

HELMINTH PARASITES OF THE BLACK-TAILED JACK RABBIT (Lepus  
californicus melanotis Mearns) IN SOUTHWESTERN KANSAS

by

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## INTRODUCTION AND REVIEW OF LITERATURE

The lagomorphs appear to be one of the most thoroughly investigated groups of wild animals in respect to their parasites. Cottontail Rabbits (Sylvilagus spp.), Snowshoe Hares (Lepus americanus), and European Rabbits (Oryctolagus cuniculus) have been the object of a great many parasitological studies. Numerous studies of this nature can be related to wide distribution, abundance, and relative ease in capturing rabbits and hares.

A review of the literature revealed that the above relatives of the jack rabbit have been studied much more thoroughly for parasites than other members of the lagomorphs. Through scattered reports of jack rabbit parasites over a period of years these hares were found to harbor several of the same parasites as other lagomorphs. However, the need for a complete study of jack rabbits appeared to be a necessity if a more thorough knowledge was to be gained of their parasitic fauna.

In connection with an ecological study, by another worker, an endoparasite study was made on the Black-tailed Jack Rabbit (Lepus californicus melanotis Mearns) in southwestern Kansas. The parasite study began in September, 1956 and extended through September, 1957. A drought existed in southwestern Kansas from approximately 1952 to 1957 at which time the jack rabbits were greatly concentrated on the edge of the sand-hills and adjacent cropland. The greater concentration of hares afforded an ideal time to study their endoparasites. Theoretically, close contact with each other should have provided a good chance for them to

become infected with a variety of parasites.

Goeze in 1782, according to Stiles (1896), described Taenia pectinata from hares and rabbits. Stiles placed it in synonymy with Cittotaenia pectinata. Stiles credited the work of Curtice in 1887, on young stages of rabbit tapeworms, as bringing leporine cestodes into prominence. The reason for this seemingly important discovery was that it was believed that these young rabbit tapeworms were involved in the life cycle of tapeworms of cattle, sheep, and other animals. According to Hall in 1910, as stated by Meyer (1955), Brandege reported the first authenticated case of Multiceps serialis<sup>1</sup> in the United States in 1890, which was found in Lepus californicus<sup>2</sup> from California.

Curtice (1892) reported an unidentified species of Taenia from L. texianus in Colorado and coenuri from L. texianus and L. californicus from Texas and California respectively. Stiles (1896) published a revision of the tapeworms of hares and rabbits in which tapeworms were reported from L. melanotis. The name he used for these tapeworms was Davainia salmoni which is now recognized as Raillietina stilesiella by Wardle and McCleod (1952).

Palmer (1897) reported that a tapeworm (Taenia), ticks

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<sup>1</sup> Multiceps serialis, Multiceps sp., Taenia serialis and Coenurus serialis are scientific names used by different authors in this thesis for the cystic stage, coenurus, of the adult tapeworm Multiceps serialis found in dogs, coyotes and related animals.

<sup>2</sup> Lepus californicus includes the following scientific names in this thesis: L. californicus, L. californicus californicus, L. texianus, L. californicus texianus, L. melanotis, L. californicus melanotis, L. californicus deserticola, and L. californicus merriami.

(Ixodes), and fly larvae (Cuterebra) were the most important parasites of the jack rabbit. He also stated that L. californicus and the White-tailed Jack Rabbit (L. campestris<sup>1</sup>) were hosts for Coenurus serialis.

Species of Cittotaenia were reported from L. melanotis by Lyman (1902). Ackert (1915) showed that Taenia serialis cysts from L. campestris would not develop to adult tapeworms when fed to fowl. The Anoplocephalidae were monographed by Douthitt (1915). A monograph was published by Hall (1916) on the parasitic nematodes of the orders Rodentia, Lagomorpha and Hydracoidea. Two lagomorph nematodes mentioned by him are Dermatoxys veligera from L. c. melanotis and Dirofilaria scapiceps (sym. Filaria scapiceps) from L. campestris.

Meggitt (1924) published on the cestodes of mammals including lagomorph cestodes. Yorke and Maplestone (1926) in a comprehensive work reported all known parasitic nematodes of vertebrates. McCambell (1926) listed some parasites of L. c. melanotis and L. townsendii from eastern Colorado. Multiceps serialis was found in both species of jack rabbits and Cittotaenia spp. was found in nine of ten black-tailed jack rabbits studied.

An extensive monograph on the cestode family, Anoplocephalidae, was written by Baer (1927). One of the early compilations on rabbit parasites and diseases was done by Schwartz and Shook (1928). Occurrence of Trichostrongylus colubriformis, a ruminant parasite,

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<sup>1</sup> Lepus townsendii includes the following scientific names in this thesis: L. campestris and L. townsendii.

in L. c. melanotis was reported from Nebraska by Skidmore (1932). A one-year study on helminth parasites of 420 Snowshoe Hares (L. americanus) in Canada, was published by Boughton (1932). Vorhies and Taylor (1933) in a bulletin on the Antelope Jack Rabbit (L. alleni) and L. californicus ssp. in Arizona reported Multiceps sp., Nematodirus sp., and Dermatoxys veligera in both of these hares as well as a specimen of Raillietina sp. from L. alleni. Four species of cestodes and three species of nematodes were discovered by Ward (1934) from L. californicus collected in Oklahoma. Erickson (1944) reported a ten-year survey of the helminth parasites of L. americanus in Minnesota.

The larval stage of Dermatoxys veligera was recovered from the cecum of L. alleni from Arizona by Dikmans (1931). Two new species of the genus Nematodirus, one from L. c. texianus and one from L. alleni, were named by Dikmans (1937).

Further contribution to the knowledge of lagomorph parasites was made by Arnold (1938) in his work on anoplocephaline cestodes of rabbits of North America. In Wyoming, Scott (1943) recovered lung worms from L. townsendii. Olsen (1948) reported L. c. merriami as a reservoir host for the common liver fluke, Fasciola hepatica in Texas. Wardle and McCleod (1952) in a comprehensive work on cestodes, brought the tapeworm information of the world up to date. Rohrbacher and Ehrenford (1954) created a new genus, Biogastranema, from nematodes found in L. c. californicus from California. Lechleitner (1955) found one nematode species and four tapeworm species in L. c. californicus from California.

A large Multiceps serialis cyst was discovered by Grundmann, Parker, and Stagg (1955) in L. c. deserticola in Utah. Honess and Winter (1956) listed several parasites of jack rabbits in Wyoming. Grundmann (1957) examined L. c. deserticola in Utah and found three species of nematodes.

There were five objectives in the present helminth survey: (1) collect jack rabbits throughout the year to investigate season fluctuations in incidence of parasitism, (2) investigate whether the total number of each species of helminth varied during the year, (3) determine if the jack rabbits in this area acted as reservoirs for cattle or sheep parasites, (4) observe if the endoparasites were associated with mortalities among jack rabbits, and (5) present a clearer picture of jack rabbit helminths in Kansas.

#### MATERIALS AND METHODS

One hundred and thirty Black-tailed Jack Rabbits (Lepus californicus melanotis Mearns) were examined for endoparasites over a thirteen-month period from September, 1956, through September, 1957. These jack rabbits were all collected within a ten-mile radius of Lakin, Kansas, in Kearny County. Monthly collections were made except for November, 1956, and January, March and May, 1957, thus making a total of nine collections. From ten to twenty jack rabbits were collected in each of the nine collecting periods. Larger collections were made when there was a lapse of one month between collecting periods, than when consecutive

monthly collections were made. These hares examined for endoparasites were selected from a larger collection of from approximately 20 to 60 animals per collection. All jack rabbits were weighed, measured, aged, and information pertaining to reproduction was collected by Frank Bronson (Bronson, 1957).

The jack rabbits were divided into two age-classes, adults and juveniles. Aging was based on size and condition of the reproductive organs and on epiphyseal closure of the humeri. By using a combination of the two aging methods, the aging was considered accurate from July, 1956, through November, 1956. During December, January and February there may have been some degree of inaccuracy in aging because of the difficulty in telling the older juveniles from the adults at that time of year. After March, 1957, Bronson considered the aging methods to be accurate again.

Collections of the jack rabbits were made with a .22 caliber rifle and a 16-gauge shotgun. Jack rabbits to be used for the parasite study, were selected from those showing no apparent shot damage of the digestive tract. Since a few of the animals in the first two collections had their digestive tracts damaged slightly by shotgun pellets, subsequent animals were selected from those shot with a rifle.

All jack rabbits were examined within a few minutes to approximately 15 hours post-collection. They were taken to Lakin where they were weighed, measured, and other data were collected. Then the ones used for the parasite study were opened by making an incision along the mid-ventral line of the body. The body cavity



worms and cysts were collected, as were the cysts from other parts of the body. These worms and cysts were then fixed and stored in vials of 70 per cent alcohol.

The heart, lungs, liver, kidneys, and gastro-intestinal tract were removed and wrapped in cheese cloth. After labeling they were placed in 10 per cent formalin, and brought back to Manhattan for examination in the laboratory.

The heart and kidneys were cut open and examined macroscopically for worms. In each case, the liver and lungs were divided into small pieces which were placed in a Petri dish containing water. The pieces then were teased apart and examined for worms with the aid of a dissecting microscope.

Each gastro-intestinal tract was divided into its component parts: stomach, small intestine, large intestine, and cecum. The parts were cut open longitudinally and the contents scraped into separate finger bowls. Running tap water was used to wash the parts of the digestive tract as they were being scraped. Generally a dissecting needle was used to open the tracts, as scissors would frequently damage the tapeworms.

Two methods were tried in separating the worms from the fine particles of chyme and feces. The first method was that of decanting the supernatant fluid after the heavier material and worms had settled to the bottom of a finger bowl. In several cases it was noticed that a few worms floated to the top of the dish, probably facilitated by air bubbles and fat particles. The second method tried was that of pouring the contents into an 80 mesh brass wire gauze and washing away the fine debris under tap water.

This second method seemed to be superior to the decantation method, so it was used for a majority of the work. Although no actual count was made of the worms lost in the two methods, none was found in the screening method after several visual checks. Very immature worms may have passed through the wire gauze but it is reasonably certain that few, if any, of the adults were lost.

Washed contents of the digestive tract were poured, in small quantities, into a Petri dish and examined for worms with the aid of a dissecting microscope. Early in this study every worm was counted; however, when large numbers of worms, principally pinworms, were found it was impossible to obtain an accurate count. A dilution technique was used for approximately 100 jack rabbits to get an index of the total worm burden of the large intestine and cecum. The dilution method involved putting the appropriate contents into a 1000 ml. Erlenmeyer flask and adding water to a 650 ml. level. The flask was stoppered and shaken by rotation for approximately one minute. Then a 65 ml. jar was filled quickly from the flask and all the worms in this sample were counted. By multiplying the total number of worms found in the 65 ml. sample by ten, an index of the total number of worms was obtained. This count from the dilution method was used when one or more worms were found in the 65 ml. sample. If there were no worms in the 65 ml. sample, all the 650 ml. of material from the flask was examined and the actual number of worms was recorded. However, for the September, 1957, collection, if there were no worms found in

the 65 ml. sample, a record was made that less than ten worms were found. The reason for this change of procedure in the September collection was that after the above counting method was used for a year it seemed unnecessary to count the worms if there were less than ten per jack rabbit.

All worms collected were placed in vials of 70 per cent alcohol for future identification. Glycerine was used to clear all the nematodes. Temporary mounts were made of all the nematodes, except for the pinworms which were identified and stored in vials of glycerine. For temporary mounts, a cleared specimen was placed in a drop of glycerine on a slide. A cover slip, supported on each corner by a small portion of hand exercise material, Thera-plast<sup>1</sup>, was then placed over the specimen. This type of mount prevented the worms from being crushed and also allowed the worms to be moved around for different views.

Larval cestodes, cysticerci and coenuri, were cleared in lacto-phenol for identification. Only the smaller coenuri and those in which the scoleces could not be seen, were cleared. All the cysticerci were cleared. After being cleared, all the specimens were stored in glycerine.

Adult and immature tapeworms were gradually dehydrated through the higher alcohols and then cleared in beechwood creosote. After identification, they were washed in xylol and gradually, decreasing percentages of alcohol were added until a concentration of 70 per cent alcohol was reached, in which they were stored. The

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<sup>1</sup> Thera-plast Co., 154 Nassau St., N. Y. C. 38.

vials were then dipped in hot paraffin to avoid evaporation.

## RESULTS AND DISCUSSION

Jack rabbits in this study harbored no cattle or sheep parasites but closely related species of Nematodirus were found. No trematodes were found in this study.

No nematodes were recovered from the kidneys, lungs, and heart. A few specimens of M. brevicauda were found on the liver; in two instances, these worms were partially embedded in the liver tissue.

Table 1 shows the endoparasites found in the study and the number and per cent of jack rabbits infected.

### Class Cestoda

Family Taeniidae Ludwig, 1886. Taenia pisiformis Bloch, 1780. There was a seven per cent incidence of larval tapeworms (cysticerci), T. pisiformis, in the jack rabbits examined (Table 1). The number of cysts recovered from each hare ranged from one to nineteen. The cysticerci were found on the mesenteries of the stomach, cecum, large intestine, lungs, liver, diaphragm, and adjacent to the spinal cord.

Cysticerci are bladder-type worms about the size of a large pea and having a single inverted holdfast organ. They are surrounded by a membrane, called an adventitious membrane by Wardle and McCleod (1952), which is produced by the host reaction to the parasite.

It was found that the cysts were generally singly attached

Table 1. Helminths recovered from 130 jack rabbits collected in Kansas

Helminths	No. Infected	Per cent Infected
<u>Passalurus nonanulatus</u>	97	75
<u>Raillietina</u> spp. (and Tapeworm spp.)	89	66
<u>Micipsella brevicauda</u>	65	50
<u>Multiceps</u> spp. (coenuri)	25	19
<u>Nematodirus</u> spp.	22	17
<u>Taenia pisiformis</u> (cysticerci)	9	7
<u>Dermatoxys veligera</u>	8	6
<u>Nematodirus arizonensis</u>	6	5
<u>Physaloptera</u> spp.	3	2
<u>Nematodirus leporis</u>	2	1.5

but a few were connected together by the host reaction material. This particular parasite has probably been studied by more workers than any other lagomorph parasite.

Multiceps spp. (Plate XI, Figs. 4, 5.). According to Erickson (1944), larvae of M. serialis and M. packii, both occurring in lagomorphs, can not be distinguished from each other. Therefore, the present study refers to these coenuri as Multiceps spp.

Each of 25 jack rabbits, twenty-three adults and three juveniles, was infected with from one to thirteen coenuri of this tapeworm species (Table 1). This represented a 19 per cent incidence of infection. The September, 1956, collection had the highest per cent incidence, 40 per cent, of any collecting period.

Almost three-fourths of the 40 coenuri recovered were from various locations in the body cavity. The rest of the cysts were recovered from the musculature. The largest cyst measured almost three inches in diameter and was located in the musculature of the right hip of one hare (Plate XI, Fig. 4). In two cases, coenuri were discovered in the heart muscles with one being in the right ventricle (Plate XI, Fig. 5). There was one case of a coenurus in the lungs.

As in the case of cysticerici, a membrane resulting from host reaction is formed around coenuri cysts. Coenuri differ from cysticerici in that each cyst contains several inverted holdfast organs rather than one.

Evidently the thickness of the adventitious membrane around each coenurus varies with the location of the coenurus in the

host. It was noticed in this study that when a cyst was loosely attached in the body cavity, the membrane was very thin or entirely absent. When a coenurus was located in the musculature the adventitious membrane was prominent. It appeared that the thicker membrane was made up of more layers of tissue than the thinner membrane. No doubt when a coenurus is in contact with the tissue of the host it causes more host reaction to be set up.

None of the hares seemed to be hindered by these larval tapeworms.

Family Davaineidae Fuhrmann, 1907. Raillietina spp. Eighty-five jack rabbits had an infection of only Raillietina spp. (Table 1). One animal had both Raillietina spp. and Tapeworm spp. while three animals harbored only Tapeworm spp. (Table 1). Probably the Tapeworm spp., a total of seven worms, were also Raillietina spp. but they were too deteriorated to make a positive identification. For purposes of convenience, Tapeworm spp. were figured in with Raillietina spp. for calculating per cent incidence and other statistical data.

Raillietina spp. have armed scoleces and single-pored proglottids which distinguish them from species of the genus Citotænia which have unarmed scoleces and double-pored proglottids. A combination of checking for armed scoleces and single-pored proglottids was necessary in a few cases, but an examination of the scoleces was generally all that was necessary for identification. Whenever the scolex was missing but the rest of the worm was present, such characteristics as single-pored proglottids,

egg capsules and other characteristics were used for identification. Some of the immature forms with missing scoleces had to be placed in Tapeworm spp.

The four suckers and retractable rostellum on the scolex were armed with tiny hooks, characteristic of the Davaineidae family. Hooks on the rostellum were generally more difficult to see than those on the suckers, because the rostellum was usually retracted. The rostellum was difficult to see unless the characteristic hooks, which marked its presence, were visible. The hooks on the suckers could not be seen in a few cases, probably because they were lost in handling the worms. In the immature worms, the characteristics of the scoleces appeared to be more easily seen than on adult worms.

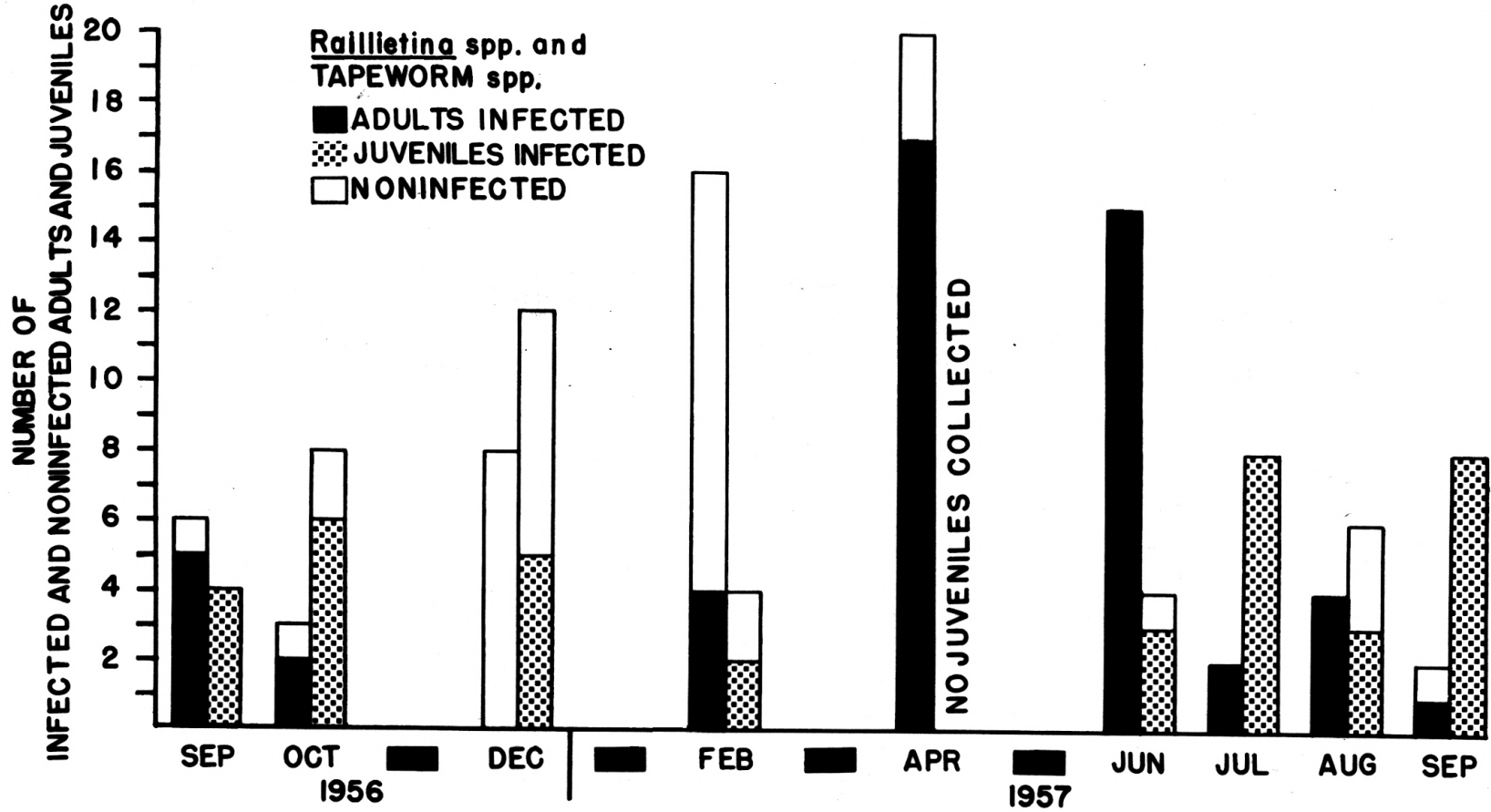
The number of infected and noninfected adult and juvenile jack rabbits was calculated (Plate I) for each of the nine collecting periods, as was the total per cent incidence (Plate II). For example, in September, 1956, ten animals, six adults and four juveniles, were collected (Plate I). Five of six adults and all of four juveniles were infected with Raillietina spp. In December no adults were infected of eight collected and five juveniles were infected of twelve collected. For the February collection, only four of sixteen adults and two of four juveniles were infected. In April, the number of infected animals increased even though only adults were collected. During the rest of the study, both adults and juveniles were collected and the ratio between infected and noninfected adults and juveniles was fairly constant. No



#### EXPLANATION OF PLATE I

Number of adult and juvenile jack rabbits that were either infected or noninfected with Raillietina spp. (and TAPEWORM spp.) in each of the nine collecting periods. The black rectangular blocks below the abscissa represent the months when no jack rabbits were collected.

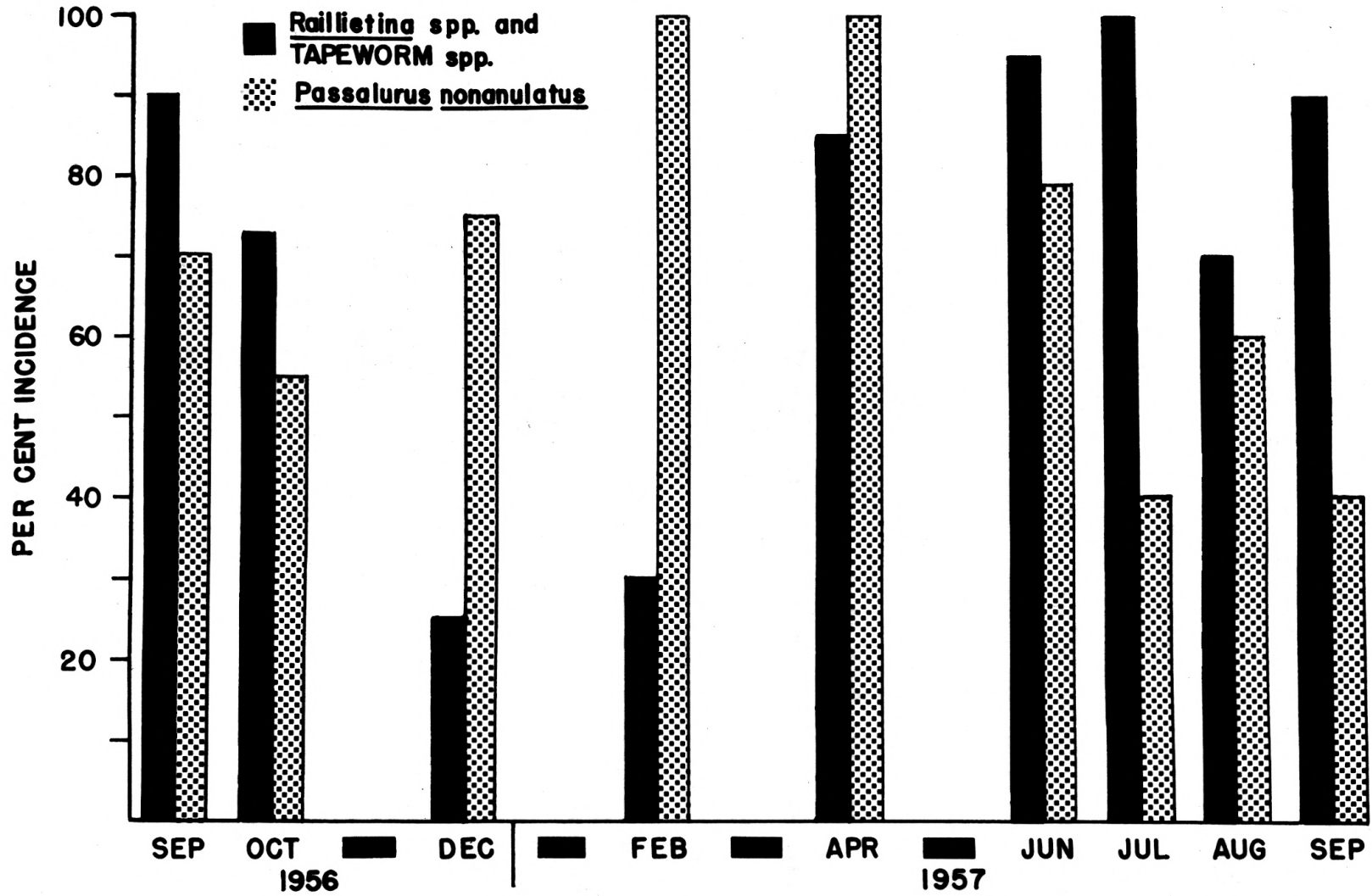
PLATE I



#### EXPLANATION OF PLATE II

The total per cent of jack rabbits infected with Raillietina spp. (and TAPEWORM spp.) and Passalurus nonanulatus in each of the nine collecting periods. The black rectangular blocks below the abscissa represent the months when no jack rabbits were collected.

PLATE II



significant difference was found between adults and juveniles, with respect to degree of infection, in a Contingency  $X^2$  Test (Table 3). A significant difference was found between infections during the winter months, December and February, and infections during the other months of the study (Table 3). The lowest per cent incidence was during the winter months of December and February (Plate II). All the other collecting periods showed a consistently higher per cent incidence than the winter collections. An attempt to explain why the winter months had low infections will be made later on in this discussion.

Each month's collection was compared as to infected and non-infected animals and a significant difference was found between months (Table 3). That is, the ratio of infected and noninfected animals was not the same in every monthly collecting period. However, the probability may have been different if a larger number of animals had been taken in each collecting period. There was no significant difference between infected males and females (Table 3).

Specific separation of the tapeworms into adult and immature groups was not done. However, several tapeworms were identified as adults by the presence of gravid proglottids, by size, and other characteristics. They were arbitrarily divided into worms with several segments, probably adults because of size when compared with known adult worms, and into worms with few segments, probably immature worms. The above separation of worms is not considered completely accurate, especially as to adult worms, because it was made mainly by size. Also it is not certain if all the worms were

the same species of Raillietina. However, the placing of worms with few segments into the immature group is probably accurate, although some of them may have been only pieces of adult worms.

During December, only immature worms were found. During February, six of fourteen jack rabbits were infected with tapeworms and all but one of the infected animals had immature tapeworms. The so-called immature worms may have been partially developed tapeworms or they may have been adult tapeworms that had lost most of their proglottids.

An explanation for the decrease of tapeworms during the winter months is difficult to make. If November and March collections had been made, the sharp decrease in infected animals between October and December, and the sharp rise in infected animals between December and February, may not have been so great. Honess (1935), in his study on the Black Hills Cottontail (Sylvilagus nuttalli grangeri) in Wyoming, found young worms of Raillietina retractilis in May, June, July, August, September, and December. While his work shows some seasonal differences in comparison with Raillietina spp. in this Kansas study, it is interesting to note some of the similarities. He mentions that the highest infection rate was in the summer months and only one infected animal was found from September through May. In other words his work is similar to this study in that there was a decrease in infections in the winter months and a rise in infections in the summer months. He found no infected animals from December through April but he collected fewer animals than in the Kansas study.

It is possible that the intermediate host, which has not been discovered for species of Raillietina in lagomorphs, may not be present during the winter months and that it reappears sometime between February and April in Kansas. More work certainly needs to be done on the life cycle of species of Raillietina in lagomorphs.

The following are the median numbers of worms in infected jack rabbits for each collecting period: September (2), October (2), December (2), February (1), April (3), June (9), July (7), August (3), and September (2). Probably the rise in number of worms in June and July is due to abundance of the intermediate host and to the susceptibility of the juveniles to higher numbers of worms at this time of year.

While the hares were divided into only adults and juveniles, the younger juveniles collected in the summer were more heavily infected with more fully developed tapeworms than were the older animals. Most work on lagomorph cestodes has been done on species of Cittotaenia in which age resistance was found to be a factor in limiting the incidence of this genus among adult animals. With Raillietina spp. this factor is not as evident, since there was no significant difference between adults and juveniles infected. If age resistance to Raillietina spp. is present, it probably is a matter of degree, as infected adult jack rabbits in this study had few mature worms.

Class Nematoda

Family Oxyuridae Cobbold, 1864. Passalurus nonanulatus

skinker, 1931 (Plate IX, Figs. 1 - 3). Skinker in 1931 created a new species, P. nonanulatus, which is similar to P. ambiguus (Rudolphi, 1819) Dujardin, 1845. Mature female P. ambiguus worms have cuticular rings on their tails and males have more than two pairs of cloacal papillae. Female P. nonanulatus worms lack cuticular rings on their tails and the males have only two pairs of cloacal papillae. After a thorough study of the type specimens of P. nonanulatus, so kindly loaned by Mr. McIntosh, from the United States National Museum Helminthological Collection, the author found that the pinworms from the Kansas jack rabbits fit the descriptions of P. nonanulatus more closely than they did P. ambiguus.

Approximately 300 adult gravid female worms examined had no cuticular rings on their tails. Six males were examined in ventral cloacal view and only two pairs of cloacal papillae were seen, one pair of large preanal papillae and one pair of large postanal papillae. Also a pair of small "projections" was found just posterior to the cloaca. Immature worms, especially females, were difficult to identify to species level because the specific characteristics are based on the adult worms. As all adult worms examined were classified as P. nonanulatus, the immature worms were considered to be the same species.

Boughton (1932), McClure (1934), Ward (1934), Philip (1938), Erickson (1944, 1947), Bravo Hollis (1950), and Grundmann (1957) have all reported P. nonanulatus from lagomorphs. Rozycki (1941) found P. ambiguus from Sylvilagus floridanus. He writes that the



female worms examined had no prominent annulations and male worms had seven perianal papillae. The seven perianal papillae were distributed as follows: one pair of large preanal papillae, one pair of small papillae close together just behind the cloacal opening, one pair of large postanal papillae lateral to the small pair, and a single medium sized papilla just behind the small pair of papillae. Other authors have listed varying numbers of anal papillae in P. ambiguus males.

A ventral cloacal view of a male specimen from Skinker's collection was examined and a small pair of "projections" was noticed just posterior to the cloacal opening, besides the two large pairs of preanal and postanal papillae reported. These "projections", not mentioned by Skinker in her description, were also noticed in males in this Kansas study. The drawing that Rozycki made of P. ambiguus, a ventral cloacal view of a male, shows the same "projections" but he calls them papillae. So the only difference noted between his reported worms and those of Skinker and the ones in this study, is the presence of a single medium sized papilla behind the small pair of projections or papillae. Rozycki implies that P. nonanulatus may be a synonym of P. ambiguus. Either the worms he described are almost identical to P. nonanulatus or he gave a description of P. ambiguus that should cause P. nonanulatus to be put in synonymy. More work certainly needs to be done on these worms.

Seventy-five per cent of the jack rabbits collected were infected with this pinworm (Table 1). The cecum and large intestine were the most common locations for this parasite. Occasionally

they were found in the small intestine and stomach, however, these may have been ingested during coprophagy (Erickson, 1944).

As mentioned in the materials and methods, a dilution technique was used for counting most of the pinworms and the number recorded was an index and not an actual count. There was a median of 178 worms and a mean of 2271 worms per hare. One animal harbored approximately 48,000 worms, and another hare had approximately 25,000 worms.

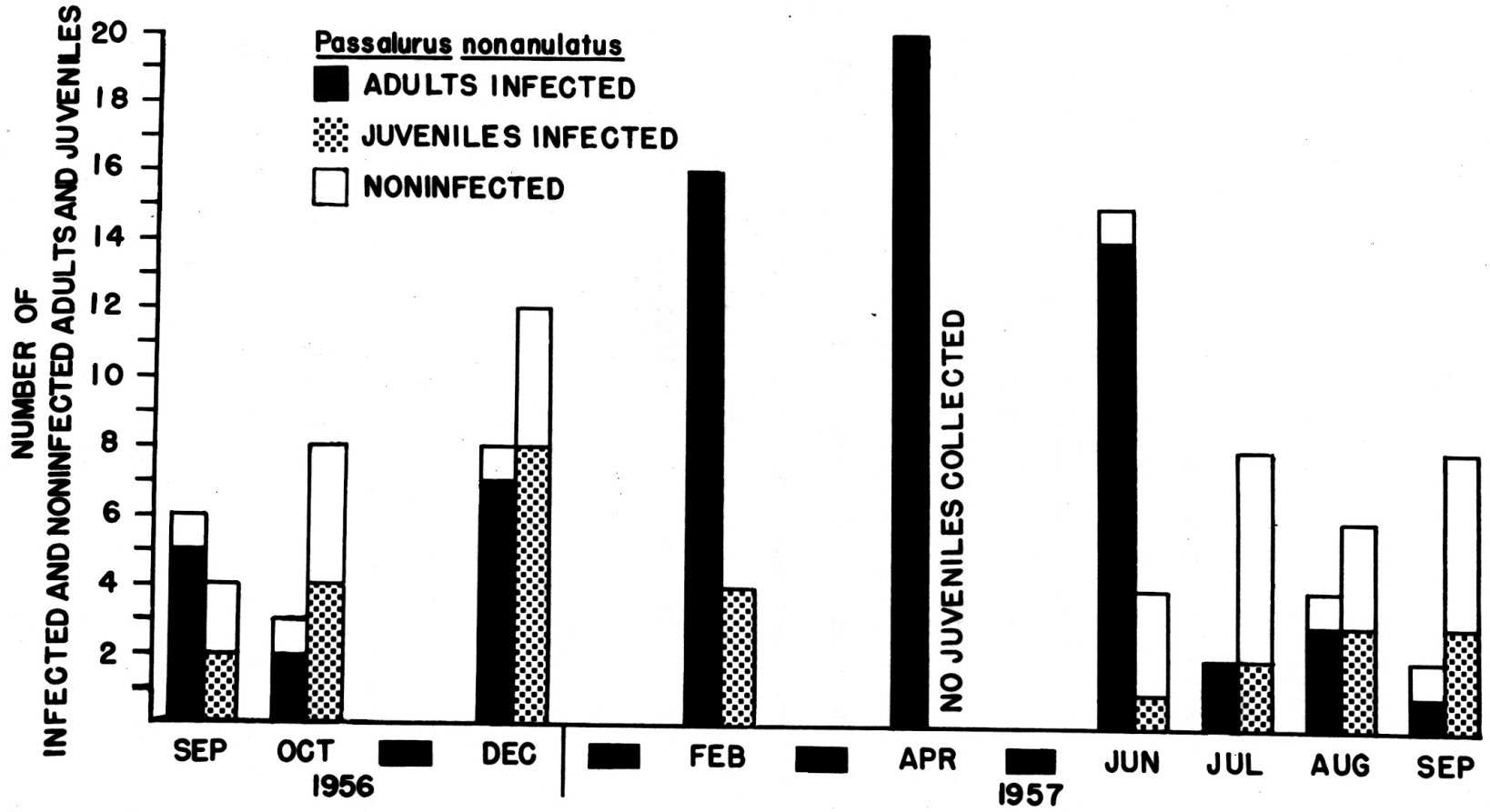
For each of the nine collecting periods, the total per cent incidence (Plate II) and the number of infected and noninfected adults and juveniles were calculated (Plate III). A significant difference was found between the number of infected adult and juvenile jack rabbits (Table 3). Since more adults than juveniles were infected, data were tested to see if there was a higher per cent incidence of infection when the lowest number of juveniles was present in the collections. When collections made in the months of February, April, and June were compared with collections of other months, a significantly higher per cent incidence of P. nonanulatus was found when there were low numbers of juvenile and high numbers of adult jack rabbits (Table 3).

Each month's collection was compared as to infected and noninfected animals and a significant difference was found between months (Table 3). That is, the ratio of infected and noninfected animals was not the same in every monthly collecting period. However, the probability may have been different if a larger number of animals had been taken in each collecting period. There was no significant difference between infected males and females (Table 3).

EXPLANATION OF PLATE III

Number of adult and juvenile jack rabbits that were either infected or noninfected with Passalurus nonanulatus in each of the nine collecting periods. The black rectangular blocks below the abscissa represent the months when no jack rabbits were collected.

PLATE III



As mentioned earlier, it was found that there was a higher per cent incidence of worms when the juvenile population was low and the adult population was high, during February, April, and June. Evans (1940) in his work on Oryctolagus cuniculus in Wales found P. ambiguus. He reported that when there was an increase of numbers of young rabbits, there was a decrease in infection rate of the population.

Evidently the life cycle of P. nonanulatus, which probably is direct, is longer than for Raillietina spp. When juvenile jack rabbits increased, the tapeworm incidence increased but the pinworm incidence decreased (Plate II). Evans mentioned an age resistance with P. ambiguus but this was not evident with P. nonanulatus. No pathological effects were noticed with high numbers of worms in jack rabbits in Kansas.

Dermatoxys veligera (Rudolphi, 1819) Schneider, 1866 (Plate IX, Figs. 4 - 5) (Plate X, Figs. 1 - 2). Six per cent of the jack rabbits were infected with D. veligera (Table 1). The incidence of infected animals may have been higher since the worms were present in such low numbers that they may not have been found by the dilution method used. Whenever specimens of D. veligera were found in the dilution method, all appropriate contents were examined with the aid of a dissecting microscope. This worm was found in the large intestine of seven of eight animals and the cecum of one animal. Only light infections, from one to two worms, were found in the infected animals.

Family Physalopteridae Leiper, 1908. Physaloptera spp.

(Plate X, Figs. 3 - 4). Morgan and Hawkins (1949) list mink, fox, dog, cat, swine, wolf, raccoon, and bobcat as hosts for species of Physaloptera. Physaloptera spp. have been found by D. E. Worley in the striped skunk (Mephitis mephitis) and by the author in the badger (Taxidea taxus) in the Lakin area.

Three adult jack rabbits, two per cent, harbored eight immature female Physaloptera spp. (Table 1). One animal had six worms and the other two animals had one worm each. The jack rabbit harboring six worms had two of these in the small intestine. All other worms were found in the stomachs of the infected hosts. Rozycki (1941), Bell and Chalgren (1943), and Erickson (1947) reported Physaloptera spp. in Sylvilagus floridanus. Rozycki writes that the worms he found were immature and the worms found in this Kansas study were immature. The other two investigators make no mention of age of the worms. Evidently this parasite is an incidental parasite that does not develop to maturity in lagomorphs.

Family Trichostrongylidae Leiper, 1912. Identification of species of Nematodirus was made mainly by using the characteristics of the bursa and spicules of the male worm. Whenever only female worms were found in an animal, they were classified as Nematodirus spp. In no case were there more than one species of male Nematodirus found in any single animal. So, whenever both male and female worms were found in a jack rabbit, all the female worms were considered to be the same species of Nematodirus as the male worms. Measurements of the female worms are so similar in

species of Nematodirus that it is difficult, if not impossible, to separate them when only female worms are present.

Twenty-seven jack rabbits, 21 per cent, were infected with species of Nematodirus. All the infected hares were adults except for one infected juvenile animal. Worms were found in every collecting period except for July, August, and September, 1957.

Nematodirus leporis Chandler, 1924 (Plate XI, Fig. 3). Two adult jack rabbits were infected with N. leporis (Table 1). One hare had one worm and the other had 18 worms. Rozycki (1941) and Bell and Chalgren (1943) reported this worm from species of Sylvilagus in Kansas.

Nematodirus arizonensis Dikmans, 1937 (Plate XI, Figs. 1, 2). Six adult jack rabbits were infected with N. arizonensis; there were one to 52 worms in each animal. Rozycki, and Bell and Chalgren also reported this worm from species of Sylvilagus in Kansas. According to Travassos (1937), N. arizonensis is a synonym of N. triangularis Boughton, 1937.

Nematodirus spp. (Plate X, Fig. 5). Immature worms, pieces of worms, and female worms with no accompanying males, were classified as Nematodirus spp. Twenty-two jack rabbits, 21 adults and one juvenile, harbored these worms. Probably most of these worms were N. arizonensis.

Family Dipetalonematidae Wehr, 1935. Micipsella brevicauda n. sp. (Plate VI, Figs. 1 - 5; Plate VII, Figs. 1 - 5; Plate VIII, Figs. 1 - 5). Sixty-five jack rabbits, 50 per cent, were infected with from one to fourteen filariid worms (Table 1). These worms,

located in the abdominal cavity, belong in the genus Micipsella Seurat, 1921, by using the key to the Filarioidea by Chaubaud and Choquet (1953). This is the first known report of this genus from the United States.

Dipetalonematidae Wehr, 1935; Splendidofilariinae Chaubaud and Choquet, 1953; genus Micipsella Seurat, 1921. Body filariform and gradually tapering at both ends which are digitiform and rounded; caudal end of the male often coiled. Mouth on summit of a hemispherical cap which carries a circle of small papillae; there are four submedian papillae a little farther back.<sup>1</sup> Cuticle thick and smooth, ornamented with small slightly projecting bosses arranged in two zigzag rows along the lateral lines which are broad and very conspicuous. Esophagus of uniform width and not divided. Microfilariae unshathed (in utero).

Male: Total length 22 to 58 mm. (36 mm.)<sup>2</sup> and maximum width 0.192 to 0.240 mm. (0.216 mm.). Width at anus 0.072 to 0.096 mm. (0.084 mm.), at nerve ring 0.067 to 0.108 mm. (0.084 mm.). Tail length 0.108 to 0.184 mm. (0.144 mm.). Nerve ring 0.156 to 0.228 mm. (0.192 mm.) from anterior end of body. Length of esophagus 0.648 to 0.984 mm. (0.840 mm.). Spicules are subequal and dissimilar. The larger left spicule 0.100 to 0.120 mm. (0.108 mm.) long; the shorter right spicule 0.067 to 0.096 mm. (0.084 mm.)

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<sup>1</sup> These papillae were not seen in M. brevicauda but little work was done on en fossa views.

<sup>2</sup> Numbers in parentheses are the median lengths.



long. Both spicules curved and measurements taken approximately through the center of the spicules to include the curvature. Pre-anal papillae present, four to six pairs. Postanal papillae absent. Caudal end generally coiled.

Female: Total length 44 to 106 mm. (65 mm.) and maximum width 0.264 to 0.408 mm. (0.300 mm.). Width at anus 0.072 to 0.110 mm. (0.084 mm.), at nerve ring 0.076 to 0.120 mm. (0.096 mm.), at vulva 0.096 to 0.192 mm. (0.120 mm.). Tail length 0.168 to 0.520 mm. (0.223 mm.). Nerve ring 0.108 to 0.240 mm. (0.192 mm.) and vulva 0.324 to 1.200 mm. (0.484 mm.) from anterior end. Length of esophagus 0.720 to 1.032 mm. (0.864 mm.). Opisthodelphic, viviparous. Microfilariae unsheathed (in utero).

Host: Lepus californicus melanotis Mearns

Location: Abdominal cavity

Locality: Kearny County, Kansas

Seurat (1917) described filarial worms from the abdominal cavity of Lepus pallidior<sup>1</sup> and Lepus kabylicus<sup>1</sup> from Algeria and named them Filaria numidica. In 1921 Seurat created a new genus, Micipsella, for this species. Kalantarian (1924) described similar worms from Lepus spp. in Armenia and created a new genus to receive Seurat's existing species. Kalantarian called this worm Cercofilaria numidica, evidently not knowing that Seurat had transferred numidica from the genus Filaria to the genus Micipsella. Yorke and Maplestone (1926) placed Cercofilaria numidica

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<sup>1</sup> Now considered a subspecies of L. capensis (All information on classification of L. capensis in this thesis was kindly provided by Dr. H. W. Setzer, Smithsonian Institution, U. S. N. M.).

in synonymy with Micipsella numidica. Rao (1938) described filarial worms from a blood clot of the portal vein of L. nigricollis in India and named them Micipsella indica. Ivashkin (1954) found filarial worms in the portal vein of L. tolai<sup>1</sup> from Mongolia which he classified as Micipsella numidica. These worms differ somewhat from Seurat's (1917) original description in dimensions and number of anal papillae. According to Ivashkin (1954), M. numidica has also been found in L. lehmani<sup>1</sup> and Lepus spp. in Russia.

M. brevicauda differs mainly from M. numidica and M. indica in the male characteristics; the tail is much shorter and has no postanal papillae. In one male, an "end on" view of the tail, examined under oil immersion, revealed two tiny papillate structures but this feature was not seen in several other worms examined. The tiny structures mentioned are the only structures that might be called postanal papillae. In other descriptions of postanal papillae in species of Micipsella, no mention was made about the size of the preanal papillae. However, the drawings by Seurat, Ivashkin, and Rao (1938) show the postanal papillae to be about the same size as the preanal papillae and none are located on the tip of the tail.

Table 2 shows a comparison of M. numidica as described by Seurat and Ivashkin, of M. indica by Rao (1938) and of M. brevicauda in this thesis. Rao gives only a few measurements for M. indica and the characteristics given seem to be very similar to

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<sup>1</sup>Now considered as a subspecies of L. capensis.

Table 2. Comparison of species of *Micipsella*. (all measurements in millimeters)

	<i>M. numidica</i>				<i>M. indica</i>		<i>M. brevicauda</i>					
	Seurat (1917)		Ivashkin (1954)		Rao (1938)		n. sp.					
	Male	Female	Male	Female	Male	Female	***	Male	No. Meas'd	***	Female	No. Meas'd
Total length	76	130	55-61	60-93	70-100	120-140	(22-58) 36	71	(44-106) 65	38		
Maximum width	0.420	0.540	0.736	0.699	--	--	(.192-.240) .216	10	(.264-.408) .300	10		
Esophagus	0.970	0.700	0.499	0.745	--	--	(.648-.984) .840	58	(.720-1.032) .864	26		
Vulva from anterior end	--	0.720	--	0.782	--	--	--	--	(.324-1.200) .484	35		
Tail length	0.420	0.480	0.299	0.234	0.392**	--	(.108-.184) .144	51	(.168-.520) .223	13		
Spicules												
Left	0.105	--	0.135	--	0.14	--	(.100-.120) .108	25	--	--		
Right	0.085	--	0.095	--	0.11	--	(.067-.096) .084	25	--	--		
Width at vulva	--	--	--	--	--	--	--	--	(.096-.192) .120	25		
Width at anus	--	--	--	--	--	--	(.072-.096) .084	42	(.072-.110) .084	12		
Nerve ring from anterior end	0.240	0.240	--	--	--	--	(.156-.228) .192	19	(.108-.240) .192	19		
width at	--	--	--	--	--	--	(.067-.108) .084	19	(.076-.120) .096	19		
Preanal papillae	5-7 pr.	--	8 pr.	--	6-7 pr.	--	4-6 pr.	--	--	--		
Postanal papillae	2 pr.	--	4 pr.	--	3 pr.	--	None	--	--	--		
Location in host	abdominal cavity		portal vein of liver		portal vein of liver		abdominal cavity					
Host	<u>L. pallidior*</u> , <u>L. kabylicus*</u>		<u>L. tolai*</u>		<u>L. nigricollis</u>		<u>L. californicus melanotis</u>					
Geographic distribution	Algeria		Mongolia		India		U. S. A. (Kansas)					

\* Now considered subspecies of L. capensis.

\*\* Calculated from his scaled drawing.

\*\*\* Range in parentheses, median recorded below range.

M. numidica except that the spicules may be a little different in shape. Ivashkin shows that there is some variation in M. numidica, especially in the tail length of both sexes and in the numbers of preanal and postanal papillae of the male. The male of M. brevicauda has a tail length of 0.108 to 0.184 mm. (0.144 mm.) with four to six pairs of preanal papillae and no postanal papillae. Ivashkin gives the male tail length for M. numidica as 0.299 mm. with five to seven pairs of preanal papillae and two pairs of postanal papillae. Seurat gives it as 0.420 mm. with eight pairs of preanal papillae and four pairs of postanal papillae. Rao gives no male tail measurements for M. indica but by measuring his scaled drawing it is approximately 0.392 mm. long and has six to seven pairs of preanal papillae and three pairs of postanal papillae.

The shape of the spicules of males of M. brevicauda is more easily seen than described (Plate VI, Fig. 2; Plate VII, Fig. 2). The shorter spicule appears to be bluntly pointed at its tip. In some specimens the tip is more pointed than in others. The tip of the longer spicules has a bifurcate appearance. According to Hyman (1951) the left spicule is generally longer than the shorter right spicule in nematodes. However, in several of the male worms examined in this study the longer spicule seemed to be on the right side and the short spicule on the left side. A little more than half the worms had the long spicule on the left side and the short one on the right side. Since most of the worms were flattened out on the slide to allow examination with an oil immersion objective, the spicules may have been displaced from their

normal positions. Other authors in describing species of Micipsella mentioned that the left spicule was longer than the right one. It is assumed in this present study that the left one is longer also.

M. brevicauda females have measurements that vary slightly from the other described species of the genus. The distance of the vulva from the anterior end is quite variable but the median distance is approximately half way between the anterior end of the body and the junction of the esophagus and the intestine. Both sexes appear to be narrower in width than the other species. This measurement probably should not be used in describing these worms as the width depended upon how flattened out they were by the pressing down of the cover slip. Total lengths of the worms, especially females, showed quite a range in length, 44 to 106 mm. The smallest female having microfilariae in utero was 44 mm. long. Only females with microfilariae in utero were used for measurements. Several female worms longer than 44 mm. and lacking microfilariae were found but were not measured although they probably were adults. The smallest female found was 18 mm. long and it was definitely immature. Wide ranges in total length seem to be common in filarids.

Distinguishing adult male from immature male worms was more difficult than the arbitrary standard of using the presence of microfilariae in females as a means for classifying them as adults. All the males found were considered adult, as even the smallest one, 22 mm., had measurements similar to larger males and also had

germinal material in the reproductive system.

In both sexes the cephalic, hemispheric cap was visible (Plate VIII, Fig. 1). A regression of this cap was evident in some of the larger worms, particularly in the females. That is, the smaller worms had a cap that was generally easily seen, but it was hardly visible in some of the larger worms.

Bosses in two zigzag rows on the lateral lines, characteristic of this genus, are found in M. brevicauda. The name for these bosses or minute projections seem to vary with different authors. Rao (1938) calls them both "papillae" and "bosses" in his paper. Seurat (1917) uses "verrues" translated to mean "warts" to describe these structures. Yorke and Maplestone (1926) call them "bosses" in the description of M. numidica. M. brevicauda has two zigzag rows of very minute projections along the wide lateral lines which no doubt are "bosses" (Plate VII, Figs. 4, 5; Plate VIII, Fig. 2). Seurat mentions that these same "bosses" are on the dorsal and ventral surfaces of the male tail of M. numidica; these are not present in M. brevicauda.

There seems to be no predisposition of this filarial worm for a particular location in the abdominal cavity of the hare. Worms were recovered from the body cavity walls and from almost all of the mesenteries. They were also found on the surface of the small intestine, large intestine, cecum, and liver. Worms were found partially embedded in the liver in two different instances. In several cases, adult worms were found partially encased in yellowish, fatty-like cysts. In two or three cases, worms were completely enveloped by the cysts. Many yellow cysts

were dissected apart in which no worms were found. It may be that these cysts, which were attached by small stalks in several cases, are involved in the life cycle.

As with the tapeworms and pinworms, a Contingency  $\chi^2$  Test was made on statistical data collected. For each of the nine collecting periods the total per cent incidence (Plate IV) and number of infected and noninfected adults and juveniles was calculated (Plate V). The number of infected animals may have been higher because the body cavity and external surface of the digestive tract were not examined closely for worms during September and October, 1956.

A significant difference was found between infected adults and juveniles (Table 3). During June and July no juveniles were infected and there was a gradual increase of infected juveniles from August through September (Plate IV). Probably the low number of infected juveniles during these months was due to the young age of the juveniles. Evidently the filariid worms take several weeks to mature.

Each month's collection was compared as to infected and noninfected animals and a significant difference was found between months (Table 3). That is, the ratio of infected and noninfected animals was not the same in every monthly collecting period. However, the probability may have been different if a larger number of animals had been taken in each collecting period.

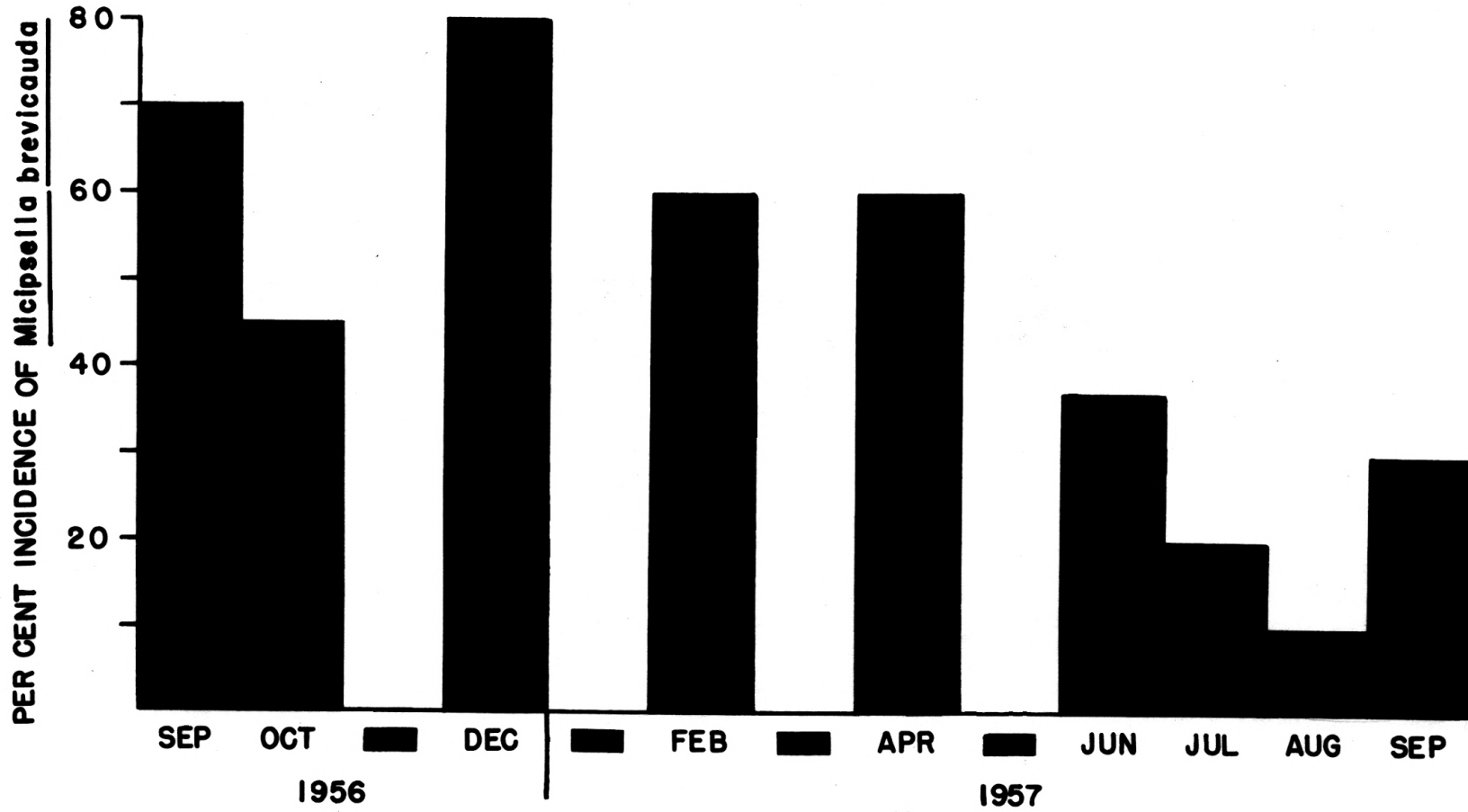
The animals collected from September, 1956, through April, 1957, had the highest per cent incidence, December being the

#### EXPLANATION OF PLATE IV

The total per cent of jack rabbits infected with Micipsella brevicauda in each of the nine collecting periods. The black rectangular blocks below the abscissa represent the months when no jack rabbits were collected.



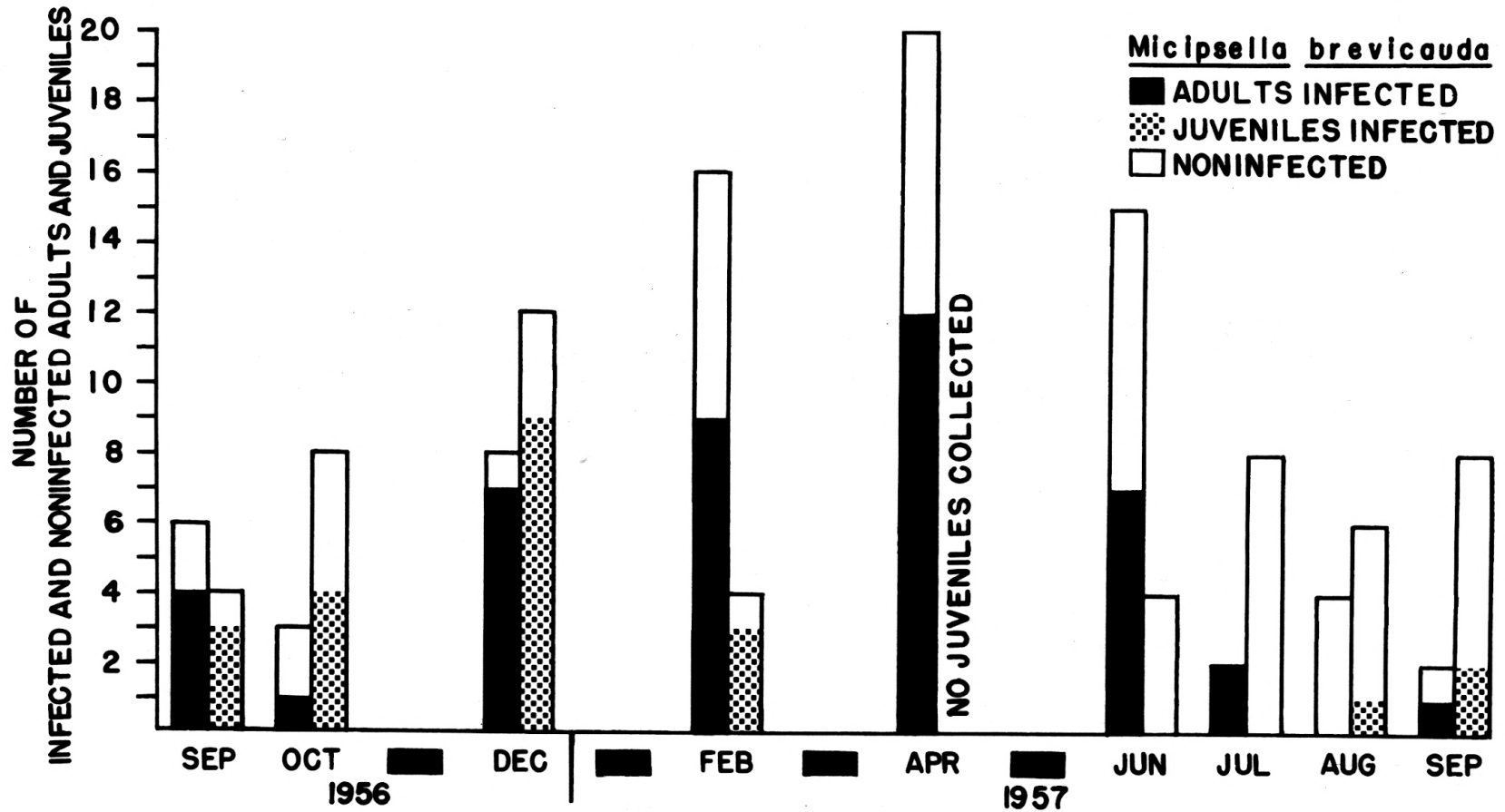
PLATE IV



#### EXPLANATION OF PLATE V

Number of adult and juvenile jack rabbits that were either infected or noninfected with Micipsella brevicauda in each of the nine collecting periods. The black rectangular blocks below the abscissa represent the months when no jack rabbits were collected.

PLATE V



highest with 80 per cent (Plate IV). From June through August there was a gradual decrease in per cent incidence and a rise occurred again in September. The absence of infected adults during August is not readily explainable but it may have been due to sampling error. No significant difference was found between the number of infected males and females (Table 3).

With such a high incidence of this worm it seems unusual that it has not been reported before in this country. The intermediate host must be common in southwestern Kansas and work on the life cycle should be an interesting challenge. Evidently the life cycle has not been worked out for the other species of Micipsella.

It may be that the variations of M. brevicauda are only host differences and that this worm is the same as an already named species of Micipsella. The ideal procedure would be to compare the anatomical structures of all the known species of Micipsella and then to experimentally transmit them to several lagomorph species and closely related animals to see if variations can be influenced by the hosts. Of course a more practical method would be to experiment with just M. brevicauda and see if there are any variations in the worms. With the present basis for classification, it appears that M. brevicauda must be considered a new species.

Ecology. From September, 1956, through April, 1957, most of the jack rabbits used in this study were collected southeast of Lakin, between the Arkansas River and the sand-hills area. This

was a drought period and food being scarce in the sand-hills, the animals concentrated on the periphery of the sand-hills to feed on adjacent cropland at night (Bronson, 1957). According to Bronson, most of the animals dispersed into the sand-hills after spring rains in 1957, helped to restore the vegetation there.

During July through September, 1957, most of the jack rabbits were collected north of Lakin. These animals concentrated in the draws in the daytime and spread out at night to feed on cropland. Irrigation water was used on cropland both north and south of Lakin.

To correlate the habitat of the host with that of its parasite burden is rather difficult. We have the problem of seasonal fluctuations of the parasite along with the drought period for the first part of the study and the wetter period in the latter part of the study.

No doubt, parasite fluctuations were caused by presence or absence of intermediate hosts, age resistance, and other factors such as concentration of jack rabbits during the drought and dispersion of them when wetter conditions prevailed. The animals normally concentrate to some extent in the winter months but during the drought period they also concentrated in the summer months.

It is probable that intermediate hosts are required for Raillietina spp., Physaloptera spp., and Micipsella brevicauda. Assuming these intermediate hosts to be arthropods, it is interesting to speculate on the greater chances of the concentrated jack rabbits becoming infected during the drought period.

If the intermediate hosts for the endoparasites are wingless, e.g. ticks, mites or fleas, their powers of actively seeking out a jack rabbit are limited. When the hares are concentrated there is more chance for these nonflying arthropods to contact their hosts. El-Rawi (1957) examined 64 jack rabbits from the Lakin area and found 456 ticks (two species) and 24 fleas (two species).

Winged arthropods, that can aggressively seek out an animal, could be involved in the life cycles. For example, mosquitoes may be the intermediate hosts for M. brevicauda. The chance for infection may have been higher when animals were concentrated because of the greater chance of the mosquitoes coming in contact with infected animals and then transmitting this filariid to non-infected animals.

The life cycle for the pinworms, D. veligera and P. nonanulatus, is unknown but is probably direct. Because of the coprophagic habit of lagomorphs (Erickson, 1944), a concentration of hares could increase the chances for infection with pinworms. Once these infections are picked up, reinfection, if present, would serve to increase the numbers of worms in the hosts.

Species of Nematodirus are known to require moisture for completion of their life cycle (Boughton, 1932). During the drought, irrigation water could have supplied the moisture necessary for the eggs and infective stage larvae to develop. However, the only months that can be compared are September, 1956, and September, 1957. Infected jack rabbits were found in September, 1956, but none was found in September, 1957. It is challenging to explain

why no worms were found from July through September, 1957, when a wetter period existed.

Aside from drought conditions and concentration of the jack rabbits, other factors may determine the existence of the endoparasites. Winter temperatures may be a limiting factor for intermediate hosts. During cold weather the intermediate hosts may be completely absent or dormant. Thus, certain parasites requiring intermediate hosts may be present in low numbers or completely absent from their hosts during the winter months.

The age of the host may determine the presence or absence of a parasite. Specimens of Raillietina spp. that were more completely developed, were found in younger animals oftener than in older animals. However, the older hares seemed to have more immature worms indicating a possible degree of age resistance rather than a complete resistance to the tapeworms.

P. nonanulatus, M. brevicauda, and species of Nematodirus were found in more adult than juvenile animals. The length of time needed for maturity of these worms may be a more important factor than their needing older animals for the completion of their life cycle.

For the larval tapeworms, Taenia spp. and Multiceps spp., the availability of the definitive hosts, dogs and coyotes, is a limiting factor.

The internal and external environmental factors the endoparasite must contend with are complex. Many attempts have been made to explain why fluctuations of endoparasites occur. No

doubt there is no single limiting factor but several factors that determine when a parasite can survive in a particular host.

#### SUMMARY

One hundred and thirty Black-tailed Jack Rabbits (Lepus californicus melanotis Mearns) were examined for helminth parasites. The hares were collected near Lakin in Kearny County, Kansas, during nine collecting periods from September, 1956, through September, 1957. The heart, lungs, liver, kidneys, gastrointestinal tract, body cavity, and musculature of the animals were examined for endoparasites.

Purposes of the study were: (1) collect jack rabbits throughout the year to investigate seasonal fluctuations in incidence of parasitism, (2) investigate whether the total number of each species of helminth varied during the year, (3) determine if the jack rabbits in this area acted as reservoirs for cattle or sheep parasites, (4) observe if the endoparasites were associated with mortalities among jack rabbits, and (5) present a clearer picture of jack rabbit helminths in Kansas.

Following is the per cent incidence of each parasite found in this study: Passalurus nonanulatus 75 per cent, Raillietina spp. (and Tapeworm spp.) 66 per cent, Micipsella brevicauda 50 per cent, Multiceps spp. 19 per cent, Nematodirus spp. 17 per cent, Taenia spp. 7 per cent, Dermatoxys veligera 6 per cent, Nematodirus arizonensis 5 per cent, Physaloptera spp. 2 per cent, and Nematodirus leporis 1.5 per cent.



P. nonanulatus and M. brevicauda showed the highest per cent incidence in the winter months. Raillietina spp. (and Tapeworm spp.) showed the highest per cent incidence in the summer months.

M. brevicauda n. sp., found in the abdominal cavity, is considered a new species mainly on two characteristics of the caudal end of the male worm. The length of the male tail is more than .100 mm. shorter than closely related species and no postanal papillae were found. Other species of Micipsella reportedly have longer tails in the male worms with two to four pairs of postanal papillae. Probably this is a new record of the genus Micipsella in the United States.

The characteristics of P. nonanulatus are so similar to those of P. ambiguus that separation of the two species is difficult. More work on these worms may reveal that P. nonanulatus is a synonym of P. ambiguus.

Age resistance, lack of intermediate hosts, and concentration of the hosts during a drought period and dispersion of the hosts during a wet period may have caused parasite fluctuations in jack rabbits in this study.

No cattle or sheep parasites were found. Also no pathological effects were noticed that might cause death in the hares. Under stress conditions, high numbers of worms may contribute to mortalities.

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## LITERATURE CITED

- Ackert, J. E.  
Experiments on cysticerci of Taenia pisiformis Bloch and of Taenia serialis Gervais. *J. Parasitol.* 1(3):151-153. 1915.
- Arnold, J. G., Jr.  
A study of the anoplocephaline cestodes of North American rabbits. *Zoologica.* 23:31-53. 241 pp. 1938.
- Baer, J. G.  
Monographie des cestodes de la famille des Anoplocephalidae. *Bul. Biol. France et Belg. Suppl.* 10. 1927.
- Bell, J. F. and W. S. Chalgren.  
Some wildlife diseases in the eastern United States. *Jour. Wildl. Mgt.* 7:270-278. 1943.
- Boughton, R. V.  
The influence of helminth parasitism on the abundance of the snowshoe rabbit in western Canada. *Canad. Jour. Res.* 7:524-547. 1932.
- Bravo Hollis, M.  
Estudio de nematodes parasitos de los leporidos del distrito federal. *An. Inst. Biol., Univ. Nac. Mexico.* 21(1):103-118. 1950.
- Bronson, F. H.  
The ecology of the Black-tailed Jackrabbit (Lepus californicus melanotis, Mearns) in southwestern Kansas. *Unpublished M. S. Thesis.* Kansas State College. 1957.
- Chabaud, A. G. and M. T. Choquet.  
Nouvel essai de classification des filaires (superfamille des Filarioidea). *Ann. Parasitol.* 28(3):172-192. 1953.
- Chandler, A. C.  
Some parasitic roundworms of the rabbit with descriptions of two new species. *Proc. U. S. Nat. Mus.* 66:1-6. 1924.
- Curtice, C.  
Parasites, being a list of those infesting the domesticated animals and man in the United States. *Jour. Comp. Med. and Vet. Arch.* 13:223-236. 1892.
- Dikmans, G.  
An interesting larval stage of Dermatoxys veligera. *Amer. Micros. Soc. Trans.* 50:364-365. 1931.

- Dikmans, G.  
Two new species of the nematode genus Nematodirus (Trichostrongylidae) from rabbits. Proc. Helminthol. Soc. Wash. 4:65-67. 1937.
- Douthitt, H.  
Studies on the cestode family Anoplocephalidae. Ill. Biol. Monogr. 1(3):1-96. 1915.
- El-Rawi, B. M.  
A study of ectoparasites of the Black-tailed Jackrabbit (Lepus californicus melanotis Mearns) in western Kansas. Unpublished M. S. Report. Kansas State College. 1957.
- Erickson, A. B.  
Helminth infections in relation to population fluctuations in snowshoe hares. Jour. Wildl. Mgt. 8:134-153. 1944.
- Erickson, A. B.  
Helminth parasites of rabbits of the genus Sylvilagus. Jour. Wildl. Mgt. 11:255-263. 1947.
- Evans, W. M. R.  
Observations on the incidence of some nematode parasites of the common rabbit, Oryctolagus cuniculus. Parasitol. 32: 67-77. 1940.
- Grundmann, A., D. Parker and G. Stagg.  
Huge helminth cyst found in the black-tailed jackrabbit. J. Parasitol. 41(1):114. 1955.
- Grundmann, A. W.  
Nematode parasites of mammals of the Great Salt Lake Desert of Utah. J. Parasitol. 43(1):105-112. 1957.
- Hall, M. C.  
Nematode parasites of mammals of the orders Rodentia, Lagomorpha, and Hydracoidea. Proc. U. S. Nat. Mus. 50:1-258. 1916.
- Honess, R. F.  
Studies on the tapeworms of the Black Hills Cottontail Rabbit, Sylvilagus nuttalli grangeri (Allen) with special reference to the life history of Cittotaenia variabilis Stiles. Univ. Wyoming Pub. 2:1-10. 1935.
- Honess, R. F. and K. B. Winter.  
Diseases of wildlife in Wyoming. Wyoming Game and Fish Commission. Bul. 9. 1956.
- Hyman, L. H.  
The invertebrates: Acanthocephala, Aschelminthes and Entoprocta. McGraw-Hill: New York. 1951.

- Ivashkin, V. M.  
Parasitic worms of hares of Mongolia. (Russian text). Trudy  
Gel'mint. Lab., Akad. Nauk SSSR. 7:220-225. 1954.
- Kalantarian, E. V.  
(Russian text) Sur la faune des vers parasites des rongeurs  
d'Armenie. Trudy Trop. Inst. Armenii. 1:18-33; Armenian  
summary, pp. 16-17 (in Armenian Suppl.); French summary, pp.  
4-5 (in French Suppl.). 1924.
- Lechleitner, R. R.  
The black-tailed jackrabbit on the Gray Lodge Waterfowl Area,  
California. Unpublished Ph. D. Thesis. Univ. Calif. 1955.
- Lyman, R. A.  
Studies on the genus Cittotaenia. Trans. Am. Micro. Soc.  
23:173-190. 1902.
- McCampbell, S. C.  
Notes on some parasites of the jackrabbits of eastern Colorado.  
Jackrabbits of eastern Colorado. Colo. Agric. Coll., Circ.  
No. 52:9-12. 1926.
- McClure, G. W.  
Nematode parasites of mammals. Zoologica. 15:49-60. 1934.
- Meggitt, F. J.  
Cestodes of mammals. London. 282 pp. 1924.
- Meyer, M. C.  
Coenuriasis in varying hare in Maine, with remarks on the  
validity of Multiceps serialis. Trans. Am. Micro. Soc.  
74(2):163-169. 1955.
- Morgan, B. B. and A. B. Hawkins.  
Veterinary helminthology. Burgess: Minneapolis. 1949.
- Olsen, O. W.  
Wild rabbits as reservoir hosts of the common liver fluke,  
Fasciola hepatica, in southern Texas. J. Parasitol. 34(2):  
119-123. 1948.
- Palmer, T. S.  
The jackrabbits of the United States. Bio. Surv. Bul. 8:88 pp.  
1897.
- Philip, C. B.  
A parasitological reconnaissance in Alaska with particular  
reference to varying hares. II. Parasitological data. J.  
Parasitol. 24:483-488. 1938.

- Rao, M. A. N.  
Micipsella indica, n. sp. Indian J. Vet. Sc. and Animal  
 Husb. 8(3):251-253. 1938.
- Rohrbacher, G. H., Jr. and F. A. Ehrenford.  
Biogastranema new genus (Nematoda: Trichostrongylidae) from  
 the California Jackrabbit, Lepus californicus californicus  
 Gray (Mammalia: Leporidae). Proc. Helminthol. Soc. Wash.  
 21(2):63-67. 1954.
- Rozycki, A. T.  
 Studies on the intestinal nematodes of the cottontail rabbit.  
 Unpublished Minn. Univ. Thesis. 1941.
- Schwartz, B. and W. B. Shook.  
 Rabbit parasites and diseases. U.S.D.A. Bulletin No. 1568.  
 1928.
- Scott, J. W.  
 A new lungworm from the Leporidae Prostrongylus sylvilagii,  
 n. sp. Wyoming Univ. Pub. 10:57-71. 1943.
- Seurat, L. B.  
 Une nouvelle filaire peritoneale des rongeurs. Compt. Rend.  
 Soc. Biol., Paris. 80:354-357. 1917.
- Seurat, L. G.  
 Orthogenese des filaires. Bull. Soc. Hist. Nat. Afrique Nord.  
 12:31-37. 1921.
- Skidmore, L. V.  
Trichostrongylus colubriformis (=T. instabilis) in the jack-  
 rabbit (Lepus californicus melanotis). J. Am. Vet. Med.  
 Assoc. 80, n.s.v. 33(5):800-801. 1932.
- Skinker, M. S.  
 Three new parasitic nematode worms. Proc. U. S. Nat. Mus.  
 79:1-9. 1931.
- Stiles, C. W.  
 A revision of the adult tapeworms of hares and rabbits.  
 Proc. U. S. Nat. Mus. 19:145-235. 1896.
- Travassos, L.  
 Revisao da familia Trichostrongylidae Leiper, 1912. Monogr.  
 Inst. Oswaldo Cruz. 1:1-512. 1937.
- Vorhies, C. T. and W. P. Taylor.  
 The life histories and ecology of jackrabbits, Lepus alleni  
 and Lepus californicus ssp., in relation to grazing in Arizona.  
 Univ. Arizona Coll. Agric. and Expt. Stat. Tech. Bul. 49:549-  
 553. 1933.

Ward, J. W.

A study of some parasites of rabbits of central Oklahoma.  
Proc. Okla. Acad. Sci. 14:31-32. 1934.

Wardle, R. A. and J. A. McLeod.

The zoology of tapeworms. University of Minnesota Press:  
Minneapolis. 1952.

Yorke, W. and P. A. Maplestone.

The nematode parasites of vertebrates. Philadelphia:  
Blakiston. 1926.

APPENDIX

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**APPENDIX**

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Table 3. Contingency  $X^2$  Test for tapeworm, pinworm and filariid parasite burden in jack rabbits.

		: Degrees of:	
	: X	: Freedom	: Probability
<u>Raillietina spp. (and Tapeworm spp.)</u>			
Infected and noninfected adults vs. infected and noninfected ju- veniles	.587	1	.30 < P < .50
Winter months (Dec., Feb.) of in- fection vs. nonwinter months (other months) of infection	44.997	1	P < .001
Infected animals vs. noninfected animals between months	49.168	8	P < .001
Infected and noninfected males vs. infected and noninfected females	.243	1	.50 < P < .70
<u>Passalurus nonanulatus</u>			
Infected and noninfected adults vs. infected and noninfected juveniles	27.530	1	P < .001
Months (Feb., Apr., Jun.,) of low number of juveniles vs. months (other months) of higher number of juveniles	18.445	1	P < .001
Infected animals vs. noninfected animals between months	28.350	8	P < .001
Infected and noninfected males vs. infected and noninfected females	.376	1	.50 < P < .70
<u>Micipsella brevicauda</u>			
Infected and noninfected adults vs. infected and noninfected juveniles	3.167	1	.05 < P < .10
Infected animals vs. noninfected animals between months	23.406	8	.001 < P < .01
Infected and noninfected males vs. infected and noninfected females	.776	1	.30 < P < .50

EXPLANATION OF PLATE VI

Micipsella brevicauda

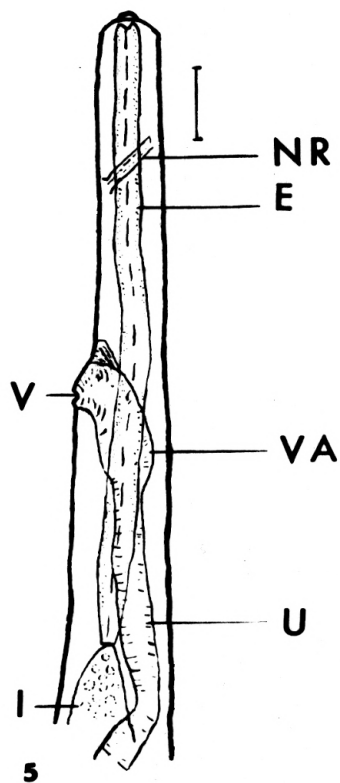
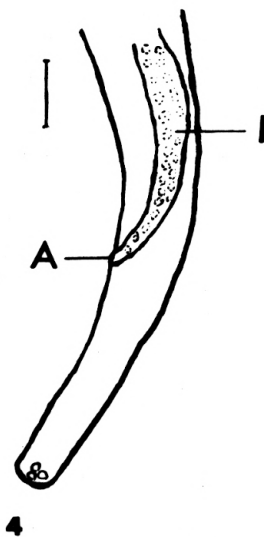
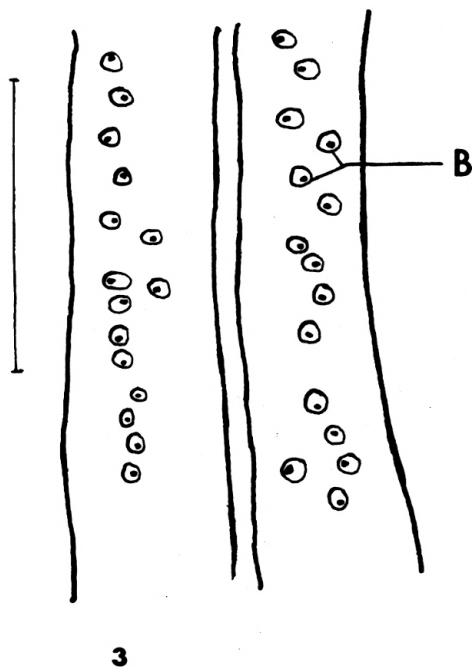
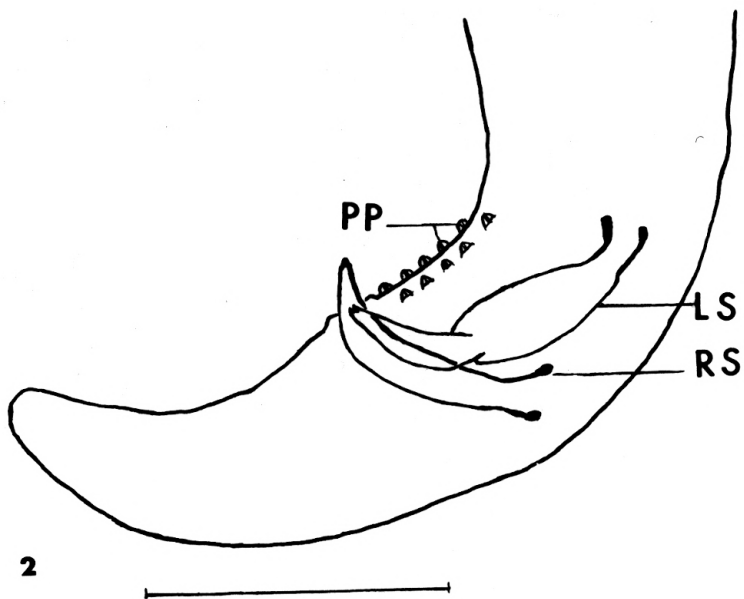
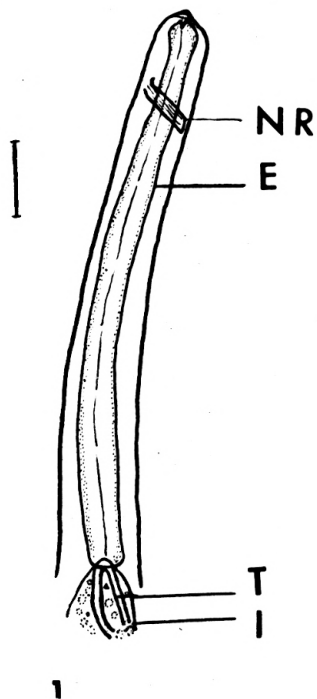
All drawings were made with the aid of a camera lucida.

All measurements are in millimeters and each scale shown equals 0.1 mm. The following abbreviations were used:

- A . . . . . anus
- B . . . . . bosses
- E . . . . . esophagus
- I . . . . . intestine
- LS. . . . . left spicule
- NR. . . . . nerve ring
- PP. . . . . preanal papillae
- RS. . . . . right spicule
- T . . . . . testis
- U . . . . . uterus
- V . . . . . vulva
- VA. . . . . vagina

- Fig. 1. Anterior end of male
- Fig. 2. Posterior end of male
- Fig. 3. Lateral line of female showing bosses
- Fig. 4. Posterior end of female
- Fig. 5. Anterior end of female

PLATE VI

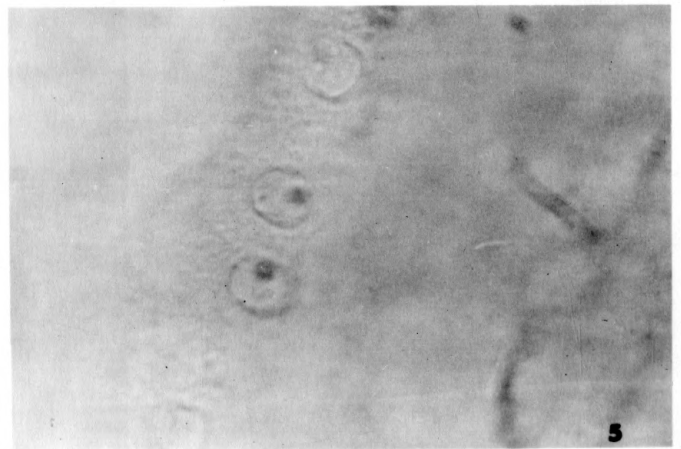
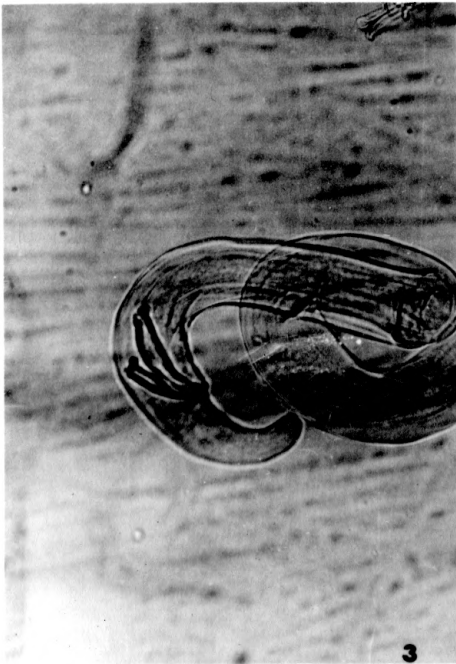
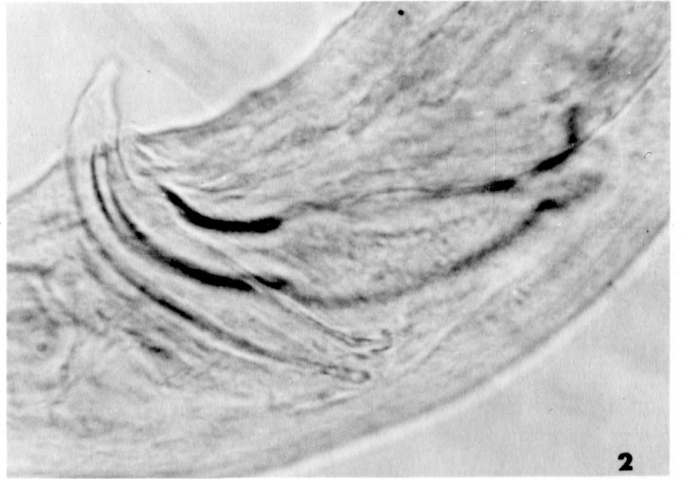
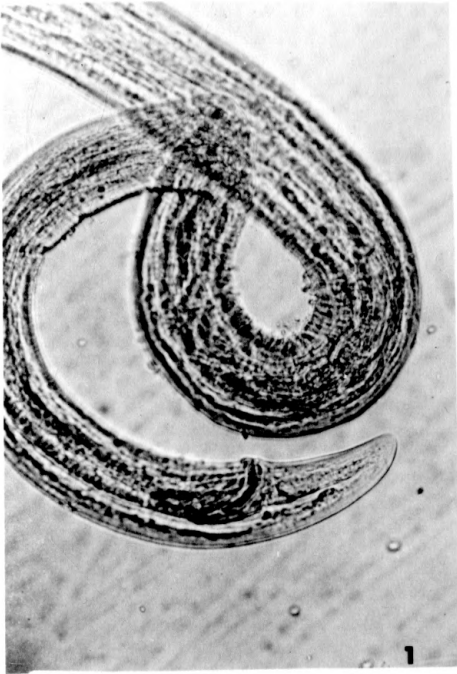


EXPLANATION OF PLATE VII

Micipsella brevicauda

- Fig. 1. Posterior end of male showing tail shape (approximately 100X)
- Fig. 2. Posterior end of male showing spicules (approximately 500X)
- Fig. 3. Posterior end of male showing spicules (approximately 100X)
- Fig. 4. Portion of female showing the bosses on the lateral line (approximately 100X)
- Fig. 5. Portion of female showing the bosses on the lateral line (approximately 970X)

PLATE VII

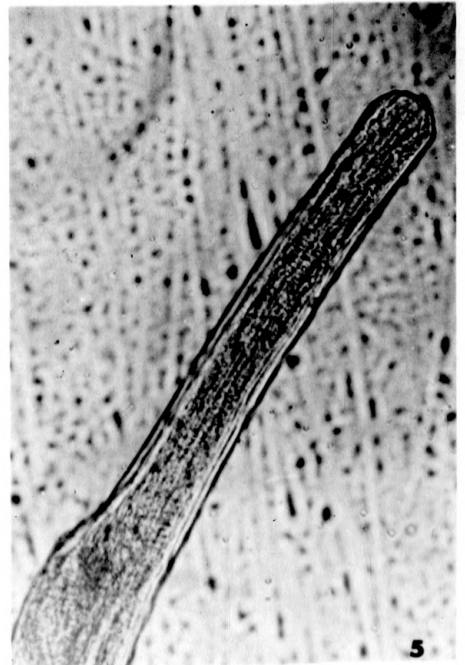
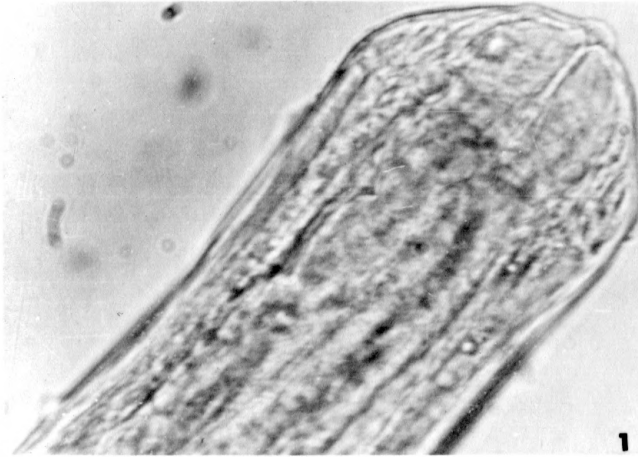


EXPLANATION OF PLATE VIII

Micipsella brevicauda

- Fig. 1. Anterior end of female showing the hemispheric cap at the very end (approximately 450X)
- Fig. 2. Portion of female showing bosses; the width of the lateral line can be seen also (approximately 970X)
- Fig. 3. Posterior end of female (approximately 100X)
- Fig. 4. Posterior end of female (approximately 450X)
- Fig. 5. Anterior end of female; vulvar opening and vagina are at the point where the worm begins to taper towards the anterior end (approximately 100X)

PLATE VIII

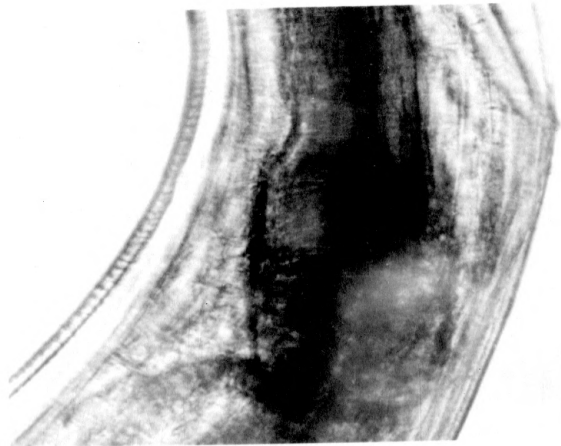
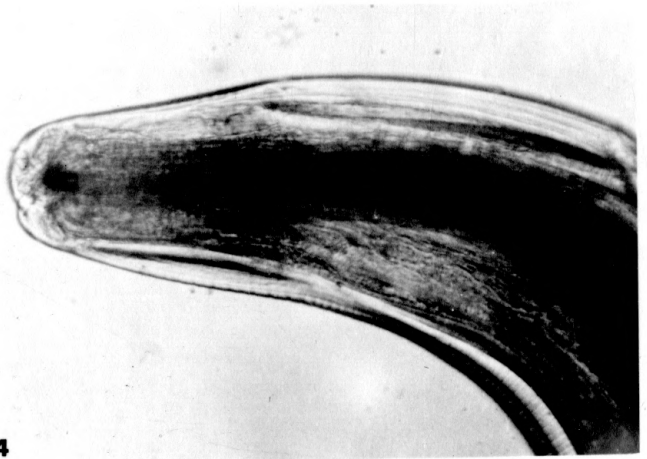
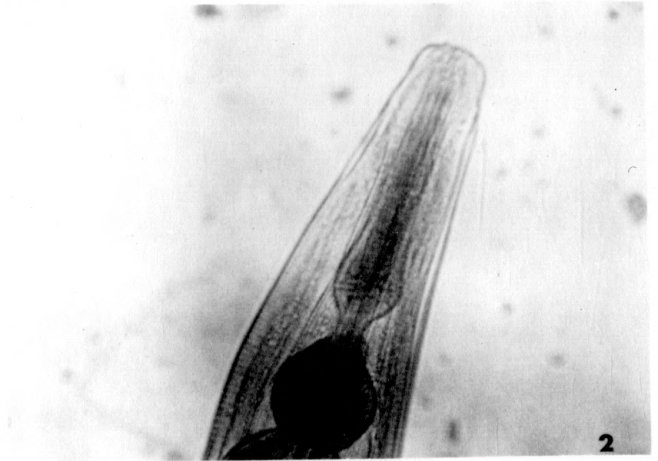
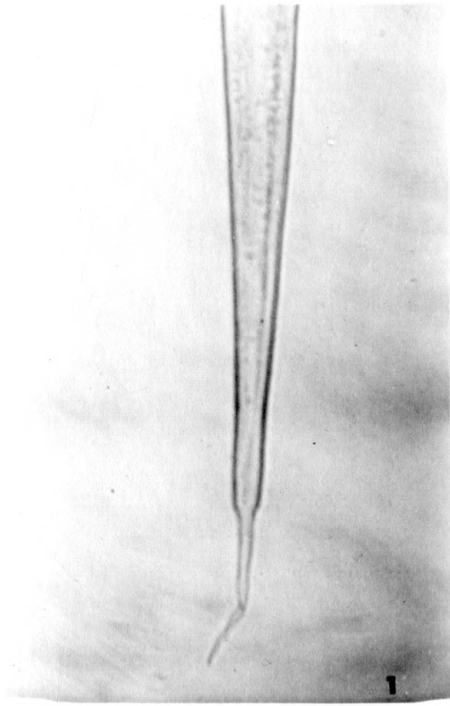


### EXPLANATION OF PLATE IX

- Fig. 1. P. nonanulatus, posterior end of female (approximately 100X)
- Fig. 2. P. nonanulatus, anterior end of female (approximately 100X)
- Fig. 3. P. nonanulatus, posterior end of male (approximately 100X)
- Fig. 4. D. veligera, anterior end of female (approximately 100X)
- Fig. 5. D. veligera, showing posterior part of esophagus which is enlarged to form a bulb where it joins the intestine (approximately 100X)



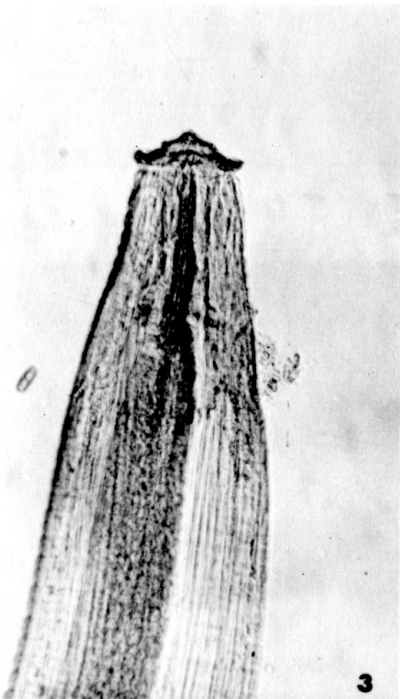
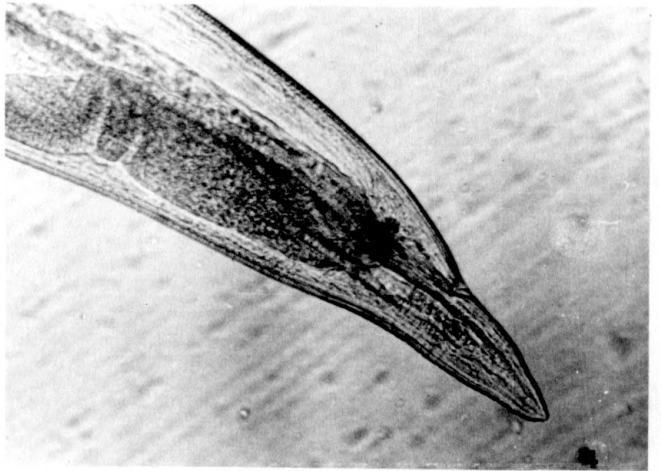
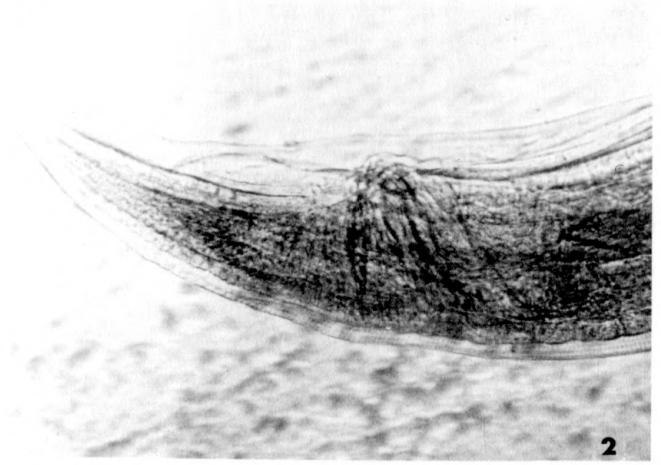
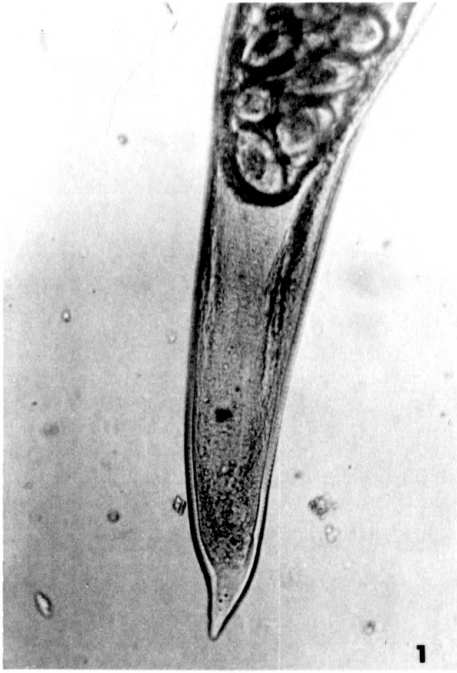
PLATE IX



EXPLANATION OF PLATE X

- Fig. 1. D. veligera, posterior end of female; eggs can be seen in utero (approximately 100X)
- Fig. 2. D. veligera, posterior end of male (approximately 100X)
- Fig. 3. Physaloptera spp., anterior end of female (immature) (approximately 100X)
- Fig. 4. Physaloptera spp., posterior end of female (immature) (approximately 100X)
- Fig. 5. Nematodirus spp., portion of immature female showing the double ovejectors (approximately 100X)

PLATE X

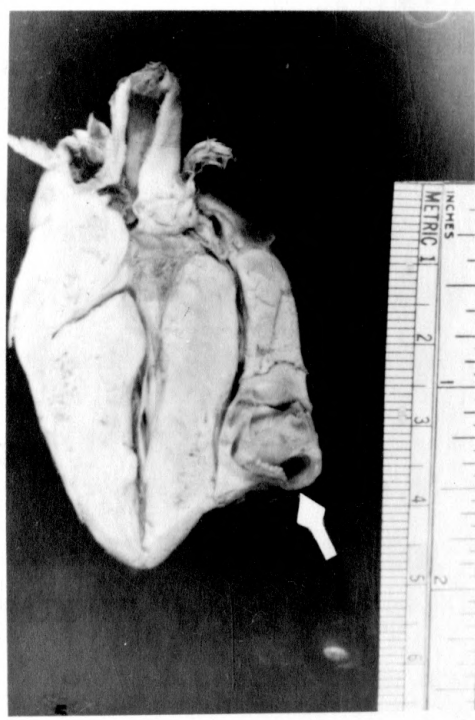
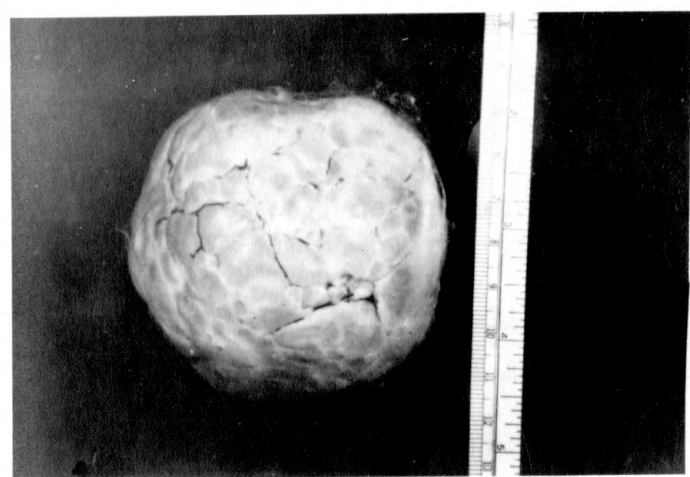
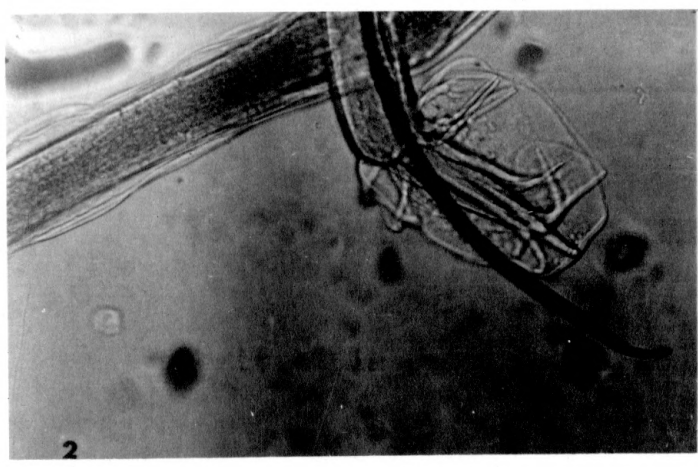
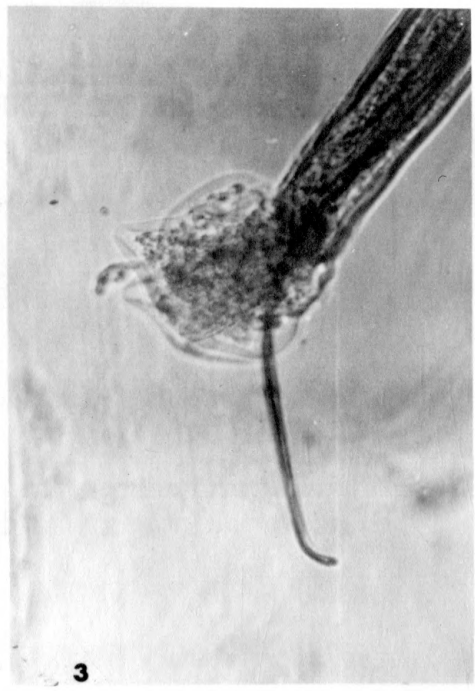
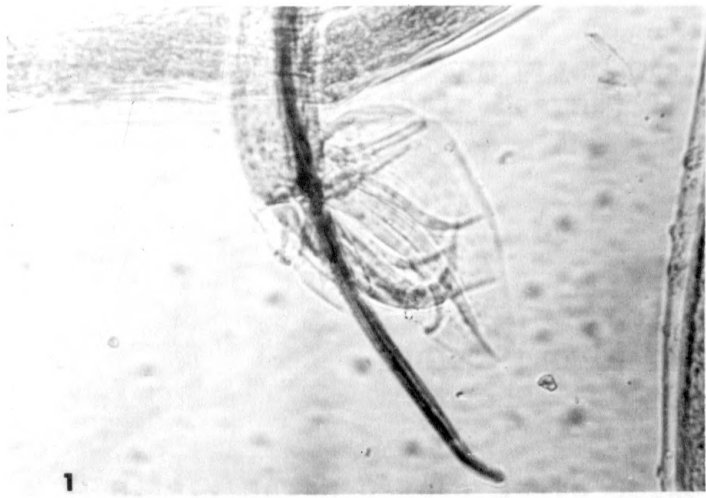


33

EXPLANATION OF PLATE XI

- Fig. 1. N. arizonensis, focused to show the triangular shape of the bursa and the distribution of the bursal rays of the male (approximately 100X)
- Fig. 2. N. arizonensis, focused to show the typical shape of the spicule tip of the male (approximately 100X)
- Fig. 3. N. leporis, focused to show the "hooked" appearance of the spicule tip of the male (approximately 100X)
- Fig. 4. Multiceps spp., coenurus from the right hip of a jack rabbit.
- Fig. 5. Multiceps spp., heart with coenurus in the right ventricle. (Note arrow). The white "knobs" are scoleces.

PLATE XI



HELMINTH PARASITES OF THE BLACK-TAILED JACK RABBIT (Lepus  
californicus melanotis Mearns) IN SOUTHWESTERN KANSAS

by

EUGENE THOMAS LYONS

B. S., South Dakota State College of Agriculture  
and Mechanic Arts, 1956

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AN ABSTRACT OF A THESIS

submitted in partial fulfillment of the

requirements for the degree

MASTER OF SCIENCE

Department of Zoology

KANSAS STATE COLLEGE  
OF AGRICULTURE AND APPLIED SCIENCE

1958

A review of the literature revealed that several lagomorphs had been studied quite extensively for endoparasites. While several scattered reports of jack rabbit helminths had been made, a more complete study of endoparasites of jack rabbits seemed necessary in order to get a clearer picture of their parasitic fauna.

One hundred and thirty Black-tailed Jack Rabbits (Lepus californicus melanotis Mearns) were examined for helminth parasites. The hares were collected near Lakin in Kearny County, Kansas, during nine collecting periods from September, 1956, through September, 1957. The heart, lungs, liver, kidneys, gastro-intestinal tract, body cavity, and musculature of the animals were examined for endoparasites.

Purposes of the study were: (1) collect jack rabbits throughout the year to investigate seasonal fluctuations in incidence of parasitism, (2) investigate whether the total number of each species of helminth varied during the year, (3) determine if the jack rabbits in this area acted as reservoirs for cattle or sheep parasites, (4) observe if the endoparasites were associated with mortalities among jack rabbits, and (5) present a clearer picture of jack rabbit helminths in Kansas.

Following is the per cent incidence of each parasite found in this study: Passalurus nonanulatus 75 per cent, Raillietina spp. (and Tapeworm spp.) 66 per cent, Micipsella brevicauda 50 per cent, Multiceps spp. 19 per cent, Nematodirus spp. 17 per cent, Taenia spp. 7 per cent, Dermatoxys veligera 6 per cent, Nematodirus

arizonensis 5 per cent, Physaloptera spp. 2 per cent, and Nematodirus leporis 1.5 per cent.

P. nonanulatus and M. brevicauda showed the highest per cent incidence in the winter months. Raillietina spp. (and Tapeworm spp.) showed the highest per cent incidence in the summer months.

M. brevicauda n. sp., found in the abdominal cavity, is considered a new species mainly on two characteristics of the caudal end of the male worm. The length of the male tail is more than .100 mm. shorter than closely related species and no postanal papillae were found. Other species of Micipsella reportedly have longer tails in the male worms with two to four pairs of postanal papillae. Probably this is a new record of the genus Micipsella in the United States.

The characteristics of P. nonanulatus are so similar to those of P. ambiguus that separation of the two species is difficult. More work on these worms may reveal that P. nonanulatus is a synonym of P. ambiguus.

Age resistance, lack of intermediate hosts, and concentration of the hosts during a drought period and dispersion of the hosts during a wet period may have caused parasite fluctuations in jack rabbits in this study.

No cattle or sheep parasites were found. Also no pathological effects were noticed that might cause death in the hares. Under stress conditions, high numbers of worms may contribute to mortalities.