THE ECOLOGY OF THE OSAGE WOOD RAT, *NEOTOMA FLORIDANA OSAGENSIS* BLAIR, WITH EMPHASIS ON THE HELMINTHS OF THE HOST

By

MELVIN F. MURPHY II

Bachelor of Science

Colorado Agricultural and Mechanical College

Fort Collins, Colorado

1948

Submitted to the Department of Zoology

Oklahoma Agricultural and Mechanical College

In Partial Fulfillment of the Requirements

for the Degree of

Master of Science

1950

THE ECOLOGY OF THE OSAGE WOOD RAT, NEOTOMA FLORIDANA OSAGENSIS BLAIR,

WITH EMPHASIS ON THE HELMINTHS OF THE HOST

MELVIN F. MURPHY

MASTER OF SCIENCE

1950

THESIS AND ABSTRACT APPROVED:

Walter P. Taylor
Thesis Adviser

Ivendell Krull
Thesis Adviser

H. J. Featherly
Faculty Representative

H. C. McClosky
Dean of the Graduate School

ACKNOWLEDGMENT

I wish to express my sincere appreciation to Drs. Wendell H. Krull and Walter P. Taylor of the Department of Zoology for their guidance and valuable suggestions in carrying out this investigation, and to Dr. D. E. Howell of the Department of Entomology for his identification of the ectoparasites.

TABLE OF CONTENTS

INTRODUCTION

The Osage Wood Rat, Neotoma floridana osagensis, was described as a subspecies by Blair in 1939, and since that time nothing has been published on either its ecology or parasites. In view of this, it seemed that much could be learned about the habits, habitats and parasites of this animal that would be of value to pure as well as applied science.

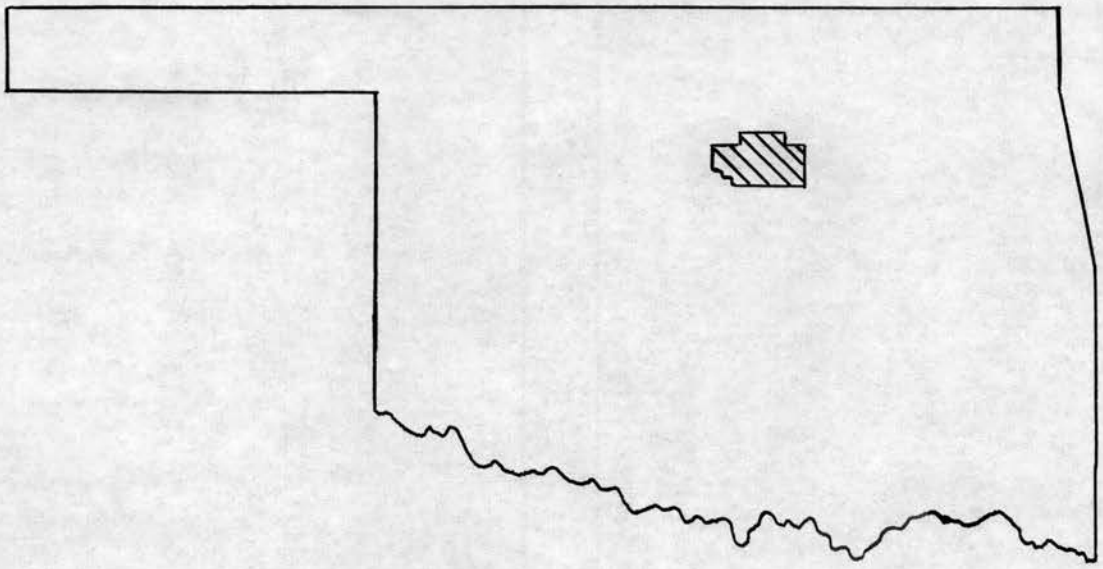
After considering the possibilities of such a problem and deciding that it might prove fruitful, the literature on both the ecology and parasites of related species and subspecies was perused. This was done not only to become familiar with the published work on wood rats but also to determine the best approach to such a problem.

From the literature it was determined that very little work has been done on the helminth parasites of wood rats. Only seven species have been reported from the entire genus Neotoma which includes over ninety named species and subspecies, all of them confined to the North American continent. The ecology of some species has been extensively studied but only short notes have been published on many of the others. The literature on the Osage Wood Rat consists of the original description and a few distribution records.

Since Payne County, Oklahoma lies well within the known limits of distribution of the subspecies N. f. osagensis, it was decided to use this area as a unit within which to study its ecology and helminths. The area of study is shown in Figure 1. It was decided that the close proximity of the area to Stillwater would be favorable from the standpoint of convenience for observational and trapping studies, and that parasites could be collected under ideal conditions for preservation.

This investigation was begun in January 1949, and continued until May 1950. The following objectives were considered to be tenable: To determine what genera and species of helminths are present in the wood rat; to determine if any of these helminths are new to science; to determine if the wood rat serves as a reservoir host for any helminths in domestic or game animals; to determine the relation between the helminths and ecology of the wood rat; to determine the habitats of the wood rat; to determine the food habits with particular emphasis on the relative amounts and composition of animal and plant matter; to determine the associates or commensals of the wood rat and to ascertain what animals use the unoccupied wood rat dens; to collect data on reproduction in the wood rat. Data were accumulated in all phases of the study, and this manuscript is based on them.

FIGURE I



AREA OF INVESTIGATION

REVIEW OF LITERATURE

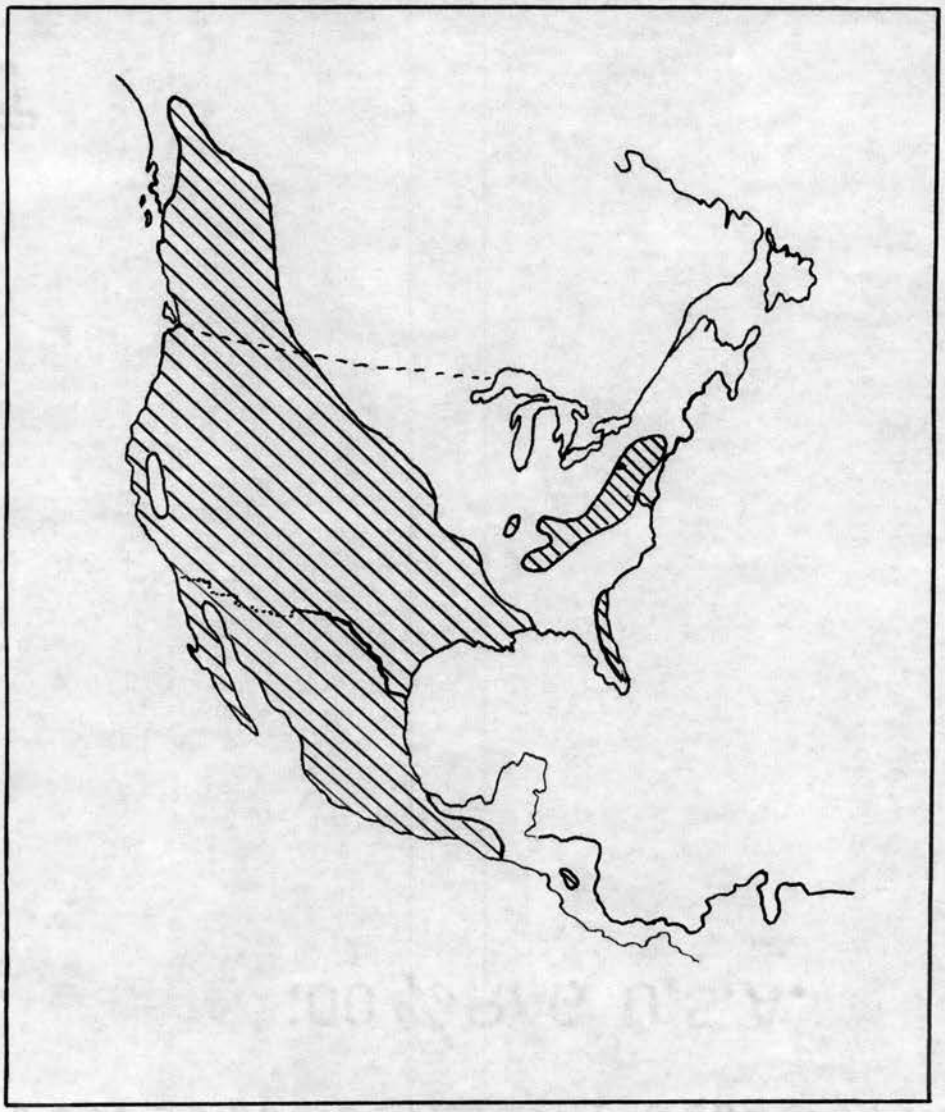
In any research work, a thorough review of the literature relative to the problem is essential. Such a review not only acquaints the worker with the accomplishments in that field but also serves as a basis for establishing any new findings that may be of some value to science. Therefore, in this problem, it was necessary to review the work that had been done on both the ecology of the Osage Wood Rat and the parasites reported from the various species in the genus Neotoma.

Apparently no research work has been done on Neotoma floridana osagensis. The subspecies was described by W. Frank Blair in June 1939, and he mentioned it again in his paper on the mammals of Oklahoma. In his original description (1939a, pp. 5-7) he gives N. f. osagensis the common name, the Osage Wood Rat, but in his paper on the mammals of Oklahoma (1939b, p. 124), he refers to it as the Eastern Wood Rat. It is the opinion of the writer that the original common name should be used, not only because of its priority, but also because of the similarity of the common and specific names. Consequently, in this paper, it will be referred to as the Osage Wood Rat.

Because so little is known about the Osage Wood Rat, it was necessary to study the literature on closely related species to gain an understanding of their habits and activities. This information could then be used as a basis for comparisons with the Osage Wood Rat.

Wood rats, commonly referred to as pack rats, trade rats, and occasionally as bush rats, are confined to the North American Continent and have been known for two hundred years. The distribution of the genus is shown in Figure 2. They were first reported by Peter Kalm in 1749, who cited John Bartram of Philadelphia as authority for the statement

FIGURE II



DISTRIBUTION OF THE GENUS NEOTOMA

FROM GOLDMAN, 1910

that he saw a large number of rats living among the rocks and cliffs in the Blue Mountains of Pennsylvania. He further stated that these rats came out only at night and were extremely vociferous. Ord (1818) sent a short description and a figure of a wood rat taken from eastern Florida to the Philomatique Society of Paris. The description and figure were published under the scientific name of Mus floridanus. De Blainville, who prepared the account for publication, questioned the generic name Mus. Meanwhile, in 1825, Say and Ord had discovered the peculiar dental characteristics of the species and published a diagnosis of a new genus Neotoma with Mus floridanus as the type. Merriam published two papers, one (1894a) on the revision of the genus Neotoma and the other (1894b) on the diagnosis of the subfamily Neotominae with a synopsis of the known species in the genus Neotoma. Goldman (1910) did the last extensive work on this group. He revised the genus, prepared keys for determining species, gave their geographical distribution, and submitted photographs of skulls to illustrate structures useful in identification.

The literature on the various species within the genus Neotoma is quite extensive. It consists mainly of short articles on some phase of the ecology or life history of particular species, but these may be fitted together so that they reveal a fairly complete composite, generalized life history.

Besides these short articles, there are three excellent publications, each of which gives a detailed account of a separate species or subspecies and they are considered here. In 1938, Vestal published his work on Neotoma fuscipes annectens in the Berkeley Hills, California, giving not only a fairly complete life history of this subspecies but also its biotic

relations. He gives a detailed account of the activities of the wood rat throughout a period of one year. His study area was 24.8 acres in size and included a total of 572 dens of which 516 were inhabited. An extensive manuscript was published by Poole (1940) giving his findings on Neotoma magister in Pennsylvania. His work was concerned with the activities of this wood rat in the field as well as in the laboratory. The third publication (Vorhies and Taylor, 1940) was on the subspecies Neotoma albigula albigula and is the most comprehensive and extensive of all. The complete life history and ecology of this subspecies were given, and also the relation of the wood rat to the grazing problems involving domestic animals in Arizona was determined.

A review of the literature on the internal parasites reported from the genus Neotoma showed that little research had been done in this field. Only seven different species of helminths have been reported for all the species and subspecies of wood rats. Only a single species of internal parasite has been reported from Neotoma floridana.

Hall (1916) reported Syphacia obvelata (Rudolphi, 1802) Seurat, 1916, in Neotoma mexicana fallax, and named and described Nematodirus neotoma from Neotoma mexicana fallax, N. desertorum, N. floridana baileyi, and N. cinerea rupicola. Stiles (1932) reported Moniliformis sp. from a wood rat in Florida, the only Acanthocephala reported from the genus Neotoma. Tucker (1942) named and described Nematodirus tortuosus from Neotoma lepida intermedia and N. fuscipes macrotis. Chandler (1945) named and described Trichuris neotomae from Neotoma fuscipes. Andrya neotomae was named and described by Voge (1946), and this is the only cestode reported from this genus. Tiner (1948) reported Rictularia sp. from the genus Neotoma. These constitute the total number of helminths reported.

METHODS AND MATERIALS

The various methods and materials used in any scientific research are of utmost importance and have a direct bearing on the success of such an undertaking. Therefore, it was concluded that these methods and materials should be considered in order to show their importance in this study, and to describe improvements that were modifications of standard techniques. The following methods and materials were used in obtaining notes on the ecology of the Osage Wood Rat.

As many different type habitats as were available were visited and the region explored for inhabited wood rat dens. Several traps, baited with rolled oats and peanut butter, were set in runways leading from the dens that showed signs of being active. This was done in the afternoon or evening because wood rats are nocturnal in habit and there would be less chance of the traps being sprung by some diurnal mammal or bird. Only two types of traps were used, the large wooden snap traps and the "Havahart" live traps. The following morning these traps were visited. If there were specimens in them, the geographical location of that den was recorded with additional notes as to the type habitat and the dominant vegetation within that area. Records also were made as to the type, size and site of the den and materials used in its construction. Some of the dens were dissected to determine the amount and type of stored food, nesting materials and the other inhabitants of the den. The wood rats that were captured alive were taken to the laboratory and placed in a cage for further study. The specimens taken in the snap traps were dissected and examined for parasites.

The cages in which the specimens were kept in the laboratory were of the "Wahamann" type. The top, sides, doors and back were made of

quarter inch mesh wire, whereas the floor was constructed of half inch mesh wire. A metal partition divided the cage, forming two separate compartments. Each compartment measured 11 inches wide, 20 inches long and 15 inches high. There were sliding trays below the floors which facilitated cleaning. Each pen was provided with a finger bowl full of water and a double handful of excelsior for nesting material. Full ration dog food of the pellet type and lettuce, celery, chard or cabbage leaves were used as food. The rats were kept in the laboratory where the research work was done which was a convenience in the study of their habits and activities in captivity.

The trapped specimens that were dead were refrigerated at a temperature of forty degrees Fahrenheit unless examined immediately. At this temperature the specimens could have been preserved for several days if necessary without destroying worms for taxonomic or other purposes, and, in addition, the worms were relaxed in their normal isotonic medium. All hosts, however, were examined for parasites within 24 hours after they were collected.

The following procedure was used in the examination of a host. The specimen was removed from the refrigerator; its weight and measurements were taken. These measurements included the totallength, length of tail, ear length from notch, length of hind foot, and weight. After recording these data, the skin was removed from the host and both the skin and body were examined for parasites, particularly the filarid type nematodes. The body cavity then was opened and the stomach, intestine, cecum, liver and lungs were placed in a container filled with cold water.

Before proceeding with the examination of the viscera, several pellets, to be examined for parasite eggs, were removed from the rectum of

the wood rat and placed in a sputum cup. A saturated salt solution was added to the pellets and the mixture was stirred with an applicator stick until the pellets were comminuted. More salt solution was added to the sputum cup until there was a reverse meniscus on the mouth of the cup. This mixture was allowed to stand for ten minutes which permitted the eggs to float to the surface. After this lapse of time, a clean slide was touched to this solution, lifted free, reversed quickly without loss of the solution, a cover glass placed on the slide and it was examined for eggs. This method was employed as a check to prevent overlooking any small helminths that might be present in the digestive tract.

After the salt flotation had been completed, the organs were separated and each was placed in a finger bowl filled with cold water. The organs were opened or teased apart and thoroughly washed. The washings were allowed to settle and the clear or semitransparent water was decanted into a separate dish. This washing procedure was repeated several times until the settled material appeared to be quite clear. The material that remained in the finger bowl was examined macroscopically for helminths. This was accomplished by placing the finger bowl under a light and above a dark background so that any worms or their movements would be quickly noticed. After removing worms by this method, the content of the finger bowl was examined microscopically with the appropriate powers of a widefield binocular dissecting microscope. The same procedure as outlined above was used to examine the original decanted material to be sure that no helminths had been lost. Any worms that were collected in either case were immediately transferred to watch glasses containing physiological saline and left until they were fixed.

The two cestode adults which were found during this study were removed from the saline and fixed in a cold solution of formalin, acetic acid and alcohol (FAA). They were in a partially disintegrated condition when they were removed from the host. After the tapeworms had remained in the fixative for twenty-four hours, they were transferred to a vial filled with seventy percent alcohol and stored in that solution until they were stained.

In order to identify the cestodes, it was necessary to stain and make permanent mounts of them. This was accomplished by transferring them from the seventy percent alcohol into successively weaker dilutions of alcohol and finally into a cochineal stain. After twenty-four hours had elapsed, they were removed from the stain, taken back up through the alcohols and into a mixture of seventy percent alcohol containing a three percent hydrochloric acid solution. The cestodes were left in this medium until most of the stain had been removed. Next they were placed in eighty-five percent alcohol and then ninety-five percent alcohol. A few drops of synthetic methyl salicylate were added to the last concentration of alcohol. This was repeated several times at twelve hour intervals and the alcohol was allowed to evaporate until the worms were finally in methyl salicylate. The tapeworms were cut into sections suitable for mounting and these pieces were placed on a slide. A drop of Canada Balsam was added to the mount and a cover slip placed over it. After the slides had dried for several days the specimens were ready for study.

The cestode larvae that were removed from the liver had to be dissected out of the cysts, placed in cold water, and kept in a refrigerator to allow them to relax. After relaxation they were fixed, under the

pressure of a slide, in FAA. Staining was accomplished in the same manner as was outlined for the adults.

The nematodes were removed from the physiological saline and fixed in a mixture of hot seventy percent alcohol containing four percent glycerine or in hot ten percent formalin. After fixation they were transferred to shell vials containing either the alcohol mixture or the formalin, labeled properly, stoppered with cotton plugs and stored in a large bottle of the appropriate solution.

In order to prepare the specimens for study, the worms that had been fixed in formalin were transferred to a solution of phenol and alcohol. This cleared the worms for temporary study but they could not be permanently mounted in this mixture.

To prepare a permanent slide of the nematodes, the worms that were fixed in the alcohol-glycerine mixture were placed in a covered watch glass and the alcohol allowed to evaporate, leaving the worms in pure glycerine. They were then transferred to slides which had been ringed with Black Asphaltum and shellac. A drop of heated glycerine jelly was placed over the specimen and a round cover glass dropped over each worm so that the edges came in contact with the asphalt ring. These slides were set aside to allow the jelly to harden, and then another ring of asphalt was applied around the edge of the cover slip so that the worm was sealed in the glycerine jelly.

Polyvinyl alcohol, another medium, proved to be quite useful in making permanent mounts of nematodes. This solution is made by mixing together fifty-six percent P.V.A., twenty-two percent phenol and twenty-two percent lactic acid by volume. The nematodes were mounted directly from either alcohol or formalin. The worms cleared and were ready

for study in forty-eight hours.

One species of nematode was extremely difficult to relax and as yet no relaxing method or fixative has proven satisfactory. These worms remained coiled when fixed with either hot alcohol or hot formalin. Some specimens were left in the refrigerator, in physiological saline, up to ten days without uncoiling. Some of the male nematodes relaxed slightly while in the refrigerator but the females remained tightly coiled. Other methods used in trying to relax or fix these specimens were as follows: Hot and cold FAA, water, nembutal added to physiological saline, killing in various fixatives from immediately after they were removed from the host to a retention period of ten days.

In studying the stomach nematodes, it was necessary to make an en face view in order to confirm the identification of species. This was accomplished by placing a worm that had been cleared in glycerine on a slide. A drop of hot glycerine jelly was dropped on the worm and allowed to gel. This slide was placed under a binocular dissecting microscope and, with the aid of a small piece of the cutting edge from a double edge razor clamped in a hemostat, the head of the worm was cut off. The gel was remelted over a flame and the head mounted in glycerine jelly as outlined for the nematode whole mounts.

After slides had been made of the helminths, they were identified, as far as possible, with the aid of a compound microscope and a camera-lucida. The camera-lucida proved extremely helpful in measuring the length of the worms while an ocular micrometer was satisfactory for measuring smaller organs and structures.

The diptera larvae and ticks, mites, and fleas were removed from the host and placed in vials of seventy percent alcohol. These specimens

were given to Doctor D. E. Howell, Department of Entomology, for identification since the ectoparasites were not part of this study.

ECOLOGY OF *NEOTOMA FLORIDANA OSAGENSIS*

There is a definite correlation between the ecology of an animal and the parasites that it harbors. Therefore, a knowledge both of the habits and habitat of the Osage Wood Rat was procured not only for its intrinsic value to science but also to gain a more thorough understanding of the parasitic fauna of this host. Both the ecology and the parasites of the wood rat are phases of this problem; however, for better continuity in presentation, these two subjects are discussed separately.

In order to appreciate more fully the ecology of the wood rat it is necessary to have a concept of the animal as to its size and physical characteristics. Consequently, a species description is given of *Neotoma floridana osagensis*.

DESCRIPTION: In general appearance the wood rat is similar to the brown rat (*Rattus norvegicus*) and many people believe them to be the same species. Taxonomically, however, they are in different families and differ in a number of respects. The pelage of the wood rat is finer and softer than the brown rat and the tail is covered with soft hair rather than hard scales. Although rat-like in appearance, the wood rat is mild in temperament, not destructive, and much cleaner. Its habits and habitats are very different and it is not associated with man as is the brown rat.

The original description of the Osage Wood Rat was given by Blair (1939a) but because he did not include the weights with the measurements and for reasons already stated, it seems plausible to include a full description here.

The Osage Wood Rat is Sayal Brown in general appearance, with a middorsal line of Snuff Brown, moderately washed with black. This line disappears in winter leaving the dorsal surface lighter in color. The hairs on both the pectoral and anal regions are white, while on the abdominal region similar hairs have slaty gray roots. The front feet are white; the hind feet are white above, while their under surfaces are a slaty gray mixed with white. The tail is sharply bicolor, being blackish above and white below.

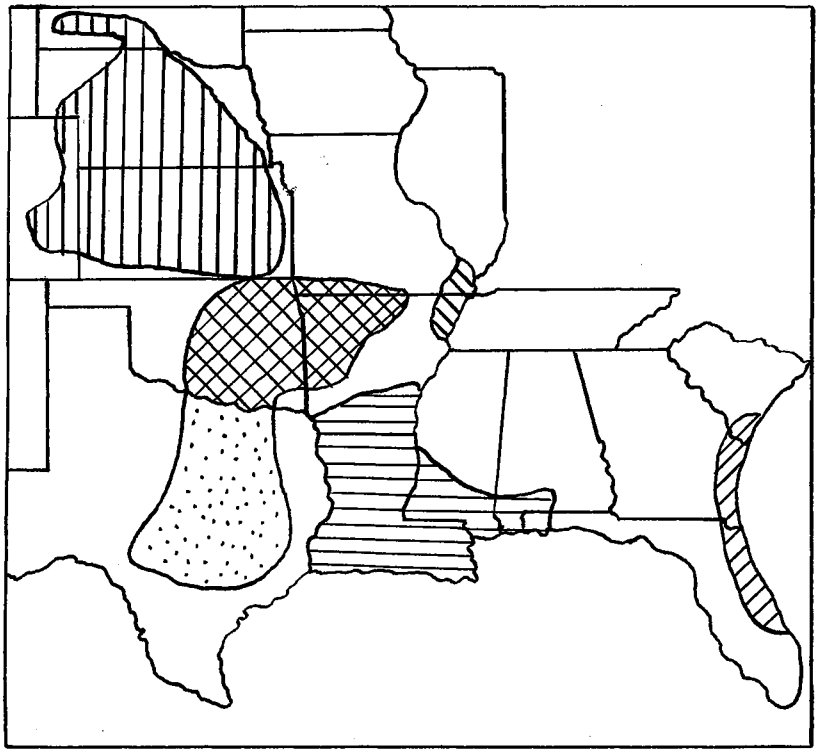
Average measurements for twenty-three males collected near Stillwater, Oklahoma, are as follows: total length, 362 mm. (range 300-404 mm.); tail vertebrae, 160 mm. (130-172 mm.); ear from notch, 26 mm. (24-27 mm.); hind foot, 39 mm. (36-41 mm.); weight, 283 grams (185-395 grams).

Average measurements for twenty-five females from the same area are: total length, 347 mm. (290-397 mm.); tail vertebrae, 156 mm. (127-171 mm.); ear from notch, 26 mm. (25-29 mm.); hind foot, 39 mm. (37-43 mm.); weight, 259 grams (171-359 grams).

Average measurements for the forty-eight adults of both sexes are: total length, 354 mm.; tail vertebrae, 158 mm.; ear from notch, 26 mm.; hind foot, 39 mm.; weight, 271 grams.

A description of a subspecies is not complete without giving its geographical distribution, but the exact range of the Osage Wood Rat is not known. However, trap records indicate that it occupies the eastern two-thirds of Oklahoma and adjoining parts of Kansas, Missouri, Arkansas and Texas. The approximate distribution of the subspecies is shown in Figure 3.

FIGURE III



DISTRIBUTION OF NEOTOMA FLORIDANA AND SUBSPECIES

REVISED FROM GOLDMAN, 1910

N. floridana

N. f. illinoensis

N. f. rubida

N. f. attwateri

N. f. baileyi

N. f. osagensis

HABITAT: The wood rats in the Stillwater area have a preference for two major type habitats - the post oak-black jack ravines and the fringed forest ravines. In addition to these, a few rats have been observed living in upland oak wood and in upland locust plantings, but, due to their insignificance to the ecology of the wood rat, these habitats will not be discussed.

Post oak (Quercus stellata)-black jack (Q. marilandica) ravines are prevalent in this region. They are dominated by these two species of trees and are characterized by having intermittent streams. On either side of such ravines there are usually projecting rocky ledges that afford ideal protection for wood rat dens. The intolerant plants in the oak ravine are yellow oak (Q. Muhlenbergii), bur oak (Q. macrocarpa) and native juniper (Juniperus virginiana). The tolerant species are smooth sumac (Rhus glabra), dwarf sumac (R. copallina), poison ivy (R. Toxicodendron), wild grape (Vitis cordifolia), common green briers (Smilax rotundifolia and S. pseudochina) and buckbrush (Symphoricarpos orbiculatus).

The fringed forest ravines are quite different from the post oak-black jack ravines in a number of respects. They have constant or intermittent streams, depending upon the time of year and amount of rainfall. These ravines are at a lower level than those of the post oak-black jack type and the soil of these has a higher moisture content. There are very few rocks here, but, when they are present, they are well covered with soil, leaving no spaces for the wood rat to construct a den. The intolerant plants in the elm ravine are the Kentucky coffee tree (Gymnocladus dioica), cotton wood (Populus deltoides), native pecan (Carya illinoensis), honey locust (Gleditsia triacanthos), hackberry (Celtis occidentalis), and black walnut (Juglans nigra). The tolerant

species are the smooth sumac, dwarf sumac, poison ivy, wild grape, common green brier, buckbrush, dogwood (Cornus asperifolia), redbud (Cercis canadensis), black willow (Salix nigra), and wild plum (Prunus americana).

These two types of habitat were surveyed equally well but there was a great difference in the number of rats collected from each. Each type habitat was visited alternately, and the same amount of ground was covered on each occasion. In the post oak-black jack association thirty-nine rats were trapped, while only thirteen were taken from the fringed forest habitat. The wood rat probably prefers the oak habitat to the fringed forest habitat for the following reasons:

1. The soil moisture content is lower.
2. There are more projecting rocky cliffs which the wood rat seems to favor for nesting sites.
3. There is a greater abundance of acorns.

THE DEN: The dens or houses of the wood rat vary widely in size and in the site chosen for their construction. In the post oak-black jack ravines the dens are usually built under projecting cliff rocks and only the entrances into the houses can be seen. These entrances may be very elaborate, consisting of openings through extensive piles of materials such as twigs, leaves, bark, stones, bones, and dried droppings of cows, horses and other animals. On the other hand, in a similar situation, the entrances to the dens may show only a few exposed sticks or leaves.

In some instances, even though projecting cliff rocks are available, the wood rat avoids the rocks and constructs its den in the open. This type of den is similar to the ones built in the fringed forest ravine habitat and will be described subsequently for that habitat.

The dens in the fringed forest ravine habitat, where rocks are few in number, are quite different from those in the post oak-black jack ravine habitat. In this environment the wood rats build their dens either around fallen trees, in brush piles at the base of a large tree, or under thick tangles of wild grape and green brier. These houses are constructed from approximately the same kind of materials that were used in building the dens in the other type habitat, but are usually much larger in size. Some of these dens measure as much as twelve feet in length by six feet in width and may have a height of over three feet.

The third type house, of which only three were found, is the aerial den which may be found in either type habitat. The first den of this type was found three feet above the ground in a juniper tree. It was constructed of juniper needles and oak leaves. This den was dissected and proved to be uninhabited. The second one observed was constructed in a locust tree and the third in a tangle of Vitis and Smilax. These two dens consisted of leaves, sticks, and other trash and both were occupied.

The number of openings into a den is variable and it seems to be correlated to some degree with the surroundings in which the den is constructed. The dens associated with rock ledges usually have only one entrance, although several dens were observed that had an additional entrance. Whenever a den had more than one entrance there was a larger space beneath the rock. This additional space apparently permitted the construction of an additional entrance. The dens having a greater number of entrances were those that were not associated with the rock ledges. In these there are usually four entrances on various sides of the den which enable the wood rat to enter or leave from almost any direction.

These additional entrances are undoubtedly related to the protection of the wood rat from its enemies.

The dens that were studied in the Stillwater area were not always occupied by wood rats. Only three wood rats were trapped in one area where sixteen dens were found. In another area of twelve nests, three rats were taken. Only fifty-five specimens were trapped from a total of 241 dens in all areas. On the basis of these data it is probable that only about twenty-three percent of the dens were occupied by wood rats. This is an exceedingly low den-rat ratio as compared with the study made by Vestal (1938) for Neotoma fuscipes. His area included 572 dens of which 516 were occupied.

However, in the fall of 1949 it was noted that many of the uninhabited dens were being reoccupied and field observations and trapping during the following spring verified the findings and indicated that the wood rat population was increasing.

The most plausible explanations for the low den-rat ratio for the year 1949 are:

1. Wood rats may be cyclic as to abundance and they were probably at a low ebb in their cycle.
2. The unusually hard winter that preceded this investigation may have killed off numerous rats.
3. Sufficient food may not have been stored to carry them through the severe winter.
4. Some epizootic may have reduced their numbers.
5. It may be a normal condition, of which no accurate knowledge has been obtained, due to predator pressure.

As a result of both the survey and dissection of the dens, it was

found that many of the uninhabited dens were occupied by animals other than wood rats. In many instances these animals lived in those dens that were occupied by wood rats. Table I lists the commensals, associates or occupants other than wood rats found in twenty-five occupied and twenty-five unoccupied dens.

TABLE I

ANIMAL INHABITANTS OF FIFTY NEOTOMA DENS

Type of Animal	Frequency 25 Occupied Dens	Frequency 25 Unoccupied Dens	No. Per Den
Invertebrate			
Ants	17	21	Numerous
Daddy longlegs	11	12	1 to 10
Other spiders	9	13	1 to 10
Sow bugs	7	11	1 to 5
Millipedes	4	9	1 to 10
Ground beetles	2	7	Few
Bumble bees		2	Few
Vertebrates			
Deer mice	3	8	1 to 2
Lizards	2	5	1 to 3
Cotton rats		3	1
Cottontail rabbits	1	2	1
Water snakes	1		1
Spotted skunk	1		1
Opossum	1		1

From Table I, it is apparent that there is little correlation between the arthropods of the occupied and unoccupied dens. Statistically, it would be impracticable to make calculations on the basis of these data for either the vertebrates or invertebrates since only fifty nests are involved. Nevertheless, it is interesting to note the variety of both invertebrates and vertebrates that inhabit or frequent wood rat dens.

THE NEST: The den consists of two major parts, an outer area composed of sticks and trash and an inner area where the wood rat lives and builds its nest. The nest is usually near the center of the den, more or less

spherical and measures approximately eight inches in diameter. It is usually constructed of several materials but occasionally only one item is used. The substances most commonly chosen for nests are grasses, shredded bark, bits of paper, string, rags and occasionally feathers.

According to Vorhies and Taylor (1940), it is the habit of some wood rats of another species to build subterranean nests beneath the surface dens. However, all the dens found by the writer have been on the surface of the ground or in trees.

Even though the nests are on the surface of the ground, they are still well protected. After severe rainfalls the inner portion of the dens and nests is still dry and warm. This is due to the fact that the den is always built where there is good drainage and the projecting cliff rocks or the twigs, leaves, bark, and debris making up the den keep the water from penetrating the nest.

GENERAL HABITS, INCLUDING CAPTIVITY: The wood rat is a solitary animal. It occupies the den which it builds and apparently lives there alone except during the breeding season and when rearing its young.

The wood rat is active throughout the year although it apparently stays within its shelter on wet or extremely cold nights.

Although the wood rat is primarily nocturnal in habit, several instances of daytime activity have been noted in the field. They have been seen especially in the late afternoon when traps were being set. Several wood rats were captured in traps about sunset but none was taken by this method during earlier hours. Consequently, it appears that, although there is daytime activity, it immediately precedes the dusk.

Trapping experience indicates that the wood rat is active during

the early hours of darkness but without more evidence it is impossible to tell whether they are equally active during all hours of the night.

The activities of the wood rat are not confined entirely to the ground. On one occasion a wood rat was chased from its den in mid-afternoon. It immediately climbed one tree and then jumped, with the agility of a squirrel, to an adjoining tree. The capture of the rat was accomplished by climbing the tree and with the aid of two sticks lifting it from its hiding place. Another rat, after being chased from its nest, ascended a tree and hid between the bark and pulp in a hollow formed by decay. After considerable harassing, the wood rat jumped to the ground some fifteen feet below and made its escape into the underbrush.

Wood rats have been kept successfully in the laboratory which made it possible to observe them in captivity. Three wood rats, two females and one male, were captured in August 1949. One female was destroyed, after giving birth to four young, because of poor physical condition. The remaining two are still alive after ten months in captivity. Another male, taken in February 1950, is also living after three months.

In the laboratory the activities are in many respects similar to those in the field. The rats sleep most of the day unless disturbed and show greatest activity during the first few hours of darkness. Their activities between midnight and morning have not been observed.

The two females showed a tendency toward giving up some of their wildness in captivity. They would come to the door of the cage for their food but never acquiesced to the extent of taking food from the hand of the feeder. The males, on the other hand, were not as gentle as the females and would cower in the back of the cage when the door was opened.

The usual sites of food storage and defecation were at opposite corners, although one male insisted on storing his food in the center of the cage. The food pellets were always kept in a neat pile. Whenever the rats were fed they carried their food to the place chosen for storage or if their existing store was scattered about the cage, they immediately returned it to the storage area.

A few interesting observations were made concerning the tolerance of one wood rat for other members of the same species. On February 10, 1950, a male wood rat that had been kept in captivity for six months was placed with a female that had been in the laboratory an equal length of time. The female attacked at once. The male, sensing trouble, squealed, scrambled to the top of the cage and hung there, trembling. Each time he braved a descent, the female drove him back to his refuge but did not follow him there. After several hours had elapsed, the male was removed from the female's cage. His tail and ears were bleeding and he left behind many tufts of hair as symbols of the occupant's victory.

A similar experiment was repeated in March, but on this occasion a recently trapped male was placed with the same female. She attacked as before but this male cuffed her sharply on the head. She backed off a short distance and charged again. The male slapped her as before. With a sudden change of attitude and tactics, she retired to her corner, preened herself, and gently approached the male. No further antagonism followed and they lived peacefully together until they were separated a week later.

FOOD AND FOOD HABITS: The methods used in determining the food and food habits of the wood rat in this region consisted of making observations

of stored food and middens in the field and making analyses of stomach content of trapped rats.

The food of the wood rat, based on the content of fifty-five stomachs, is almost entirely plant material. Only three stomachs contained any animal matter and then only in an exceedingly small amount. One of the three stomachs contained a scorpion tail, another a snail shell (Succinea avara) and the third had small pieces of partially digested grasshopper.

On the basis of stored food and middens, it was further determined that the early summer diet of the wood rat is mainly grasses. Later in the summer acorns, sumac bark, fruit of sumac, poison ivy and dogwood are apparently eaten.

The winter food seems to consist largely of acorns, sumac bark, and seeds of red bud, Kentucky coffee tree, and sumac. Acorns are eaten from the time they are available in the summer until the supply is exhausted in the early spring of the following year and they constitute one of the main winter foods.

The wood rat usually provides its habitation with some food storage but occasionally nests were dissected with no evidence of stored food. Consequently, it is assumed that food storage is a minor and, therefore, variable factor in the economy of the wood rat. The provisions hoarded are mostly acorns, Kentucky coffee tree pods, sumac seeds and short twigs of the sumac, approximately eight inches in length.

There is little indication that the regular food of the wood rat makes it an animal of economic importance, and only in a few instances did stored food give information to the contrary. In one instance, eight dens were located near a quail food patch in the Lake Carl Black-

well area. These dens contained a good supply of sorghum heads that had been looted from the adjoining patch. At another time a single den was located near a corn field. The nest did not contain corn but there were numerous cobs without kernels on the midden pile. It would be impossible to state with certainty whether the rat carried the cobs of corn to its den for food because the evidence is only circumstantial. It may have been attracted only to the cobs lying in the field which it carried to its den and later cast on the midden pile.

Midden piles are confined to the outside of the wood rat den and are quite common. They are composed largely of seed hulls, seed pods, barked twigs, and fecal pellets. Cahalane (1947) states that the size of the midden piles are indicative of the length of time that the wood rat nest has been occupied. Since some rats in this area store very little or no food, an old house may possibly have only a small midden pile; consequently, its value in this connection is questioned.

These wood rats apparently need no drinking water to survive, but they are not entirely refractory to it as shown by experiments. Many of the dens are situated so far from water that during periods of drought the wood rat must either obtain water from succulent vegetation, dew, or as a by-product from the utilization of carbohydrates.

Several experiments were carried on in the laboratory to determine if water is necessary or essential to the wood rat. In August, one male and one female, immediately after capture, were placed on a diet consisting of full ration dog pellets and lettuce leaves. No water was offered these animals throughout the experiment and at the end of one month both rats appeared to be normal and healthy.

Subsequent to this test, the same two rats were used in another experiment. The lettuce leaves were discontinued in the diet and a bowl of water was placed in each cage. Several days, however, were allowed to elapse before the experiment was initiated in order to accustom the rats to the absence of vegetation and the presence of bowls of water. After this period the bowls were cleaned and 200 cc. of water were poured in each of the bowls. A third bowl with the same amount of water was placed on top of one cage as a control. After forty-eight hours the amount of water remaining in each bowl was measured. The water outside of the cage was used to determine the loss from evaporation and the amount used by the rats could be measured. This experiment was repeated three times. As a result of these, it was determined that the male used an average of 156 cc. of water in the forty-eight hour period and the female an average of 51 cc.

Throughout these experiments the wood rats had not been seen drinking water so that it was not known whether the water was consumed or used in other ways. The following procedure was tried in order to find out what use the rats were making of the water. The water was removed from the cage for two days and then the same containers with water in them were replaced. Both rats started to drink immediately, lapping the water in a cat-like manner.

From these tests it is apparent that the wood rat will drink water if it is available but it is not necessary for survival.

REPRODUCTION: Sexual activities and reproduction are important phases of study in the ecology of the wood rat, but because these animals are entirely nocturnal, there is little opportunity to observe them except

with specialized techniques and equipment.

Some information concerning pregnancy and gestation was gained by the dissection of trapped animals and by observations of pregnant females in the laboratory. Of eight females that were trapped between March 5 and April 15, 1949, four were pregnant. The uterus of each of the pregnant ones contained four embryos, although an embryo in one female appeared to be in the process of resorption. The embryos were divided equally in the paired horns of the uterus of each female, except where resorption seemed to be taking place. In this rat there were three embryos in the left horn and the one nearest the cervix was being resorbed.

On April 15 a female with a litter was collected and when chased from her nest, she had three young clinging to her teats. These young wood rats averaged 105 mm. in total length and 19.5 grams in weight. No attempt was made to rear the young to determine their growth rate.

A pregnant female also was collected in a live trap on August 6, 1949. It was retained in the laboratory and yielded further information on reproduction. The wood rat was placed in one side of a double cage. The adjoining half of the cage, separated by a solid partition, contained a non-pregnant female which had been trapped in a similar manner.

On entering the laboratory at 11:30 a.m. on August 15, 1949, it was noticed that the female wood rat had just given birth to a rat. The mother did not respond by running to the back of the cage as she sometimes did when she was approached, but continued licking and cleaning the young one without acknowledging the writer's presence. After cleaning the young wood rat thoroughly, the female walked to a back

corner of the cage, leaving the first born near the front.

The first indication of a second parturition was muscular contractions of the abdominal region. At this time she was in a position in which her back was extremely arched and her hind feet extended well forward and parted slightly. Her tail and hind legs formed a triangle which supported her body. Her front feet and head were held off the floor. Her head was bent down and her eyes were closed. In this position the second young was born at 11:34 a.m. She cleaned it by licking, as the young rat moved in search of a teat. After finding a teat the young attached itself and remained so during the following two births.

The third young was born with the mother in a similar position except that her head was bent down until the crown rested on the floor. This presentation was at 11:36 a.m. just two minutes after the preceding birth. The mother immediately cleaned the third born which soon succeeded in attaching itself to a teat.

The female then moved, with the young attached, to the other far corner of the cage. She appeared extremely exhausted and slept a few minutes, still in the standing position.

At 11:47 a.m. the fourth and final young was born with the mother in the same position. The afterbirth was eliminated following this birth which the mother ate as she cleaned the young. After clawing and crawling, this new born became attached to a teat.

The first born was still some ten inches from the mother and was crawling about in the excelsior. It seemed to have no set direction as it crawled but at 12:25 p.m. it found the mother and after some difficulty attached to the fourth and final teat.

During the rest of the afternoon the female rested either in a squatting position similar to the position during birth of the young or leaning to one side with her head resting on the floor.

Throughout the entire parturition the mother neither ate nor drank or gave any indication of the writer's presence. The female wood rat in the adjoining cage moved about nervously and made sharp thumping noises with her hind feet as if she knew something unusual was happening in the adjoining cage.

The rats were not observed from 5:00 p.m. until the following morning. At this time two young were found in the finger bowl of water where they apparently died as a result of drowning. The remaining two seemed to be in good condition but the mother appeared tired and listless. She showed no desire for food or water but during the night she had apparently visited the water dish and dropped the young into it either accidentally or intentionally.

On the second morning following the births no young rats could be found. A detailed search of the litter revealed a small piece of one head. The mother probably had become frustrated during the night due to an uncontrollable disturbance in the laboratory and had devoured the remaining two young.

The two drowned rats were measured for data on the size of Neotoma at birth, since no such information had been available. Measurements of one rat were as follows: total length, 94 mm.; tail length, 26 mm.; hindfoot, 12.5 mm.; weight, 12.3 grams, and those for the other rat were: total length, 93 mm.; tail length, 25 mm.; hindfoot, 12.5 mm.; weight, 12.2 grams.

Because of limited data on reproduction, no attempt is made to draw

any conclusions on the number per litter, length of gestation or other sexual activities.

PARASITES OF NEOTOMA FLORIDANA OSAGENSIS

The parasites encountered in the examination of fifty wood rats were exceedingly interesting in a number of respects. A nematode that inhabits the small intestine is considered to be new to science and its description, as it will appear for publication, is related in this chapter. The stomach nematode, Bohmiella wilsoni, described by Lucker (1943) from the squirrel, is a new host record; indeed, it is the only representative of the genus Bohmiella in the Americas. Trichuris muris, a cecal whipworm, is a common rodent nematode but this is the first time it has been reported from the wood rat and therefore, constitutes another new host record. Only one rat was infected with adult cestodes but the material was not in a suitable state of preservation for positive species identification. The cestode larvae, usually found in hepatic tissue, are common strobilocerci, Taenia taeniaeformis, infecting certain rodents, but this is the first record of their occurrence in this host. It is also interesting to relate that no trematodes were found in this investigation.

Table No. II gives the host numbers, the dates they were collected, the helminths and number in each host for fifty wood rats examined in this study.

Although the ectoparasites were not the primary interest in this survey, they were, nevertheless, collected. In this connection it is interesting to note that the wood rat harbors fleas, ticks, mites and occasionally Cuterebra larvae. Since these forms were not identified by the writer, they will not be fully discussed, and their disposition has been indicated.

TABLE II

HELMINTHS ACCORDING TO HOSTS

Host No. and Date Collected		*B. wilsoni*	*T. muris*	*L. neotoma*	*Andrya* sp.	*T. taeniaeformis*
1	2-27-49	1	4	1	-	-
2	"	7	3	-	-	-
3	3-5-49	1	-	-	-	-
4	"	13	3	-	-	-
5	"	33	-	-	-	3
6	"	11	-	-	-	-
7	3-12-49	3	3	-	-	-
8	"	15	-	-	2	-
9	"	5	1	-	-	1
10	"	5	2	-	-	-
11	"	4	-	-	-	-
12	3-19-49	-	6	-	-	-
13	"	-	3	-	-	-
14	"	-	-	-	-	-
15	4-9-49	-	-	-	-	-
16	"	5	1	-	-	-
17	5-7-49	9	3	-	-	-
18	"	-	-	-	-	-
19	5-14-49	-	-	-	-	-
20	"	-	-	-	-	-
21	"	-	-	-	-	-
22	"	-	-	-	-	-
23	6-17-49	-	-	-	-	-
24	"	3	-	-	-	1
25	"	1	-	-	-	-
26	"	-	2	-	-	-
27	"	-	-	-	-	-
28	"	1	-	-	-	-
29	"	-	-	-	-	-
30	7-8-49	-	-	-	-	-
31	"	-	-	-	-	-
32	7-15-49	-	-	-	-	-
33	7-21-49	-	5	-	-	-
34	"	-	-	-	-	-
35	8-6-49	-	-	-	-	-
36	"	-	-	-	-	-
37	8-26-49	4	-	-	-	-
38	"	2	7	-	-	-
39	"	-	-	34	-	-
40	"	67	-	6	-	-
41	"	9	-	-	-	3
42	"	-	10	33	-	-
43	"	-	1	-	-	-
44	"	3	-	68	-	-
45	11-26-49	2	-	40	-	-
46	12-12-49	-	-	-	-	-
47	12-26-49	4	-	180	-	-
48	1-7-50	2	1	9	-	-
49	"	-	4	3	-	-
50	1-9-50	-	-	2	-	-
Hosts Infected		24	17	10	1	4
No. of Worms		1-67	1-10	1-180	2	1-3

ENDOPARASITES: A description of each species of helminth found in the wood rat is given. It seems reasonable to include these since one species is new to science and some of the original descriptions of the other helminths encountered either were based on very limited material or were not sufficiently complete.

Longistriata neotoma, n.sp.: Trichostrongylidae

Description: Worms small, delicate, spirally coiled, bright red in color and active when freshly collected; cervical inflation 0.055 to 0.065 mm. long by 0.035 to 0.041 mm. wide, marked usually with five annular striations; width of head, exclusive of inflation, 0.015 mm.; cuticle of body inflated and marked with longitudinal striae, each showing cross striations; esophagus 0.285 to 0.345 mm. long by 0.038 to 0.045 mm. wide at its distal end; nerve ring 0.150 to 0.180 mm. from anterior end; excretory pore 0.210 to 0.255 mm. from anterior end.

Male: 3.0 to 3.8 mm. long by 0.086 to 0.120 mm. wide just anterior to bursa; bursa symmetrical, with two lateral lobes and one dorsal lobe; spicules similar, 0.395 to 0.410 mm. long; filiform, ending in a single point; gubernaculum very rudimentary; ventro-ventral ray directed forward to margin of bursa and widely separated from latero-ventral ray; latero-ventral ray long and extending to margin of bursa; externo-lateral ray directed forward; externo-dorsal and externo-lateral only rays not reaching bursa margin; externo-dorsal ray long, originating from dorsal ray; dorsal ray divided for half its length, each bifurcating again at the tip, the outer member being slightly longer and thicker.

Female: 4.0 to 5.7 mm. long by 0.100 to 0.120 mm. wide at level of ovejector; ovejector well developed, single, 0.103 to 0.135 mm. long;

EXPLANATION OF PLATE

Fig. 1. Posterior end of female showing typical coiling and eggs in uterus.

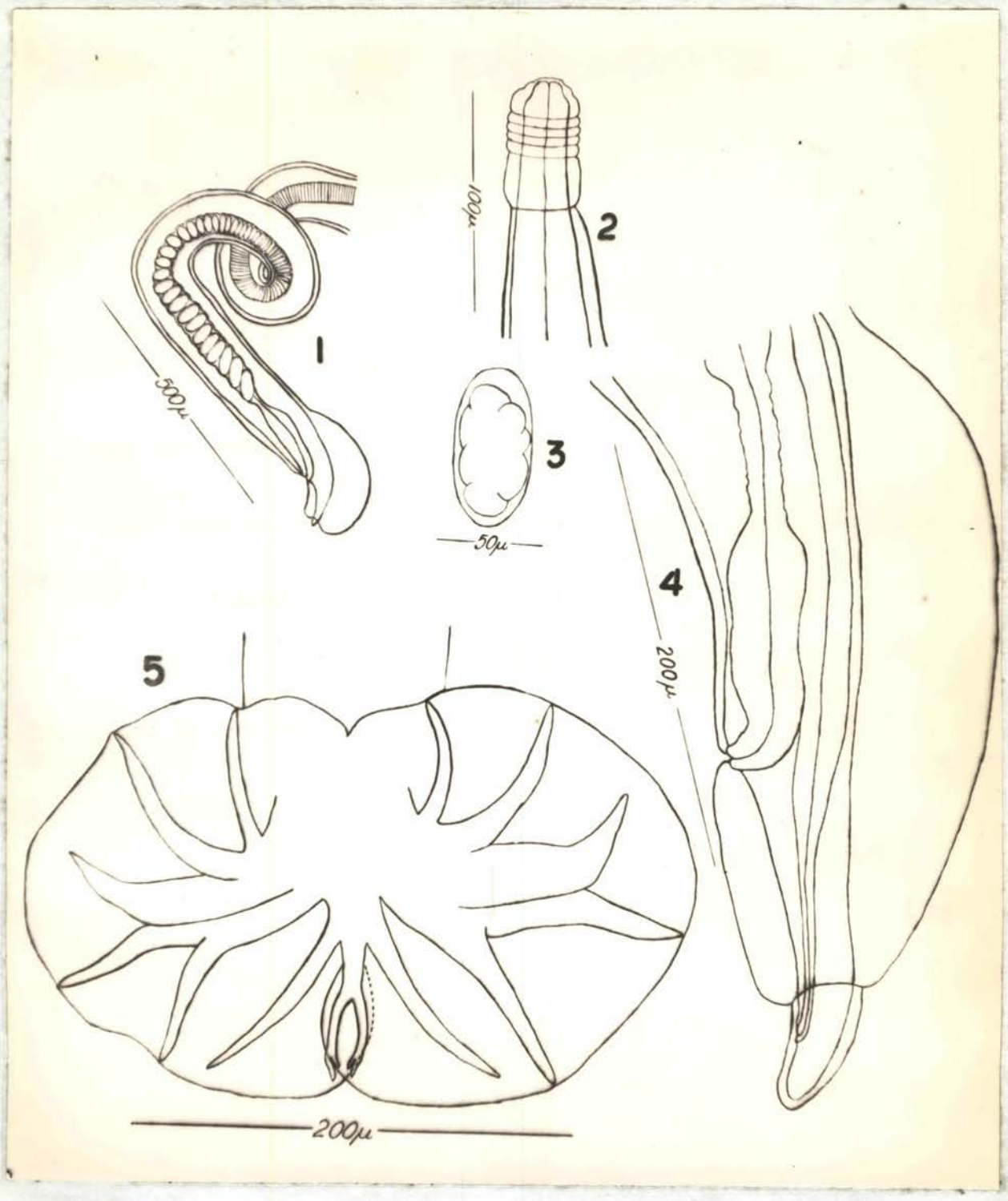
Fig. 2. Anterior portion showing cuticular inflation with annular striations.

Fig. 3. Egg at time of oviposition showing segmentation.

Fig. 4. Posterior end of female showing ovejector, inflated cuticle and retractile tail.

Fig. 5. Ventral view of bursa showing position and size of bursal rays.

PLATE



LONGISTRIATA NEOTOMA

distance from vulva to anus 0.110 to 0.131 mm.; anus to tip of tail 0.037 to 0.041 mm.; tail ends in a sharp point which may be retracted into a prepuce-like sheath; eggs very uniform in size, average 0.070 mm. long by 0.033 mm. wide.

Host: Neotoma floridana osagensis

Location: Small intestine

Locality: Sec. 18-T19N-R1E Payne County, Oklahoma

Type specimen:

The measurements were taken from ten live males and ten live females. The nerve ring was difficult to identify and was observed only in six of the twenty specimens.

It is extremely difficult to relax and uncoil these nematodes and as yet no good technique has been discovered. The best results were obtained by leaving the worms in a refrigerator in an isotonic solution at a temperature of forty degrees Fahrenheit for a period of several days. The males usually uncoiled fairly well by using this technique but the females remained tightly coiled.

The specimens here described as Longistriata neotoma are, in many respects, similar to L. dubia (Travassos, 1921), but differ in having a longer spicule, shorter esophagus and no prebursal papillae.

Dikmans (1935) placed the genus Longistriata in the family Heligmosomidae using Yorke and Maplestone (1926) as authority. Since no such family is given in Yorke and Maplestone, he apparently meant to place it in the subfamily Heligmosominae and the family Trichostrongylidae as indicated in this reference. By using Dikman's key to the species in the genus Longistriata, this species keys to L. beta, but differs

from it in consistently having a bilobed rather than a trilobed bursa.

Bohmiella wilsoni Lucker, 1943: Trichostrongylidae

Description: Head small, diameter 0.040 to 0.050 mm.; lips absent; shallow buccal cavity communicating with esophagus by minute triangular opening; esophagus swollen at anterior extremity; cervical papillae large, located slightly posterior to level of nerve ring; excretory pore medioventral, between nerve ring and cervical papillae.

Male: 17 to 18.4 mm. long by 0.21 to 0.23 mm. wide just anterior of bursa; esophagus 0.77 to 0.83 mm. long; nerve ring 0.25 to 0.29 mm. from anterior end; cervical papillae 0.36 to 0.39 mm. from anterior end; spicules similar, 0.295 to 0.310 mm.; gubernaculum 0.127 to 0.135 mm. long; pair of prebursal papillae present; bursa symmetrical, lateral lobes somewhat triangular, dorsal lobe small; ventral rays with common origin, directed postero-laterally about two-thirds their length, curving anteriorly to bursal margin in their distal one-third, separated, but with their tips close together; ventro-ventrals smallest of paired rays, appearing as branches of latero-ventrals which are most robust of bursal rays; lateral rays with common origin, directed postero-laterally, except for externo-laterals, which parallel medio-laterals for most of their length, then curve anteriorly in their distal one-third so that their tips, which do not reach bursal margin, are anterior to tips of medio-laterals; medio-laterals and postero-laterals longest of bursal rays, parallel and reaching bursal margin; externo-dorsals robust, originating from proximal end of dorsals, paralleling postero-laterals for most of their length but curving antero-dorsally at their

distal ends, tips reaching bursal margin; dorsal ray short, symmetrical, stem wide, bifurcated in distal one-fourth, each branch typically tridigitate, but some bidigitate or even single and may show asymmetry as to branches; only lateral rays appear chitinized throughout their length, externo-dorsals usually chitinized at base; chitinization of these bursal rays present only in mature males, in young males all rays have similar unchitinized appearance; spicules equal, robust and inflated proximally, brownish and complex, each having one median and one lateral branch; when spicules are retracted, branches are quite inconspicuous; when protruded, main branch extends laterally in an arc ending in blunt tip; median branch originating two-fifths distance from proximal end of main branch, directed posteriorly and may cross median branch of other spicule, shorter than main branch and ending with bidigitate tip; lateral branch paralleling main branch for most of its length, distal end curved dorsally, tip bidigitate.

Female: 26-29 mm. long by 0.30 to 0.48 mm. wide at vulva; esophagus 0.97 to 1.08 mm. long; tail 0.27 to 0.34 mm. long; distance from vulva to posterior extremity 4.4 to 7.5 mm. (ratio to body length, 1:4 to 1:5); eggs 82 to 90_u by 41 to 49_u; tail digitiform, bent slightly dorsad at tip.

Host: Neotoma floridana osagensis

Location: Stomach

This description is based on ten females and ten males from eighteen different hosts. The specimens were killed in a mixture of seventy percent alcohol and four percent glycerine and mounted in glycerine jelly.

The original description of B. wilsoni was based on three males

and six females, which is a comparatively small number for describing a new species. However, the description by Lucker was exceptionally good, especially for the male. The only discrepancy encountered by the writer was in the measurements of the female. In comparing the lengths of the female worms from the wood rat with those of the original description from the squirrel, it was found that the writer's specimens were from 11 to 14 mm. shorter, 0.10 mm. narrower and 0.14 to 0.22 mm. shorter in tail length.

Trichuris muris (Schrank, 1788) Hall 1916: Trichocephalidae

Description: Body divided into two parts, a thin elongate anterior esophageal part and a thick short posterior part containing reproductive organs. Cuticle with transverse striations at intervals of 0.0027 mm. near head to 0.0050 mm. on posterior part; striations interrupted anteriorly by a longitudinal bacillary band extending from head to junction of the two parts of the worm, bacillary band three-fifths to three-fourths width of anterior part.

Male: 20.5 to 24 mm. long; anterior part 14.5 to 15.7 mm. long by 0.03 mm. wide at anterior end to 0.21 mm. wide at point where esophagus joins intestine; posterior part 7.5 to 9.7 mm. long by 0.41 mm. wide; relative length of two body parts approximately 5:3; head 0.013 mm.; esophagus continuous from mouth to beginning of enlarged part; anterior part containing numerous cuticular vesicles 45 to 51; intestine coextensive with larger body part; anus terminal; posterior end spiraled into 360° arc; spicule 0.78 to 0.81 mm. long by 0.03 mm. wide, curved to form a semicircle; sheath, which encloses distal end of spicule, varies in size and shape and is covered with short spines except

for distal end.

Female: Larger than male, 25.7 to 33.9 mm. long; anterior part 14.6 to 18.5 mm. long by 0.03 mm. wide at anterior end to 0.19 mm. wide at level of vulva; posterior part 10.2 to 15.2 mm. long by 0.49 mm. wide; relative length of two body parts 7:5; head 0.018 mm. in diameter; esophagus as in male; anterior contains numberous cuticular vesicles 56 to 66; posterior end bluntly rounded, not curved as in male; vulva at junction of anterior and posterior parts; eggs typically trichurid, with prominently rounded plugs, measuring 0.057 to 0.060 mm. long by 0.029 to 0.033 mm. wide.

Host: Neotoma floridana osagensis

Location: Cecum

The description is based on ten males and ten females taken from eleven different hosts. The worms were killed and fixed in a mixture of seventy percent alcohol and four percent glycerine and mounted in glycerine jelly. All measurements were made from mounted specimens although live worms were studied in a few cases to verify the existence and relationship of structures, but structures not observed were nerve ring, excretory pore, and papilliform projections on sides of cloaca.

These specimens differ from those described by Hall by being slightly larger, by having more cuticular vesicles and displaying a variable rather than a constant width between the transverse cuticular striations. Hall gives measurements for the spicular sheath, but in the writer's specimens the sheath was so variable as to size and shape that measurements were considered to be worthless. These differences are not considered to be of sufficient magnitude to warrant a new species.

Andrya sp.: Anoplocephalidae

Description: Scolex diameter 0.900 to 0.975 mm.; sucker diameter 0.390 to 0.435 mm.; segments broader than long, progressively larger; genital pores irregularly alternating, situated in posterior third of lateral edge of proglottid; testes 0.042 to 0.050 mm. in diameter, numbering 50 to 70, and extending beyond aporal longitudinal excretory canal; cirrus pouch 0.180 to 0.225 mm. long by 0.085 to 0.093 mm. wide extending medially to inner wall of poral longitudinal excretory canal; seminal vesicle within cirrus sac; vagina dilated to form seminal receptacle measuring 0.270 to 0.300 mm. long by 0.120 to 0.150 mm. wide; lobed ovary situated slightly toward poral side of proglottid and just anterior to transverse commissure of excretory canal; vitelline gland posterior to ovary; eggs 32 to 42$_{u}$ in diameter.

Host: Neotoma floridana osagensis

Location: Small intestine

These two mature cestodes were collected on March 12, 1949, from the small intestine of a male wood rat. Their state of disintegration has been described, and, therefore, many of the organs and structures were difficult to identify, but of the known species it most nearly fits the description of Andrya macrocephala Douthitt, 1915.

Taenia taeniaeformis (Batsch, 1786) Wolffhugel 1911: Larva: Taeniidae

A total of eight strobilocerci was found in the hepatic tissues of four wood rats but since this larva is so well known it will not be described here. It is interesting to note, however, that this is a new host record and that the wood rat, therefore, may serve as an intermediate host for Taenia taeniaeformis, and aid in its propagation in members

of the cat family.

ECTOPARASITES: The most conspicuous ectoparasites of the wood rat are bots or warble fly larvae of the genus Cuterebra. These are found beneath the skin of the throat and a fully developed larva may form a cyst the size of a marble. Only four of fifty wood rats were infested, but no rat harbored more than one specimen. The incidence of infestation by warble fly larvae in this study is identical to that found by Vorhies and Taylor (1940) in their survey of Neotoma albigula.

The fleas, ticks and mites are common parasites of the wood rat and the incidence is high. The ticks and mites were determined to be species of Ixodes and Eutrombicula respectively. The fleas, in the family Dolichopsyllidae, presented a problem in identification and have been sent to the U. S. National Museum.

RELATIONSHIP OF ECOLOGY TO PARASITISM

There is a definite correlation between the ecology of an animal and the type, kind, distribution, and intensity of a parasitic infection that it may harbor. But in order to determine this relationship, the life cycle of the parasites and the habits of the host must be known.

Since the life cycle of only one of the helminths (Taenia taeniaeformis) is known, it is necessary to assume the phases of the life cycle of the other parasites of this host on the basis of known cycles of related species in the same or related genera. Such an assumption is always dangerous, for there can be great differences in the life cycles of even closely related species.

The nematode, Longistriata neotoma, is closely related to L. musculi. Schwartz and Alicata (1935) discovered the life cycle of L. musculi and found that the host became infected either by the larvae penetrating the skin or by being taken per os. However, nothing is known concerning the effects of climatic conditions on the larvae or eggs of this species.

Haemonchus contortus, a near relative of Bohmiella wilsoni, is a stomach nematode of ruminants. The life cycle is direct and the infection is acquired by ingesting infective larvae with grass and other contaminated feed. These larvae develop in the open and are resistant to long periods of cold and dryness.

The dog whipworm, Trichuris vulpis, is a near relative of T. muris, and has a direct life cycle. It is known that infective eggs, when eaten, hatch in the small intestine. The larvae eventually reach the cecum and sew themselves into the mucosa. The eggs are fairly resistant

to environmental conditions but require a high degree of moisture to develop embryos. The details of none of the many species, however, are known.

The anoplocephaline tapeworms constitute a large group of worms but only three specific life cycles are partially known. In all cases an intermediate host is involved. The tapeworm egg is eaten by an oribatid mite and it in turn is ingested with grass by the definitive host. The effects of climatic conditions on the eggs are not known which is also true of the life cycle of the mite.

On the basis of this information and the life cycle sketches, it is obvious that few authentic data can be ascertained. However, food habits and other activities also play a part in relation to parasitism, and since these have been determined, more can be concluded in regard to parasitic infections from this angle. Most of these habits, however, do not favor extensive parasitism.

The unusual habits of the wood rat, as compared with most other rodents, play an important role in the kind and number of parasites harbored. The fact that the wood rat lives alone in habitat situated on a well drained soil is reason enough for a low infection. But this is not all. The wood rat has no affinity for water, and due to this, many of the parasites that go through an aquatic environment before entering the definitive host have no opportunity to infect the rat.

The wood rat is an extremely clean rodent. The place of fecal deposition is outside of the den where the pellets are exposed to direct sunlight and other climatic factors that normally destroy eggs or larvae. Only in a few cases have fecal pellets been found within the den and along runways leading from it. In considering these data, the pos-

sibilities of the wood rat's becoming infected through self-contamination is very limited as compared with most other rodents.

The food habits of the wood rat also are unfavorable for producing a high degree of parasitism. Since the food is almost all vegetation, the possibility of the wood rat's eating the intermediate hosts or contaminated materials is reduced. This is probably one of the reasons responsible for the low incidence of tapeworms and the absence of trematodes, since these life cycles are all indirect.

After considering these habits of the wood rat, one may wonder how or why the animal becomes infected. There are, however, a few habits that do favor parasitism. The fact that wood rats tolerate the presence of other species of rodents in their dens is one possible source of contamination. Another possible way that a given individual may become exposed to infection is from the opposite sex during the breeding season.

Another factor that has been recognized by parasitologists as a possible and constant source of parasitism is the close association of the young and mother. In suckling and keeping warm, the young wood rats have ample opportunity to acquire an infection from the mother. The possibility of prenatal infections also should not be overlooked, especially if one of the portals of entry for Longistriata neotoma should be through the skin.

Undoubtedly there are other factors that contribute to parasitosis but the above means of infection seem to be the most outstanding when considering both the ecology and parasites of the wood rat.

SUMMARY

1. The Osage Wood Rat (Neotoma floridana osagensis), that occupies the eastern two-thirds of Oklahoma, is similar in appearance to the brown rat (Rattus norvegicus) but differs in its habits, habitat, and destructiveness as well as certain details of morphology.
2. The wood rat apparently prefers the post oak-black jack ravine to the fringed forest ravine because of lower moisture, better protective cover, and more available food.
3. Only twenty-three percent of the 241 wood rat dens, located either in the open, under projecting rocky cliffs or in trees, were occupied.
4. The most common commensals and den associates of the wood rat are ants, spiders, deer mice and lizards, and others are found occasionally.
5. The nests of the wood rats, although not subterranean, are protected from adverse climatic conditions by rocky cliffs or den debris.
6. The wood rat is primarily nocturnal and is active throughout the year.
7. The wood rat is active in trees as well as on the ground.
8. Wood rats have been maintained successfully in the laboratory for a period of ten months and their activities were determined to be similar to those in the field.
9. The food of the wood rat as determined by storage, middens and stomach analyses is almost entirely vegetation.
10. The wood rat does not seem to compete with animals of economic importance in this region.

11. The wood rat will drink water if it is available but it is not necessary for its survival.
12. A female, that gave birth to four young in the laboratory, supplied considerable data on reproduction.
13. Longistriata neotoma infected twenty percent of the fifty wood rats collected and is described here as a new species.
14. The most common helminth of the wood rat is Bohmiella wilsoni and constitutes a new host record.
15. Trichuris muris, another new host record, infected thirty percent of the wood rats.
16. The only sexually mature cestode collected is a species in the genus Andrya but on the basis of materials collected it could not be classified to species.
17. The hepatic tissue of four wood rats contained cestode larvae, Taenia taeniaeformis, a new host record.
18. The ectoparasites collected were Cuterebra larvae and ticks and mites in the genera Ixodes and Eutrombicula respectively, and fleas in the family Dolichopsyllidae.
19. The habits, food and habitat of the wood rat do not favor extensive parasitism.
20. Since the life cycles of the helminths infecting the wood rats are not known, few authentic data could be determined concerning helminth relation to ecology.

REFERENCES

Beamer, R. H., L. R. Penner, and C. W. Hubbard
1943.-Some notes on the biology of the pack rat cuterebrid (Cuterebra beameri Hall) in Kansas. Jour. Kans. Ent. Soc., 16(2):47-50.

Blair, W. Frank
1939a.-New mammals from Texas and Oklahoma, with remarks on the status of Thomomys texensis Bailey. Occas. Papers Mus. Zool. Univ. Mich., 403:5-7.

1939b.-Faunal relationships and geographic distribution of mammals in Oklahoma. Amer. Midl. Natur., 12(1):85-103.

Cahalane, Victor H.
1947.-Mammals of North America. Macmillan Co., pp. 487-500.

Cerecero, C., Maria C.
1943.-Algunos helminthos de las ratas domesticas y silvestres de Mexico., Tesis Universidad Mac. Auton de Mex., Facultad de ciencias, Mexico, 59-65.

Chandler, Asa C.
1945.-Trichuris species from California rodents. Jour. Parasit., 31(4):284-286.

Colton, Harold S.
1930.-The activities of pack rats. Ariz. Wildlife, 2(3):1.

Dikmans, G.
1935.-New nematodes of the genus Longistriata in rodents. Jour. Wash. Acad. Sci., 25(2):72-81.

Donat, Tal.
1933.-Notes on the life history and behavior of Neotoma fuscipes. Journ. Mammal., 14(1):19-26.

Douthitt, Herman
1915.-Studies on the cestode family Anoplocephalidae. Ill. Biol. Monogr. 1(3):1-92.

Gander, Frank F.
1929.-Experiences with wood rats N. fuscipes macrotis. Jour. Mammal., 10(1):52-58.

Gebauer, Otto
1932.-Bohmiella perichitinea n.sp. eine neue Trichostrongylidae (nematodes) des Nutria. Zeitschr. Wiss. Biol. Abt. F., Zeitschr. Parasitenk. 4(4):730-736.

Goldman, Edward A.
1910.-Revision of the wood rats of the genus Neotoma. North Amer. Fauna, No. 31, 107 pp.

Hall, M. C.
1916.-Nematode parasites of mammals of the orders Rodentia, Lagomorpha, and Hyracoidea. Proc. U. S. Nat. Mus., 50:1-258.

Harkema, R.
1936.-The parasites of some North Carolina rodents. Ecological Monographs, 6:153-232.

Lay, Daniel W. and Rollin H. Baker
1938.-Notes on the home range and ecology of the Attwater wood rat. Jour. Mammal., 19(4):418-423.

Lucker, John T.
1941.-Climate in relation to worm parasites of livestock. Yearbook Agric., U. S. Dept. Agric. 517-527.

1943.-A new trichostrongylid nematode from the stomachs of American squirrels. Jour. Wash. Acad. Sci., 33(3):75-79.

Merriam, C. Hart
1894a.-Abstract of a study of the American wood rats, with descriptions of fourteen new species and subspecies of the genus Neotoma. Proc. Biol. Soc. Wash., 9:117-128.

1894b.-A new subfamily of Murine rodents - The Neotominae - with description of a new genus and species and a synopsis of the known forms. Proc. Acad. Nat. Sci. Phila., 46:225-254.

Poole, Earl L.
1940.-A life history sketch of the Allegheny wood rat. Jour. Mammal., 21(3):249-270.

Rausch, Robert
1947.-Andrya sciuri n.sp., a cestode from the northern flying squirrel. Jour. Parasit., 33(4):316-318.

Rausch, Robert and Everett L. Shiller
1949.-A critical study of North American cestodes of the genus Andrya with special references to A. macrocephala Douthitt, 1915 (Cestodes: Anoplocephalidae). Jour. Parasit., 35(3): 306-311.

Schwartz, Benjamin and Joseph E. Alicata
1935.-Life history of Longistriata musculi, a nematode parasitic in mice. Jour. Wash. Acad. Sci., 25(3):128-146.

Stiles, C. W.
1932.-Helminthological notes. Soc. Proc. Helm. Soc. of Wash., Jour. Parasit., 19:90.

Svihla, Arthur and Ruth Dowell Svihla
1933.-Notes on the life history of the wood rat Neotoma floridana rubida Bangs. Jour. Mammal., 14(1):73-75.

Taylor, Walter P.
1920.-The wood rat as a collector. Jour. Mammal., 1:91-92.

Tiner, Jack D.
1948.-Observations on the Rictularia (Nematoda: Thelaziidae) of North America. Trans. Amer. Micro. Soc., 67(2):192-200.

Travassos, Lauro
1921.-Contribuicoes para o conhecimento da fauna helmintolojica brasiliero. Ensaio monografico da familia Trichostrongylidae Leiper, 1909. Mem. Inst. Oswaldo Cruz 13:5-125.

1937.-Revisao da familia Trichostrongylidae Leiper, 1912. Monog. Inst. Oswaldo Cruz. No. 1, 512 pp.

Tucker, Hal
1942.-Nematodirus tortuosus n.sp. (Nematoda) from the rat, Neotoma. Jour. Parasit., 28(2):159-161.

Vestal, Elden H.
1938.-Biotic relations of the wood rat (Neotoma fuscipes) in the Berkeley Hills. Jour. Mammal., 19(1):1-36.

Voge, Marietta
1946.-A new anoplocephalid cestode, Andrya neotomae, from the wood rat Neotoma fuscipes. Jour. Parasit., 32(1):36-39.

Vorhies, Charles T. and Walter P. Taylor
1940.-Life history and ecology of the white-throated wood rat, Neotoma albigula albigula Hartley, in relation to grazing in Arizona. Univ. Ariz. Agric. Exp. Sta. Tech. Bull. 86, 72 pp.

Warren, Edward R.
1926.-Notes on the breeding of wood rats of the genus Neotoma. Jour. Mammal, 7(1):97-101.

Yorke, W., and P. A. Maplestone
1926.-The nematode parasites of vertebrates. P. Blakiston's Son and Co., 584 pp.

Typist: Jerry Clendenin