LYNXRUrus WILSONI N.G., N.SP. (Nematoda: Metastrongylidae) FROM THE LUNGS OF THE BOBCAT, LYNX RUFUS RUFUS (SHREBER)

by

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INTRODUCTION

In February and March of 1952, many bobcats, *Lynx rufus rufus* (Schreber) collected for study (1) by The Virginia Cooperative Wildlife Research Unit were observed to be infected with a lungworm parasite. Of sixty-four bobcats examined, all collected in Virginia and North Carolina, twenty-five per cent were found to be infected with these parasites.

The infections were massive and in all specimens, only one type of lungworm was observed. Macroscopically, these nematodes were found in the bronchial tubes, the bronchioles and in the lung tissues. None were found in the pulmonary blood vessels.

1. This study was made by Donald R. Progulske, graduate fellow, and was reported (Progulske, 1952) in partial fulfillment of the requirements for the degree of Master of Science, Virginia Polytechnic Institute, June 1952.
REVIEW OF THE LITERATURE

There is perhaps no greater confusion, in the ever growing field of parasitology, than is encountered in the taxonomy. Seemingly, every taxonomic parasitologist employs some different criteria for the classification of nematodes. The roundworms, under which the parasite of this study falls, are in controversy even as to their position, in the Animal Kingdom. Most textbooks consider the roundworms to be representatives of the class or order Nematoda of the phylum Nemathelminthes while one very eminent worker would like to see them elevated to the status of a phylum (Chitwood 1950) and another would lower them to an aschelminth class. (Hyman 1951).

The nematodes of the family Metastrongylidae, the lungworms, have recently been reclassified into subfamilies from the host-parasite relationship, the morphology of the genera within the group and finally by the apparent evolutionary radiation. (Dougherty, 1943, 1945, 1946 a, 1946 b, 1949 a, 1949 b, 1951 a, 1951 b, 1952). His work is by far, the most extensive, conclusive, and detailed done with the metastrongylid worms.

The literature of the metastrongylid nematodes records nine species from the lungs or respiratory apparatus of the family Felidae. These species are as follows: (1) Aelurostrongylus abstrusus (Railliet, 1898) Cameron, 1927 from Felis catus; (2) Anafilaroides rostratus Gerichter, 1948, from Felis catus; (3) Bronchostrongylus subcrenatus (Railliet and Henry, 1913) Cameron, 1931, from Felis pambé and Felis tigris; (4) Curtilis paralyzensis Woffhugel, 1933, from Felis catus and
Felis g. guinae; Metathelazia californica Skinker, 1931, from Lynx rufus californicus; (6) Metathelazia felis (Vogel, 1928) Dougherty, 1943, from Felis pardalis; (7) Metathelazia massino (Davtian, 1933) Dougherty, 1943, from Felis catus; (8) Troglodstronyx pseudovexler Gerichter, 1945, from Felis ocreatus; (9) Troglodstronyx troglodstronyx Vever, 1922, from Felis bengalensis.

It is of importance to note that the literature does not record a lungworm parasite from the bobcat, Lynx rufus rufus. There is, however, a lungworm Metathelazia californica Skinker, 1931, from the lynx, Lynx rufus californicus. Skinker places the genus Metathelazia in the family Thelaziidae. Dougherty (1952) does not agree with this classification. He prefers, due to the morphology of the cephalic region and certain evolutionary deduction, to place the genus Metathelazia in the family Metastrongylidae.

The position of the genus Aelurostrongylus in the classification is greatly confused. Cameron 1927, who named the genus, considered it a member of the family Protostrongylidae. Skrjebin and Yershov (1933) placed Aelurostrongylus in the subfamily Synthecaulinae and Bohm and Gebauer (1934) regarded it as a member of the Metastrongylinae. Dougherty (1943, 1946) transferred it to the subfamily Filarioidea. Gerichter (1948 a, 1948 b) has returned it to the family Protostrongylidae. A. abstrusus is the only species of this genus that has been described from the Felidae.

Dougherty (1949a) places the genera Bronchostrongylus Cameron, 1931 and Troglodstronyx Vever, 1923 in the subfamily Skrjabingylinae
(Skrjabin, 1933). In a later paper (Dougherty, 1951) it is indicated that he wishes to combine these two genera into one. In his key (Dougherty, 1949 a) of the subfamily Skrjabingylinae, based chiefly on male characters, the genus *Troglostrongylus* and *Bronchostrongylus* differ only in the lateral rays of the pattern. The one species of *Bronchostrongylus*, *B. subcrenatus* has been found in the lungs of both *Felis pardus* and *Felis tigris*. *Troglostrongylus troglostrongylus*, from *Felis bengalensis*, and *Troglostrongylus brevior*, from *Felis ocreatus*, according to Gerichter, (1949) differ in the size of the worms, the length of the spicules and gubernaculum, and the pattern of the lateral bursal rays.

Two genera, of the subfamily Filariodinae, *Gurltia*, Woffmugel, 1933, and *Anafilaroides* should cause no confusion in classification unless they gain more members. They are both represented by only one species each, they are *Gurltia paralytica* Woffmugel, 1933, and *Anafilaroides rostratus* Gerichter, 1949. Both of these genera parasitize the lungs of *Felis catus* while *Gurltia* also parasitizes *Felis g. guinea*. 
THE INVESTIGATION

Objective:

Since the literature does not record the existence of a lungworm parasite from the bobcat Lynx rufus rufus it is the purpose of this thesis to show that this is a previously unknown parasite. The description, naming and classification of this lungworm are to be considered in this objective.

Materials and Methods:

The bobcats were collected either by shooting or by traps. All specimens were placed in formalin until they could be studied conveniently. During subsequent examination of the preserved bobcats, all lungworms were removed and placed in seventy per cent alcohol. These nematodes were dehydrated in an alcohol series to one hundred percent and then transferred to beechwood cresote, to which had been added a small amount of fast green stain. After the parasites had cleared, they were mounted on slides in permount. These whole mounts were subjected to intensive microscopic study and all measurements were made by means of a calibrated ocular micrometer.

Stippled drawings were drawn to scale: of the anterior end of the worm, an en face view of the mouth, the posterior end of the female, and the posterior end of the male. These drawings were all photographed. In addition, photomicrographs were taken of slides showing the extended spicules of the male and the position of the vulva of the female. In one instance, a female worm was dissected at the caudal end and the reproductive organs allowed to float out in water. This was done in
an attempt to ascertain the position of these organs. A diagram of the terminal portion of this system was drawn and photographed.

After complete familiarity with this lungworm had been accomplished, a comparative investigation of the literature of related lungworms was undertaken.

A description of the parasite

The body of the parasite was found to be elongate with the outer body covering or teguminal sheath (Gerichter, 1942) thrown into folds at the anterior end (Fig. 1). On examining the cephalic end from an ep face section (Fig. 2), there was observed to be a circular opening, displaying no teeth or papillae. A very thorough search was made under oil immersion for these structures but none could be seen. There were, however, four lip-like structures present. In whole mount slides, a shallow buccal capsule that joined the straight muscular esophagus could be distinguished. The esophagus was short and was observed to be larger at the anterior end than at the posterior. Measurements showed that this structure was 300 micra long by 50 micra wide. The nerve ring was situated 175 micra from the anterior end of the esophagus (Fig. 1). Both the male and female worms were identical at the anterior end. The esophagus was joined, in both male and female, to the simple straight intestine. This structure extended the length of the body and opened on the ventral surface, a short distance from the posterior extremity of the female and at the dorsal ray of the bursa in the male. In the female four unpaired pre-anal papillae were evident.

The body length and width of twenty unmounted mature worms of each sex were measured. The average length of the male worms was 10.9 mm with
with a range of from 10.2 to 12.0 mm. The average male width, excluding the bursal portion, was .22 mm ranging from .19 to .24 mm. The female worms were somewhat larger with an average length of 21.6 mm and ranging from 19.6 to 23.4 mm. The average female width was .36 mm, with a range of from .35 to .40 mm.

The body width of the male diminished in size to an average of 100.8 micra just anterior to the bursa. The bursa of the male, measuring 137.5 micra long by 175.0 micra wide, was small and fan-shaped. From a ventral view the rays of the bursa were paired and symmetrical. The fused ventroventral and lateroventral rays of the bursa were short, adhered closely to the body and were bifurcated at the extremity. Upon measurement with an ocular micrometer, these fused rays were determined to be 30 micra long and the bifurcation began 6.2 micra from the base. Measurement of the fused externolateral and mediolateral rays showed them to be 40.7 micra and 34.5 micra respectively in length, while the bifurcation occurred 10.1 micra from the base. The fused posterolateral and externodorsal rays were 42.5 micra and 37.5 micra long and the bifurcation was found to be 12.3 micra from the base. The dorsal ray was single, broad at its origin and tapering caudally to enlarge at its end. It was without bifurcation, and measured 50.3 mm from base to tip. The bursal pattern may be seen in Figure 4. The paired spicules of the male worm were extremely long, delicate, equal in length and provided with striated laminae. They measured from 1.70 to 1.85 mm in length and were 5.6 micra wide. Each spicule was provided with an accessory appendage at the terminal end. These appendages were joined to the spicules 100 micra from the posterior extremity of the spicules, and measured 150 micra in length (Fig. 5). There was a paired gubernasulum present that measured laterally 171 micra in
length and 6.2 in width.

In considering the female reproductive system of the lungworm parasite, whole mount slides and a dissected female were studied. The posterior end of the worm when dissected and floated out in water showed that there was no ovejectoral apparatus and the organs themselves were arranged in a prodelphic didelphic pattern (Fig. 7). That is, the vulva was found situated at the posterior end of the worm just anterior to the anus (Fig. 3 & 6). The vagina ran toward the anterior and ended in paired uteri that coiled about themselves. The uteri extended to the paired oviducts and ovaries. The vulva was .097 mm from the anus.

The uteri of the mature females were filled with embryonated eggs. These ova measured 50.1 to 53.4 micra in length by 25.3 to 27.6 micra in width. The layers of the egg shell were undeterminable but the entire shell measure 3.75 micra thick (Fig. 3 & 6).

These descriptive measurements have been arranged in tabular form in Tables I, II, and III.

**Taxonomic Diagnosis:**

As a result of the previous description a new genus, *Lynx rufus*, and a new species, *Lynx rufus wilsoni* are assigned to the family Metastrongylidae, subfamily Skrjabingylinae.

*Lynx rufus*, n.g.

Generic diagnosis—Skrjabingylinae; body elongate, cuticle thrown into folds at anterior end. Mouth circular, displaying no
teeth or papillae but four lip-like structures present when viewed from an **en face** view (Fig. 2). Shallow buccal capsule present joining a straight muscular esophagus short and larger at anterior end than at posterior. Bursa of male small and fan shaped; ventroventral and laterolateral rays of bursa short and fused on each side, adhering closely to body and bifurcating at extremity; externolateral and mediolateral rays largely fused on each side, but bifurcate at extremity; fused postero-lateral and externodorsal rays, bifurcation at extremity; dorsal ray single, broad at origin then tapering only to enlarge again at unbifurcating extremity (Fig. 4). Spicules very long, delicate and equal; each provided with accessory appendage at posterior end; spicules provided with striated laminae. Gubernaculum present. Female with slightly pointed tail; vulva located at posterior end of body close to anus (Fig. 3 & 4); no ovejectoral apparatus; didelphic, prodelphic (Fig. 7). Type species: *Lynx rufus wilsoni*. 

*Lynx rufus wilsoni*, n. sp.

**Specific diagnosis**—*Lynx rufus*. Male: 10.2–12.0 mm long, 0.19–0.24 mm wide. Esophagus 300 micra long by 50 micra wide; nerve ring 175 micra from anterior end of esophagus. Bursa 137.5 micra long by 175 micra wide. Bursal rays, with exception of dorsal, in fused groups, each tapering toward extremity and bifurcating near extremity; dorsal ray narrowing from base toward extremity enlarging at extremity; without bifurcation. Fused ventroventral and latero-ventral rays 30 micra long bifurcating 6.2 micra from base; fused
externolateral and mediolateral rays 40.7 and 34.5 micra long, bifurcate 10.0 micra from base; fused posterolateral and externodorsal rays 42.5 micra and 37.5 micra long, bifurcation 12.3 micra from base; dorsal ray 50.3 micra long (Fig. 4). Spicules 1.70-1.85 mm long by 5.7 micra wide measured dorsally; accessory appendages joined to spicules 100 micra from end; accessory appendage 150 micra long (Fig. 5). Gubernaculum, lateral measurement, 171 micra long by 6.2 micra wide. Body proper diminishing in size to 100 micra just previous to bursa.

Female: 19.6-23.4 mm in length by 0.35-0.40 mm in width. Anterior end identical with male. Vulva 0.97 mm from anus. Four small paired preanal papillae situated longitudinally just anterior to anus on ventral surface (Fig. 3). Internal reproductive organs didelphic prodelphic. Embryonated eggs 50.1-53.4 micra long by 25.3-27.6 micra wide; layers of shell undeterminable but entire shell 3.75 micra thick.

Host: Lyra rufus rufus (Shreber)

Location: Lungs

Geographic distribution: Virginia and North Carolina
### TABLE 1. Comparable measurements of the male and female of *Lynx rufus wilsoni*

<table>
<thead>
<tr>
<th></th>
<th>Male</th>
<th>Female</th>
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<tr>
<td>Body length</td>
<td>10.2-12.0 mm Av. 19.9mm</td>
<td>19.6-23.4 mm Av. 21.6mm</td>
</tr>
<tr>
<td>Body width</td>
<td>0.19-0.24mm Av. 0.22mm</td>
<td>0.35-0.40 mm Av. 0.36mm</td>
</tr>
<tr>
<td>Length of esophagus</td>
<td>300 micra</td>
<td>300 micra</td>
</tr>
<tr>
<td>Width of esophagus</td>
<td>50 micra</td>
<td>50 micra</td>
</tr>
<tr>
<td>Situation of nerve ring from anterior end of esophagus</td>
<td>175 micra</td>
<td>175 micra</td>
</tr>
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TABLE 2. A tabulation of the measurements of the male reproductive parts of *Lynx rufus wilsoni*

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<th>Reproductive Parts Male</th>
<th>Measurements</th>
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<tr>
<td>Bursa length and width</td>
<td>137.5 X 175.0 micra</td>
</tr>
<tr>
<td>Length of fused ventroventral &amp; lateroventral rays bifurcation</td>
<td>30 micra 30 micra 6.2 micra</td>
</tr>
<tr>
<td>Length of fused externolateral &amp; mediolateral rays bifurcation</td>
<td>40.7 micra 34.5 micra 10.1 micra</td>
</tr>
<tr>
<td>Length of fused posterolateral &amp; externodorsal rays bifurcation</td>
<td>42.5 micra 37.5 micra 12.3 micra</td>
</tr>
<tr>
<td>Length of dorsal ray</td>
<td>50.3 micra</td>
</tr>
<tr>
<td>Length and width of spicules</td>
<td>1.70-1.85 mm X 5.6 micra</td>
</tr>
<tr>
<td>Length of accessory appendage</td>
<td>150 micra</td>
</tr>
<tr>
<td>Gubernaculum</td>
<td>171 X 6.2 micra</td>
</tr>
</tbody>
</table>
TABLE 3. A tabulation of some of the measured female parts of *Lynx rufus wilsoni*.

<table>
<thead>
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<th>Female Parts</th>
<th>Measurements</th>
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<tr>
<td>Distance from vulva to anus</td>
<td>.097 mm</td>
</tr>
<tr>
<td>Length of ova</td>
<td>50.1-53.4 micra</td>
</tr>
<tr>
<td>Width of ova</td>
<td>25.3-27.6 micra</td>
</tr>
<tr>
<td>Thickness of shell</td>
<td>3.75 micra</td>
</tr>
</tbody>
</table>
Figure 1. Anterior end, showing oral region, esophagus, nerve ring and the beginning of the intestine of *Lynx rufus wilsoni*.

Figure 2. *Lynx rufus wilsoni*, en face view of anterior end.
Figure 3. Posterior end of female of *Lynxrixus wilsoni*, ventral view, showing small amount of the egg filled uterus, the vagina, the vulva and the anus with preanal papillae.

Figure 4. Posterior end of male, ventral view, showing pattern of the bursal rays and contracted spicules of *Lynxrixus wilsoni*. 
Figure 5. Photomicrograph of the posterior end of the male *Lynx rufus wilsoni*, lateral view, showing spicules, accessory piece and gubernaculum. 100 x.

Figure 6. Photomicrograph of posterior end of female, *Lynx rufus wilsoni*, showing position of *vulva*. 
Figure 7. Diagram of the female reproductive system of *Lynx rufus wilsoni*. 
DISCUSSION OF RESULTS

It seems pertinent at this point to discuss *Lynceurus Wilsoni* and its position in the family Metastrongylidae. Dr. Ellsworth C. Dougherty, Department of Zoology, University of California, Berkeley, California, was kind enough to look over and criticize the primary research on *Lynceurus Wilsoni*. At that time a female worm had not been dissected to ascertain the anatomy, position, *et cetera* of the reproductive organs. It was thought that the female was monodelphic. Dr. Dougherty, in a note on this point wrote:

"I think *Lynceurus Wilsoni* would make a perfect member of the genus *Troglostrongylus* but for one thing—the remarkable position of the vulva and monodelphy." Further he wrote:

"I should also point out that in the posterior position of the vulva of *Lynceurus* is transitional between the rest of the subfamily Skrjabinyllae (wherein I should place it) and members of the other subfamilies of the Metastrongylidae (except *Dictyocaulus*). However, the fact of monodelphic of which you apparently are unsure, makes this less significant. This last is such a crucial point that I strongly recommend your dissecting out the terminal female reproductive tract and settling this point once and for all. If *Lynceurus Wilsoni* is in fact didelphic, it represents a very important transitional form in the Metastrongylidae as I conceive them."

After receiving the foregoing suggestion of Dr. Dougherty's, the posterior portion of a female worm was dissected and proved to be didelphic, as had been indicated in the previous section. Also, there are the facts that the female reproductive organs of *Lynceurus Wilsoni* run anteriorly from a posteriorly located vulva and there is no ovejectoral apparatus. The genera of the subfamily Skrjabinyllae (Skrabin, 1933) as recognized by Dougherty (1948, 1949) consist of *Dictyocaulus, Skrjabinyllus, Crenosoma, Otostrongylus, Troglostrongylus,*
and *Bronchostrongylus*. The females of these genera have three things in common; namely; an ovejectoral apparatus, a vulva situated toward the middle of the body and amphidelphy. Dougherty has since modified the Skrjabingylidae by placing *Dictyocaulus* into a subfamily all its own.

Dougherty (1945) felt in his earlier studies on the evolution of the metastrongylid family that the Skrjabingylinae, because of the position of the vulva and the structure of the ovejectoral apparatus, were a link between the Trichostrongylidae and the family Metastrongy- 
idae (i.e., they had a common ancestor, Strongylina) and he placed the skrjabins under Trichostrongylidae. He has since removed the sub-
family Skrjabingylinae to the family Metastrongylidae (Dougherty 1951 b).

This change of view was brought about by the work of Gerichter (1948 and 1949) which clearly showed that the morphology of the larval forms of *Troglostrongylus braylor* were closer to the metastrongylids than to
the trichostrongylids. Gerichter further suggested to Dougherty that the position of the vulva near the mid-portion of the body in the skrjabins might be a secondary evolutionary shift from the preanal position found in most of the metastrongylids. Since the male of
*Lymantrius* rather closely resembles two genera of the subfamily Skrja-
bingylinae, it is understandable that Dougherty in the previously
mentioned communication should feel that the posterior position of the vulva and the didelphy of the female of *Lymantrius wilsoni* causes it to become "a very important transitional form in the Metastrongylidae".

The male of *Lymantrius wilsoni* resembles two genera of the
subfamily Skrjabingylinae, *Bronchostrongylus* Cameron, 1931, and *Troglostrongylus* Ververs, 1923. The males of these three genera have in common (Ververs, 1922, Cameron 1931, Dougherty 1947) a dorsal ray that is a single stalk, a small, though normal, bursa with a full complement of rays, a tegumental sheath that is not thrown into striated annulations and thin delicate spicles with striated laminae. The bursal pattern of the three genera differs mostly in the arrangement and fusion of the paired lateral bursal rays. The externolateral and mediolateral rays are fused in the proximal portion as are the posterolateral and externodorsal in genus *Lynxrufus*. The externolateral and mediolateral rays are fused in *Troglostrongylus* but the posterolaterals arise independently. In *Bronchostrongylus*, the externolateral rays arise independently and the mediolaterals and posterolaterals are partly fused.

It is of interest to note that with one exception, all the species of the previously mentioned genera parasitize the respiratory system of the family Felidae. *Troglostrongylus delicatus* Travassos, 1946 is that one exception; it is a parasite of the opossum, *Didelphis*.

The cephalic region of *Lynxrufus* should certainly be discussed. Dougherty insisted, in the personal communication about *Lynxrufus*, that papillae could be seen if a slide were properly prepared and viewed under oil immersion. The author has tried many times to see papillae but even with the clearest of *en face* preparations studied under oil immersion, papillae were not discerned. In a new classification of the suborder Strongyline (Dougherty 1951), the family
Metastrongylidae is described in part as having unfused submedian papillae of the external circle.
CONCLUSIONS

It is concluded that the new genus *Lmxrufus* should be placed tentatively in the subfamily Skrjabingylineae because of the similarity of the male reproductive organs to those of the genera *Troglostrongylus* Vevers, 1923, and *Bronchostrongylus* Cameron, 1931. Further, it is concluded that the genus represents a transitional form between the subfamily Skrjabingylineae and the other subfamilies of the family Metastrostrongylidae because of the posterior position of the vulva, the lack of ovejectoral apparatus and the paired condition of the female reproductive organs.

Since actually, it has not been ascertained, the author concludes that the cephalic region of *Lmxrufus wilsoni* may have cephalic papillae but with the technique and ocular equipment at hand, papillae could not be seen.
SUMMARY

Of sixty-four bobcats, *Lynx rufus rufus*, collected in Virginia and North Carolina, twenty-five percent were found to be infected with an unidentified lungworm.

As the literature showed no record of lungworm parasites from *Lynx rufus rufus*, a study was made of the lungworms of the cat family, Felidae.

A new metastrongyloid genus and species is here described, named and classified. The name is designated as *Lynx rufus wilsoni*. *Lynx rufus wilsoni* is placed tentatively in the subfamily Skrjabingylinae due to the similarity of its male reproductive organs to the male reproductive organs of the other members of that subfamily.
ACKNOWLEDGEMENTS

As one thinks over the work put into a thesis, it becomes very evident that one's teachers, friends and associates have given more than can be expressed in a page of typewritten words. Therefore, with a great feeling of inadequacy, I should like to pay tribute to some of the many who have made this work possible.

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