A LABORATORY COLONY OF THE POLYNESIAN RAT, *RATTUS EXULANS*

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ABSTRACT.—A colony of Polynesian rats, *Rattus exulans*, descended from stock captured in the Marshall Islands was maintained in captivity through eight generations. Most monogamous pairs remained compatible for life. Females are polyestrous and breed throughout the year. Litter size ranged from one to 10 (average 3.8); the mode was four. Efforts to increase litter size by selection were unsuccessful. Females bore one to 13 (average 5.2) litters per year but usually had a lifetime production potential of 12 months or less. The maximum litters per lifetime was 18. Minimum nonlactating gestation was 23 days. Lactation prolonged gestation 3 to 7 days. The breeding cycle includes a post-partum estrus.

The Polynesian or Pacific Island rat, *Rattus exulans*, is common on islands of the central and western Pacific Ocean and on the mainland of southeastern Asia. Although sometimes associated with humans, it is not an obligate commensal and well-established populations occur far from man and his culture (Harrison, 1957). Except for limits probably imposed by climatic tolerances, *R. exulans* seems almost as adaptable and resourceful as *R. rattus* and *R. norvegicus*. Recent studies (Storer, 1962) provide a vast array of information on the ecology of *R. exulans* in the Pacific area. Rats on the Marshall Islands, where my foundation stock originated, were assigned by Johnson (1962) to *Rattus exulans exulans* (Peale, 1848).

This report deals with a laboratory colony maintained for the past 6 years (1962 to 1968) at the Faunal Laboratory to provide Polynesian rats for experimental studies by the staff of Ecology and Epizoology Research, a University of Utah project at Dugway, Utah. Methods used to rear the rats through eight generations are presented together with data on reproduction and behavior. Of special interest is the information on reproductive potentials, details of which have not previously been reported. The colony was still in existence in 1969 and producing about 200 animals per year.

The Polynesian rat is among the smaller species in the genus *Rattus* and presents a generally more delicate, attractive appearance than many of the larger species. Laboratory-reared males are significantly heavier than females; average weights of 55 adult males and 49 nonpregnant, nonlactating adult females were 145.5 and 107.5 grams, respectively. Weight in grams of 31 newborn *R. exulans* ranged from 2.1 to 3.4 (average 2.6). Relatively speaking, growth and development is similar to that of the Norway rat.

MATERIALS AND METHODS

Source of Original Stock

Foundation stock was obtained by an Ecology and Epizoology Research field party in May of 1962 on Japtan Islet, Eniwetok Atoll, Marshall Islands. The animals were shipped

by air to Dugway, where they were quarantined for 90 days. After it was certain that all were free of disease and ectoparasites, four pairs were selected and transferred to the Faunal Laboratory and held 3 more months apart from other animal colonies and disturbances connected with normal work routine. The breeding program was initiated during this latter period. All the animals produced thus far were descendants of three males and two females that successfully bred.

Care and Management

Breeding stock and weaned young were housed in stainless steel cages (60 by 35 by 20 centimeters) with lids slotted in a design that left the corners of the cages darkened but permitted adequate light and ventilation. Shavings of coarse sawdust were used for floor material and cotton linters were provided for nesting. Temperatures in the building averaged 70° (65 to 75) F. Humidity was unregulated. Natural light entered the animal rooms through a few widely spaced windows; during working hours, three fluorescent lights provided additional illumination.

All rats were fed a basic mixture composed by volume of 60 per cent rolled barley, 20 per cent alfalfa hay leaves, 10 per cent sunflower seeds, and 10 per cent pigeon feed (wheat, corn, milo, dried peas, and vetch) supplemented with commercial mouse pellets *ad libitum*, dry dog food, and a weekly feeding of a quarter of an orange and piece of raw carrot. About every 6 or 8 weeks the orange was dipped in a water soluble multivitamin preparation. I forced breeding stock to subsist partly on the mouse pellets and dog food by regulating the amounts of their other rations. Water was provided at all times and was a necessary part of the diet.

Rats were handled with 12-inch, rubber-tipped forceps. A rat gripped firmly but not painfully tight at the base of its tail usually could be lifted and transferred without causing the animal to struggle or otherwise attempt to free itself. When changing cages or removing litters, every effort was made to capture animals without unduly alarming those remaining. If possible adults were captured first. Young rats were less likely to panic or recognize the open lid as an escape route. Adult females were more excitable than males.

Initially, pairs were separated as soon as the female became visibly pregnant and were reunited when the litter was weaned. This policy was continued until sufficient stock had accumulated to risk testing other arrangements. The best results were obtained from pairs chosen when the animals were 1 to 2 months of age. Once found to be compatable, pairs were left together as long as they continued to produce young. Animals that failed to reproduce within 6 months after pairing were discarded. Cages were inspected weekly for new litters and changed each time a litter was weaned or every 5 or 6 weeks, if no young were born. Litters were removed when they were 23 to 25 days of age and separated by sex into groups of not more than four individuals.

Results and Discussion

Breeding Habits

No data on breeding habits for wild *R. exulans* from Japtan Islet were obtained, making it impossible to identify any changes in reproductive mechanisms attributable to captivity. Many small islands of the Eniwetok Atoll provide seemingly ideal conditions for Polynesian rats. Natural enemies and competing species are absent and there is an unfailing supply of coconuts for food. On Japtan Islet, for example, the field team collected as many as 100 rats in one night from a line of 10 traps checked 10 times at regular intervals. It seems unlikely that conditions favoring high populations and low mortality

could continue for many generations without genetic selection for changes in physiological and behavioral mechanisms that regulate numbers. Diseases and density-dependent stress phenomena are other possibilities but none was detected in the short-term studies on the islet.

In captivity, Polynesian rats were polyestrous and bred throughout the year but with a moderate, regular slackening of the birth rate in August and September for most years. This generally agrees with the findings of Harrison (1955) for *R. exulans* in Malaya, but is contrary in some respects to data presented by Jackson (1962) for the species in the Pacific area, where breeding in wild populations varied with locality and patterns sometimes changed annually in the same population.

The cage design did not permit observations of courtship behavior and no studies were made of breeding cycles. Presumably, sexually mature females experience the 3-day to 6-day estrus found in related species such as *R. norvegicus* (Long and Evans, 1922), *R. conatus* (McDougall, 1946), and *R. assimilis* (Taylor, 1961). The minimum interval between the date of pairing and birth of the initial litter was 23 days, which probably approximates the gestation period for nonlactating pregnancies. Lactation prolonged gestation by 3 to 7 days. Post-partum heat usually occurred 24 hours or less after parturition.

Polynesian rats bore one to 13 (average 5.2) litters annually. The number of litters per lifetime ranged from one to 18 but the lifetime average of 6.3 was only slightly higher than the annual average, indicating that few females bred longer than 12 months in captivity. The maximum number of young produced in a lifetime was 84 (by a female that bore 18 litters).

Females were 28 to 170 days of age when they were paired and were 72 to 239 (average 137.1) days old when they produced their first litter. The interval of 23 to 145 days (average 62.9) between date of pairing and birth of the initial litter seemed independent of the age of the female when she was paired. The youngest females to conceive were 49 days of age; the oldest breeding female bore her final litter when she was 782 days old. About 28 per cent of the pairs failed to produce young but this rate began to decline after the sixth generation.

Litter Size

Females have eight mammae, arranged as two pectoral and two inguinal pairs, and should be potentially capable of rearing as many as 12 young (deer mice, *Peromyscus maniculatus*, with only six mammae, reared litters of 12 and 13 at this laboratory).

Litter size in *R. exulans*, based on 832 young in 221 litters, ranged from one to 10 (average 3.8). The mode was four. These represent the lifetime efforts of 37 females and include the smaller than average initial litters as well as litters of one and two that often preceded reproductive senility. The average

litter size according to litter number did not vary much from the overall average until litter 15, when it fell to 2.0 and did not rise above 2.5 through litter 18. Harrison (1955) reported a mean of 4.3 embryos for wild *R. exulans* in Malaya.

In my experience, 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. The California mouse (*Peromyscus californicus*), canyon mouse (*Peromyscus crinitus*), and Polynesian rat are examples. The latter species seemingly has the best possibilities in this direction because the number of mammae greatly exceed its average litter size. Other species such as the deer mouse responded readily to breeding programs designed to increase litter size or lengthen the breeding season; the average litter size in this colony was increased by two young per litter in 12 generations. The average litter size for *R. exulans* remained virtually unchanged through eight generations of captivity despite the careful selection of breeding stock and other efforts to increase it.

Sex Ratio

The sex ratio among 198 litters that suffered no known losses between birth and weaning was 47.3 per cent males to 52.7 per cent females. Jackson (1962) found that sex ratios of wild Polynesian rats varied according to age and weight class with an average of 51.1 per cent males.

Behavior

Polynesian rats tolerated their own kind to a degree unknown among most of the larger rodents with which I am familiar. For example, up to 10 animals of mixed ages but of the same sex could be housed together without signs of strife. Adult females endured the presence of weaned young after the birth of their next litters and all usually shared a common nest. Several old adults of the same sex would live together indefinitely without establishing obvious hierarchies or peck orders. In breeding pairs, social dominance was often demonstrated. Females with nursing young invariably nested apart from their mates, and the location where the male rested at this time was determined by the female. Some permitted the male to take up a position just outside the entrance to the natal nest, but others forced him to occupy the corner farthest removed from the young. These arrangements seemingly were accepted by males, and they never seriously challenged the *status quo*. The more aggressive females reinforced their dominance by biting males on the tail, hindquarters, and scrotum. Many of the older males in the breeding colony had partly docked, badly scarred tails. In contrast, even the oldest females had complete tails, and they generally presented a sleeker, better groomed appearance than their mates. Harrison (1955) found more wild male *R. exulans* than females with damaged tails. Two pregnant females near term killed their mates. These deaths were

not sudden, but were the cumulative result of numerous wounds and constant harassment that prevented the animals from obtaining sufficient food and water for several days.

Polynesian rats have a sebaceous gland along the midventral region of the abdomen (Quay and Tomich, 1963), but I never observed them posturing in a manner suggesting the use of this gland for marking objects with scent.

Polynesian rats are poor at constructing nests. Cotton may be an unsuitable substitute for what is used in nature. Most females bore their litters in simple depressions excavated in floor material under the cotton. The cotton usually was not incorporated into the nest proper and was seldom moved from the location where it was placed when the cage was prepared for occupancy. When the accumulation of hay, shavings, and cotton permitted, a simple system of tunnels was established. Males excluded from natal nests never attempted to move nesting material to the part of the cage where they rested.

I never observed rats of any age storing food even though some of the items in their rations were always present in excess of needs.

A few rats, perhaps 1 per cent of those born, became what I called compulsive twirlers. This behavior appears to be genetic and analogous to heritable stereotyped somersaulting in house mice (Grüneberg, 1952). Afflicted individuals were always thin and undersized, some being less than half the size of normal animals of the same age. Most (90 per cent) of the twirlers were females, and this may have been coupled with their naturally nervous, more excitable nature. Only two twirlers produced litters and the young died before weaning age. Some of the animals twirled spontaneously but most of the twirling was triggered by some small disturbance such as removal of the water bottle or raising the cage lid.

Approximately 10 per cent of the offspring in the first four generations did not adjust well to captivity. Most of these spent much more than a normal amount of time in hiding, became obese and developed abnormally long nails, especially on the hind feet. Few produced young, and I avoided saving any of them for breeders. By the eighth generation, selection had apparently eliminated animals of this kind from the colony.

Conclusions

Polynesian rats offer some possibilities as a laboratory animal. They are larger than hamsters but smaller than the Norway rat, relatively easy to rear, and virtually odorless. No disease of any kind has been detected in the colony. Succeeding generations in captivity should result in continued improvement of reproductive performance and better adjustment to cage life. Nutritional studies no doubt could improve the diet.

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