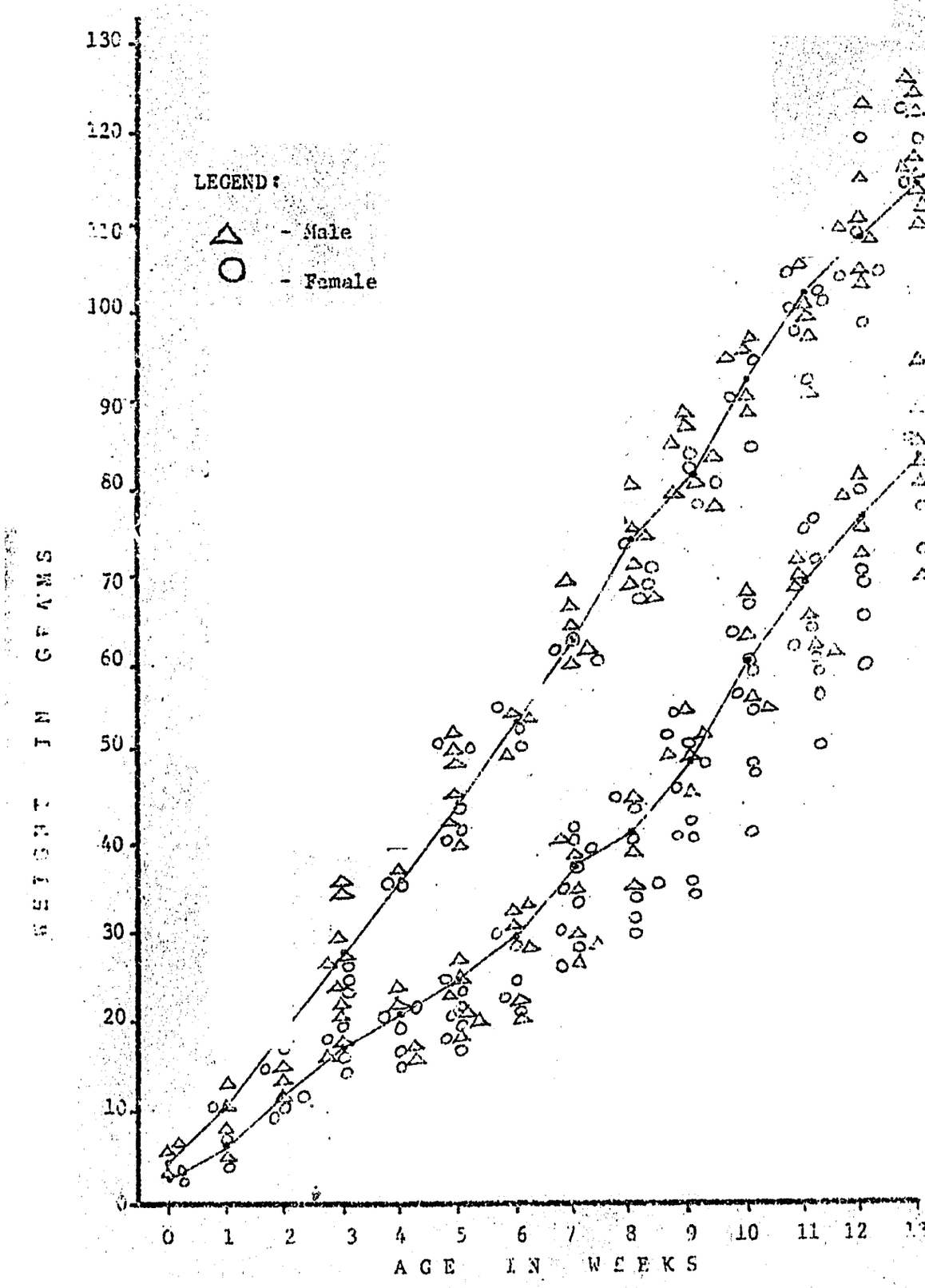

Figure 2. Weekly weight of two groups of young Rattus rattus mindanensis. The lines indicate the average weight at weekly intervals.

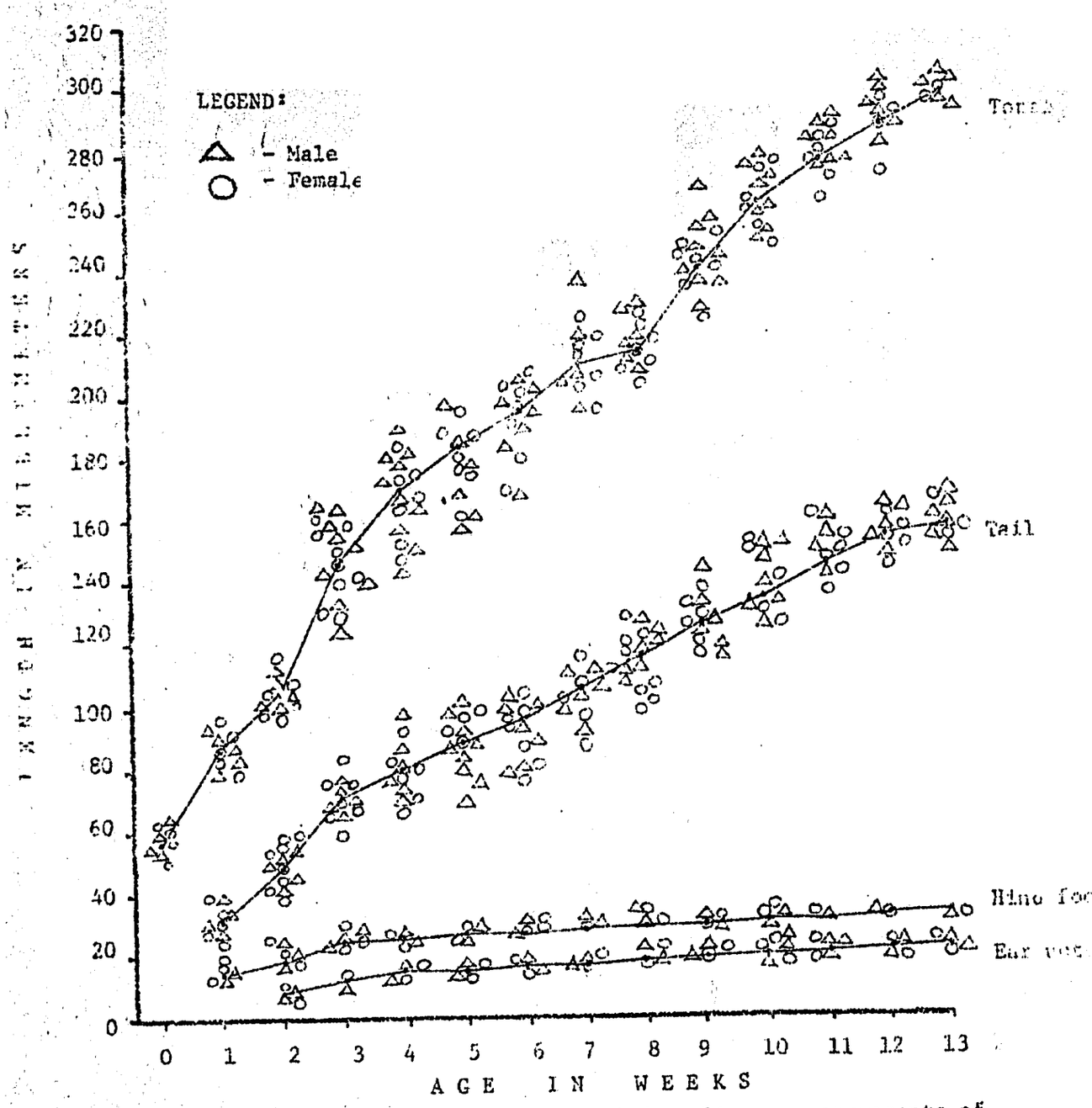

Figure 3. Absolute growth curve of four linear measurements of Group I *Rattus rattus mindanensis*. The lines are the average values of the eight litters at weekly intervals.

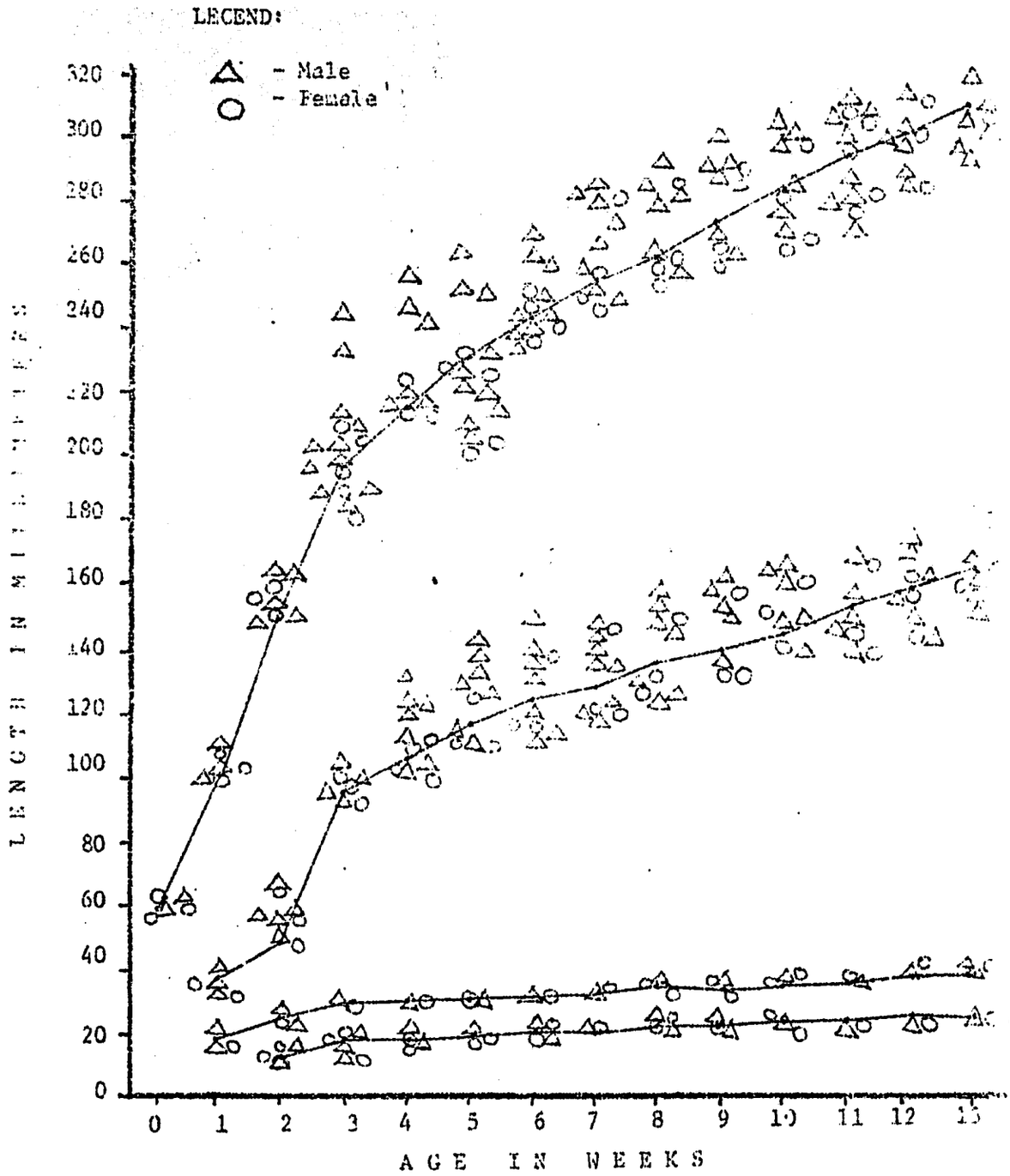

Figure 4. Absolute growth curve of four linear measurements of Group 2 Rattus rattus mindanensis. The lines are the average values of the six litters at weekly intervals.

Figure 5. Male (lower) and female (upper, Rattus rattus mindanensis Mearns at sixth day of age. (Litter 1, rat 5 & 1).

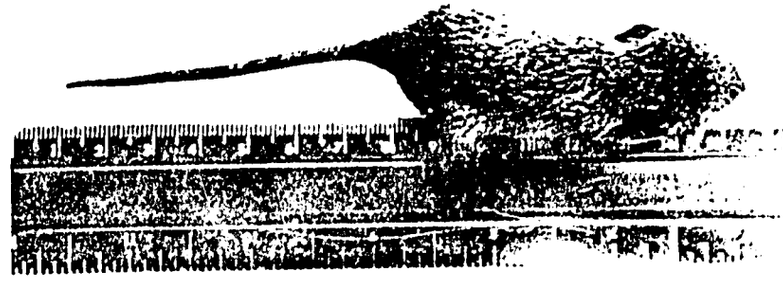

Figure 6. A male R. r. mindanensis at fifteenth day of age. (Litter 7, rat 3).

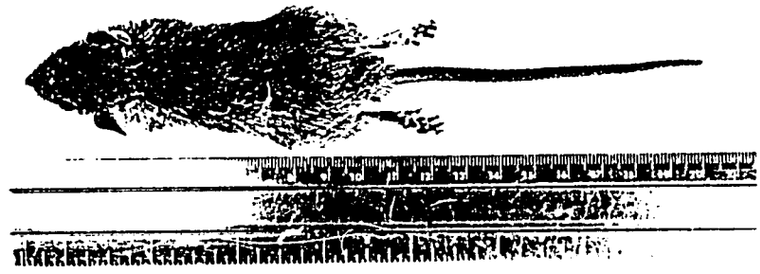

Figure 7. A male Rattus rattus mindanensis Mearns at twentieth day of age. (Litter 8, rat 2).

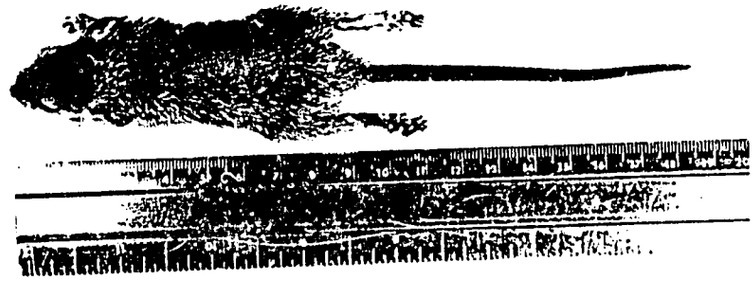

Figure 8. A female R. r. mindanensis at twentieth day of age. (Litter 9, rat 1).

(Table 11) indicates a highly significant difference between Group I and Group 2 animals and between males and females of the two groups taken together. There was also significant difference in the interaction between groups and sexes. Correlation analysis at birth (Table 12) showed that there were significant differences between weight and total length in the females of both groups, and in males and females combined of Group I. There were no significant differences between weight and total length in males of both groups and in males and females combined of Group 2.

Initial average total length was 59.53 millimeters, ranging from 54 to 65 millimeters. No other measurement was taken at birth of the young rats. With respect to total length, animals of Group I were slightly shorter than those of Group 2.

Two weeks after parturition, the average weight for males was 15.6 grams (range, 10.5 to 22.3 grams) and the mean total length was 130 millimeters (range, 106 to 164 millimeters). The females attained an average weight of 14.8 grams, ranging from 9.5 to 19.2 grams and the mean total length was 134 millimeters with a range of 105 to 159 millimeters.

Apparently, in nature young rats increase in weight as the number of day increases. [illegible] data obtained for the relation between total length, lengths of head plus body, tail, and hind foot of the young rats and age gave similar results. Table 13 presents the correlation coefficient and regression line between age and each of the dependent variables. The results showed highly significant differences at 1 per cent level.

Table 11. Analysis of variance for the weight of male and female rat at zero age.

Sources of variation	Degrees of freedom	Sum of squares	Mean squares	F-values
Group	1	1.841	1.841	19.795**
Sex	1	1.203	1.203	12.940**
Interaction	1	0.441	0.441	4.740*
Error	44	4.092	9.299	

Table 12. Simple correlation analyses between variables in males, females, and combined for Group I and Group 2 at birth, weaning, and maturity time.

	Group I (field-bred)			Group 2 (laboratory-bred)		
	Male	Female	Combined	Male	Female	Combined
Birth						
Wt.-to. length	.3991	.8021*	.7270*	.1774	.6230*	.0640
Weaning						
Wt.-to. length	.5860*	.6798*	.6244*	.8945*	.3437	.7949*
Wt.-body + head	.4004	.1418	.2650	.8896*	.5640*	.8130*
Wt.-tail length	.5663*	.8421*	.7141*	.2678	.6721*	.0883
Wt.-hind foot	.3954	.7308*	.5952*	-.1776	-.1105	-.1344
Wt.-ear notch	-.2706	.4238*	.0202	-.2730	.0678	-.1704
To. lt.-body + hd.	.6725*	.7255*	.8002*	.9615*	.9291*	.9510*
To. lt.-tail lt.	.6835*	.7088*	.6904*	.4000	-.0310	.3302
To. lt.-hind foot	.3821	.5373*	.4660	-.2264	-.1870	-.1986
To. lt.-ear notch	.1924	.1758	.1798	-.2196	.1430	-.1407
Body + head-tail lt.	.2397	.0289	.1185	.1426	-.3984	.0224
Body + head-h. foot	.4193	.0593	.1872	-.1682	-.1716	-.1628
Body + head-ear n.	.4431	-.1656	.2381	-.2338	.1909	-.1489
Tail lt.-h. foot	.1328	.7197*	.5455*	-.2568	.0006	-.1453
Tail lt.-ear notch	-.2795	.4251	.0104	-.0147	-.1773	-.0003
H. foot-ear notch	-.1614	.6638*	.1877	.7885*	.3568	.6818*
Maturity						
Wt.-to. length	.4624*	.3346	.8654*	.6555*	.8175*	.8339*
Wt.-body + head	.4051	.1598	.8087*	.4414	.8769*	.8179*
Wt.-tail length	.4332	.2843	.8252*	.7018*	.6956*	.7952*
Wt.-hind foot	.0078	-.5991	.4877*	.2583	.1062	.7745*
Wt.-ear notch	.7509*	.6122*	.7535*	-.1278	.3580	.5949*
To. lt.-body + hd.	.9092*	.6931*	.9392*	.8819*	.9663*	.9410*
To. lt.-tail lt.	.9028*	.8144*	.9543*	.9777*	.9627*	.9781*
To. lt.-h. foot	.2524	.2410	.6529*	.5491*	.2800	.7353*
To. lt.-ear notch	.0850	-.0040	.5053*	-.3186	.5313	.4564*
Body + head-tail lt.	.6419*	.1754	.7990*	.7633*	.8608*	.8498*
Body + head-h. ft.	.4830*	.0871	.6328*	.2764	.2159	.6234*
Body + head-ear n.	-.0135	-.2148	.4054	-.2184	.5314	.5255*
Tail-hind foot	.0212	.3180	.6176*	.6295*	.3[illegible]0	.7577*
Tail-ear notch	.1705	.1417	.5365*	-.3394	.4325	.3873*
Hind ft.-ear n.	-.0957	-.3405	.2112	-.3103	.5888*	.5640*

Table 13. Correlation coefficient and regression line between age and each of the dependent variables.

Dependent variable	r	Regression line[1/] $\log Y = a + bX$
	Male	
Weight (gm)	0.9203**	2.2650 + 0.0338X
Total length (mm)	0.9764**	4.6208 + 0.0160X
Body + head (mm)	0.9862**	3.8637 + 0.0383X
Tail length (mm)	0.9612**	3.1194 + 0.0695X
Hind foot (mm)	0.9877**	2.4977 + 0.0394X
	Female	
Weight (gm)	0.9133**	2.1267 + 0.0353X
Total length (mm)	0.9771**	4.5828 + 0.0163X
Body + head (mm)	0.99879**	3.8255 + 0.0392X
Tail length (mm)	0.9586**	3.0530 + 0.0708X
Hind foot (mm)	0.9857**	2.4310 + 0.0394X

[1]Y is the dependent variable, a is Y-intercept, and X is time.

Weaned and mature rats

At weaning, average weight of the ricefield rat was 22.81 grams (range, 15.5 to 37.1 grams). Male rat weighed 1.05 grams more than the female at this time, until the ninety first day when the difference became 12.1 grams. The average total length, body plus head length, tail length, hind foot length, and ear notch length were 177 94, 83, 26, and 14 millimeters, respectively. Simple correlation analyses between variables in males, females, and combined for the two groups at weaning and at maturity are presented in Table 12.

There were more significant differences between weight and total length, weight and body plus head length, weight and tail length, total length and body plus head length, total length and tail length, and hind foot and ear notch lengths. At weaning, the correlation analyses of hind foot length and ear notch length to any of the variables were declared not significant. Also, the relation between body plus head length and tail length was not significant.

At maturity, descent of testes for males and vaginal perforation for females, individual weights ranged from 33.3 to 89.2 grams and averaged 63.20 grams. Average total length was 248 millimiters; body plus head, 120 millimeters; tail, 128 millimeters; hind foot 30 millimeters; and ear, 19 millimeters.

The correlation analyses obtained between variables reaching the age of maturity were declared all significant, except for four relationships between total length and ear notch, body plus head and ear notch, tail and ear notch, and hind foot and ear notch, which were not significantly different.

Table 14 summarizes the size of the ricefield rat at various stages of maturity with reference to weight and body plus head length. The use of weight and body plus head length at which 50 per cent of the animals possess a given characteristic is preferable to the 100 per cent level, since the latter may be unduly affected by a few slowly maturing individuals (Jackson and Barbehenn, 1958). These 50 per cent points were approximated by visually fitting data plotted on arithmetic probability paper (Davis, 1964).

The weight and body plus head length at which 50 per cent of the rats have eruption of third molar was 38 grams and 101 millimeters, respectively. Skull ossification was attained at a weight of 45 grams and at 105 millimeters body plus head length. Jackson and Barbehenn (1958) noted a slight difference of these characters in the Rattus rattus.

The weight and body plus head length at which 50 per cent of the 34 females have the vagina perforate was 49 grams and 108 millimeters, respectively. Marges (1972) obtained 54.45 grams weight for the same species.

In the males, testes became scrotal in position at 68 grams and when the body plus head length was 123 millimeters. The appearance of sperms in the cauda epididymis among the 12 male rats examined was attained at a 50 per cent point weight of 99 grams and at a body plus head length of 142 millimeters. The lightest fecund male recorded was heavier than the lightest fecund female which was also recorded in the populations of Mus musculus in different environments (Laurie, 1946).

Table 14. Size of the ricefield rat at various stages of maturity.

Characters	No. of rats	Weight (gm) at 50% point	Body + head length (mm) at 50% point
Eruption of third molar	74	38	101
Ossification of skull	74	45	105
Vaginal orifice perforate	34	49	108
Testes scrotal in position	40	68	123
Sperm in cauda epididymis	12	99	142

Other Observation

Foster mothers

Foster mothers may be substituted with marked success, particularly in the albino strain (Harris, 1965). This observation proved true with the ricefield rat when three young (two males and one female) grew and reached maturity from nourishment and care provided by foster mother.

A litter of six newly born individuals were found in a lowland ricefield and brought to the laboratory. The three were discarded while the other three were distributed each to mothers of litter no. 7, 8, and 9 with six young each who by the time were nourishing their litter.

No daily weighings and measurements were performed on these animals except on the day of captivity, weaning and maturity. Table 15 shows the mensural data gathered. At birth the males weighed 3.6 grams while the female weighed 3.4 grams; total lengths were almost the same. The males have descended testes at 63 and 61 days while the female had perforate vagina at fifty third day. The three rats when grown to maturity were comparable in weight and measurements with the animals whose litter they were being mixed with during their pre-weaning growth.

Table 15. Weight (grams) and linear dimensions (millimeters) at birth, weaning, and maturity time of three rats reared by foster mother.

Rat no.	Sex	Weight	Total length	Body & head	Tail length
		Birth			
1	M	3.6	59		
2	M	3.6	58		
3	F	3.4	58		
		Weaning			
1	M	24.5	184	87	97
2	M	22.6	157	84	73
3	F	23.8	169	93	76
		Maturity			
1	M	58.2	275	130	145
2	M	51.9	273	128	145
3	F	42.4	238	113	125

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