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**Some Observations on Cestodes of the Genus *Paranoplocephala*  
Luehe, Parasitic in North American Voles  
(*Microtus* spp.)<sup>1</sup>**

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Although cestodes of the genus *Paranoplocephala* Luehe, 1910, are common parasites of voles and certain other rodents in North America, their taxonomic status to the present time has been much confused. It is the purpose of this paper to clarify the situation in regard to those species parasitic in voles of the genus *Microtus* Schrank.

While certain of the cestodes considered here occur in hosts of other microtine genera, they are by far more abundant in the various species of *Microtus*. At least two are also common in geomyid rodents. With the possible exception of *Paranoplocephala brevis* Kirschenblatt, 1938, discussed further below, none of the North American species has been recorded from Eurasian rodents.

The material upon which this work is based has resulted from the examination by one of us (R.R.) of nearly a thousand voles and related microtine rodents. Most of the animals were collected over the past six years from the North

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<sup>1</sup> This work supported in part by the Research Committee of the Graduate School from funds supplied by the Wisconsin Alumni Research Foundation.

Central States region, although some were also collected in Wyoming and Manitoba. Five species of *Microtus* have been considered: *Microtus p. pennsylvanicus* Ord, *M. pennsylvanicus drummondii* (Audubon and Bachman), *M. pennsylvanicus modestus* (Baird), *M. montanus nanus* (Merriam), and *M. ochrogaster* (Wagner). The material resulting from the examination of hosts of other genera (*Pitymys*, *Synaptomys*, *Phenacomys*, *Clethrionomys*, etc.) is not considered here, since this is essentially an attempt to make it possible to differentiate the species parasitic in *Microtus*. It seems desirable to avoid any complications brought about by possible host variation.

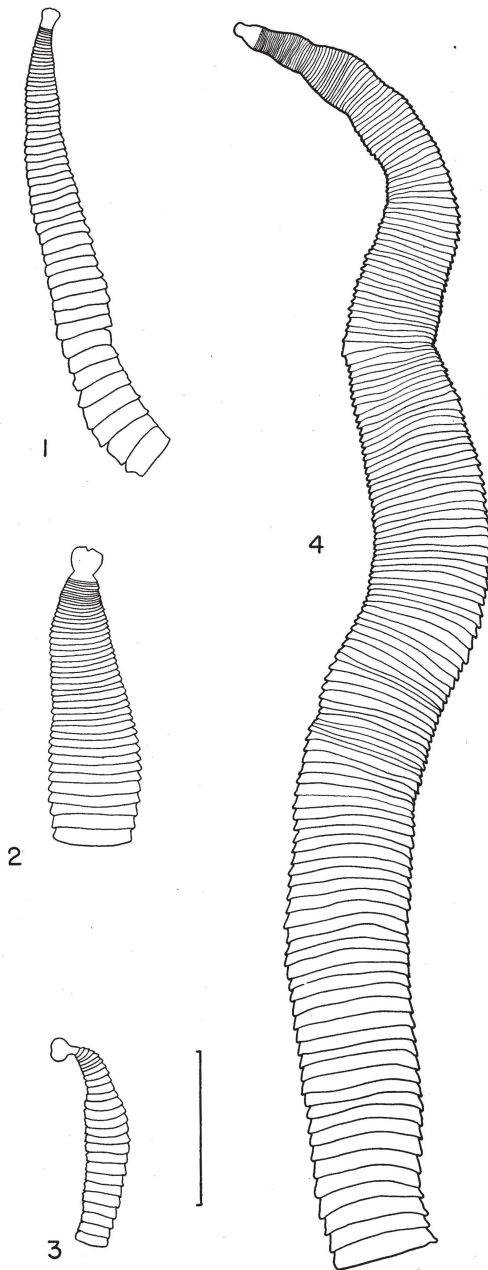
All material has been treated in the same manner, in order to avoid differences brought about by different degrees of relaxation of the cestodes. After being allowed to relax in tap water, the worms were killed and fixed, without pressure, by the application of hot formalin-acetic acid-alcohol solution. Whole mounts were routinely stained with Semichon's acetic carmine, and serial sections were stained with haematoxylin-eosin.

Early in our studies of the helminths of voles it was recognized that three distinct species were present, although it was not possible to identify them according to existing descriptions. Douthitt (1915), in his monograph of the cestode family Anoplocephalidae, described two species, *Anoplocephala variabilis* and *A. infrequens*. He further recognized a subspecies of the former, *A. variabilis borealis*. Douthitt's species were all described from *Geomys bursarius* (Shaw), although he also recorded *P. infrequens* from *Clethrionomys* (= *Evotomys*). Baer (1927) reassigned Douthitt's species to the genus *Paranoplocephala*, and, at the same time, indicated that *P. variabilis* was identical with *P. infrequens*. Rausch (1946) described *P. troeschi* from the common meadow vole. Only two species, therefore, have been considered as parasitic in North American rodents. Hansen (1947) considered *P. variabilis* and *P. infrequens* to be separate, on the basis of skirt-like extensions observed on specimens identified by him as *P. infrequens*. Harkema (1946) reported *P. omphalodes* (Hermann, 1783) from the cotton rat. Dr. Harkema kindly allowed us to examine his material, and it was found that his original identification was incorrect.

Since Douthitt's work relatively little has been done with these cestodes, except that they have been recorded from additional host species. Harkema (1936) and Erickson (1938) included *Paranoplocephala infrequens* in their lists of helminths from rodents. This species was also mentioned briefly by Rausch (1946) and by Hansen (1947). There has been a tendency by some workers to confuse the genera *Andrya* and *Paranoplocephala* when attempting to identify cestodes from voles. This is hardly justifiable in view of the form of the uterus in the two genera; other details, such as form of strobila, are characteristic for American species.

Through the kindness of Dr. E. W. Price we have examined 56 slides, mostly serial sections, of Douthitt's original material. Dr. Jean G. Baer has supplied slides of certain European forms, and Mr. Merle Hansen allowed us to examine his material from Nebraska voles.

After a study of Douthitt's material, we are of the opinion that *Paranoplocephala variabilis* should be considered a valid species. It was found that *P. infrequens* is a composite of what appears to be small specimens of *P. variabilis* and which has since been described by Rausch (1946) as *P. troeschi*. Examination of slides of the former led Baer (1927) to consider *P. variabilis* identical with *P. infrequens*. Since, when *P. troeschi* was described, the types of *P. infrequens* were not examined, and since there was no agreement with the diagnosis of the latter as given by Baer (1927), *P. troeschi* was not recognized as



FIGS. 1-4. Macroscopic appearance of species of *Paranoplocephala* parasitic in voles. The scale has the value of 5 mm. 1—*Paranoplocephala borealis* (Douthitt, 1915) n. comb. 2—*P. infrequens* (Douthitt, 1915). 3—*Paranoplocephala* sp. 4—*P. variabilis* (Douthitt, 1915).

being identical with it. The present study, however, has revealed that the name *P. troeschi* Rausch, 1946, must be considered a synonym of *P. infrequens* (Douthitt, 1915).

We are also of the opinion that Douthitt's subspecies, *Paranoplocephala variabilis borealis*, should be elevated to full specific rank, since it appears to be quite distinct.

This results, then, in three recognizable species; *Paranoplocephala variabilis* (Douthitt, 1915), *P. borealis* (Douthitt, 1915) n. comb., and *P. infrequens* (Douthitt, 1915). A fourth species, of uncertain status, is discussed below.

We have included a brief diagnosis for each species, based on material from voles. A key is also presented. It is ordinarily possible to recognize these species at the time they are removed from the host (see Figs. 1-4).

*Paranoplocephala variabilis* (Douthitt, 1915)

(Figs. 4, 8, and 12)

*Synonyms.*—*Anoplocephala variabilis* Douthitt, 1915; *Anoplocephaloides variabilis* (Douthitt, 1915) Baer, 1924; *Paranoplocephala infrequens* (Douthitt, 1915) in part.

*Diagnosis.*—Length 15 to 41 mm.; maximum width, attained in post-mature segments, 2 to 4 mm. Strobila much attenuated anteriorly, increasing gradually in width posterad. Segments from 42 to 199 in number, much wider than long (ratio of length to width about 1:12 in mature segments), increasing somewhat in length in post-mature segments. Scolex from 210 to 370  $\mu$  long by 380 to 560  $\mu$  wide; relatively very small and weak. Suckers weakly developed, from 140 to 210  $\mu$  in diameter; neck short, of about same diameter as scolex. Muscle fibers strongly developed. Ventral and transverse longitudinal excretory canals measure from 10 to 20  $\mu$  in diameter. Dorsal excretory canals measure about 6  $\mu$ . Genital pores are unilateral, dextral, situated near middle of margin of segment. Genital ducts pass dorsal to longitudinal excretory canals. Testes, spherical, are 60 to 80 in number, and from 20 to 30  $\mu$  in diameter in mature segments. They extend from about middle of segment to beyond ventral excretory canal on aporal side; usually from 6 to 8 testes are found lateral to the ventral canal. Cirrus sac, elongate pyriform, measures from 115 to 200  $\mu$  long by 28 to 56  $\mu$  wide in mature segments. Cirrus aspinose. Cirrus sac does not reach across poral ventral excretory canal. Internal and external seminal vesicles well developed. Vagina opens posterior and partly ventral to cirrus sac. Seminal receptacle enlarges to extend from proximal end of cirrus sac to well beyond poral margin of ovary in mature segments. Ovary strongly lobed, situated somewhat porally near middle of proglottid. Vitelline gland, irregularly elongate, is partly posterior and dorsal to ovary. Uterus, tubular, extending ventrally beyond longitudinal excretory vessels; mostly ventral to ovary. Uterus becomes sacculate and finally fills entire gravid segment. Eggs measure from 20 to 26  $\mu$  wide by 26 to 33  $\mu$  long. Pyriform apparatus well developed.

A whole-mount of a typical specimen has been deposited in the Helminthological Collection of the U. S. National Museum, slide number 46371.

This is the largest species of the genus that we have found parasitic in voles (Fig. 4). It is commonly found in the duodenum of the host, with the scolex just below the pyloric valve. We have never observed more than one worm in a single host animal, although Douthitt (1915) reported as many as 50 specimens in a single *Geomys*. Douthitt's specimens were often larger, a situation perhaps brought about by occurrence in a different host species. This cestode is uncommon enough that we can make no statement concerning distribution or seasonal occurrence.

*Paranoplocephala borealis* (Douthitt, 1915) n. comb.

(Figs. 1, 5, and 9)

*Synonym.*—*Anoplocephala variabilis borealis* Douthitt, 1915.

*Diagnosis.*—Length 10 to 14 mm.; maximum width, attained usually near middle of strobila, 1.4 to 2 mm. Proglottids from 43 to 84 in number, much wider than long (ratio of length to width in mature segments about 1:4); they increase somewhat in length as they become older, but are never longer than wide. Scolex from 284 to 355  $\mu$  wide by 230 to 270  $\mu$  long. Suckers from 100 to 130  $\mu$  in diameter. Scolex rather prominent, considerably wider than neck; suckers weakly developed. Muscle fibers not so strongly developed; living worm somewhat translucent. Ventral excretory canals 10 to 16  $\mu$  in diameter; transverse canals from 6 to 16  $\mu$ . Dorsal canals about 6  $\mu$  in diameter. Genital pores unilateral, sinistral, situated near middle of margin of proglottid. Genital ducts pass dorsal to longitudinal excretory canals. Testes ovoid, from 38 to 52 in number; from 20 to 30  $\mu$  in length in mature segments. Testes extend from aporal edge of vitelline gland to well across the aporal ventral excretory canal. They also extend anterior to the uterus and posterior to the transverse excretory canal in mature segments; this may be seen in segments that are well relaxed, so it cannot be attributed to state of contraction of the segments. From 5 to 12 testes may be found lateral to the aporal longitudinal excretory canals. Cirrus sac elongate, from 30 to 62  $\mu$  wide by 100 to 150  $\mu$  long in mature segments; it does not extend past ventral longitudinal excretory canal. Cirrus aspinose. Internal and external seminal vesicles well developed. Vagina opens posterior and somewhat ventral to cirrus sac. Seminal receptacle well developed, extending from proximal margin of poral ventral excretory canal to near middle of vitelline gland in mature segments; it becomes nearly spherical in older segments. Ovary, situated near middle of segment, strongly lobed; ovarian lobes relatively fine and elongate. Vitelline gland posterior and dorsal to ovary; rather semi-lunar in shape. Mehlis' gland spherical, just anterior to vitelline gland and situated in anterior depression of latter. Uterus tubular, becoming sacculate and filling entire segment when completely gravid. Eggs measure from 20 to 23  $\mu$  wide to 30  $\mu$  long. Pyriform apparatus well developed.

A whole-mount of a typical specimen has been deposited in the Helminthological Collection of the U. S. National Museum, slide number 46373.

We have observed no tendency in this species to intergrade with *Paranoplocephala variabilis*, although Douthitt was of the opinion that this occurred. In fact, we have collected both species in the same latitude in the North Central States region. It appears, however, that *P. borealis* is more common in the northern section of that region. On the basis of morphological differences, it seems entirely justifiable to consider *P. borealis* a distinct species. This cestode is found in the small intestine of the host.

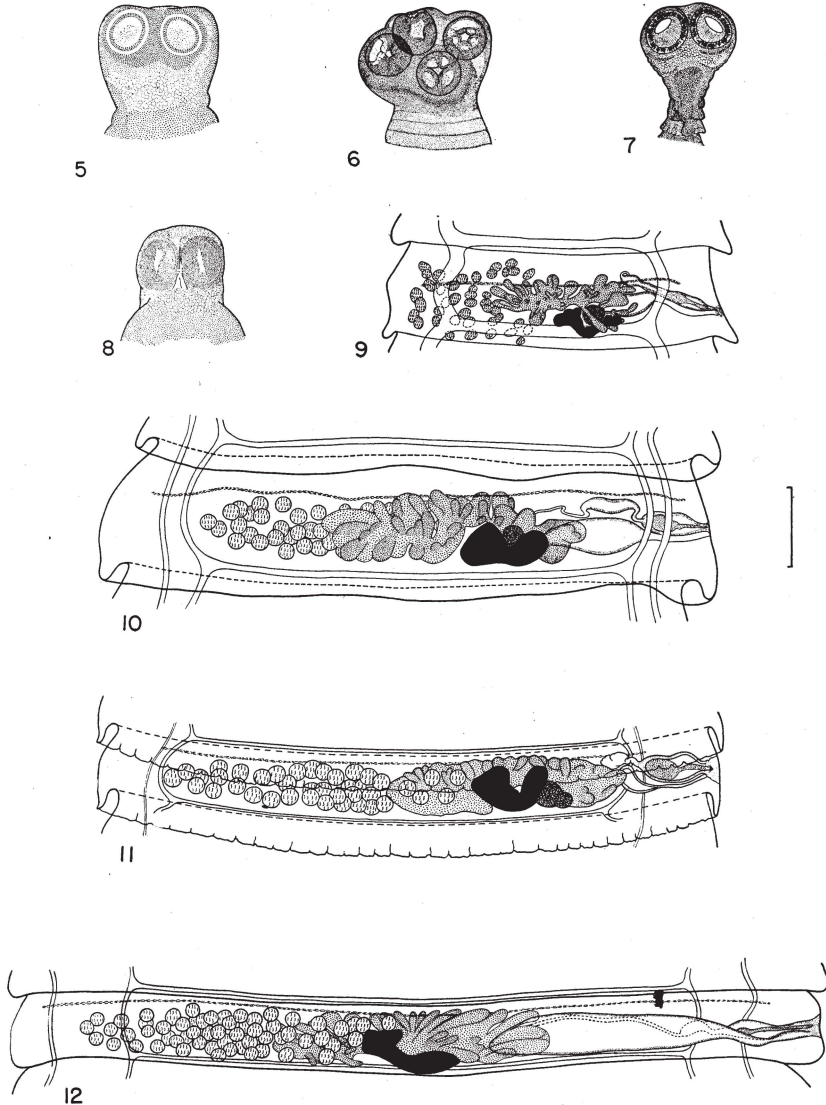
*Paranoplocephala infrequens* (Douthitt, 1915)

(Figs. 2, 6, and 10)

*Synonyms.*—*Anoplocephala infrequens* Douthitt, 1915; *Anoplocephaloides infrequens* (Douthitt, 1915) Baer, 1924; *Paranoplocephala variabilis* (Douthitt, 1915) in part; *P. troeschi* Rausch, 1946.

*Diagnosis.*—Length 4 to 11.5 mm.; maximum width, attained at posterior end of strobila, 1.3 to 3.5 mm. Strobila distinctly wedge-shaped; segments from 25 to 51 in number. Scolex from 640 to 940  $\mu$  wide by 568 to 710  $\mu$  long; very powerfully developed and quite distinct from the neck. Suckers, strongly developed, from 298 to 340  $\mu$  in diameter. Neck short and not prominent. Muscle

fibers strongly developed. Ventral excretory canals 14 to 22  $\mu$  in diameter; transverse canals 12 to 18  $\mu$ . Dorsal canals about 12  $\mu$  in diameter. Genital pores



FIGS. 5-12. Morphological details of species of *Paranoplocephala* parasitic in voles. The scale has the value of 600  $\mu$  for figs. 5, 6, and 7; 900  $\mu$  for fig. 8; 200  $\mu$  for figs 9, 10, 11, 12. 5—Scolex of *Paranoplocephala borealis* (Douthitt, 1915) n. comb. 6—Scolex of *P. infrequens* (Douthitt, 1915). 7—Scolex of *Paranoplocephala* sp. 8—Scolex of *P. variabilis* (Douthitt, 1915). 9—Mature segment, ventral view, of *P. borealis*. 10—Mature segment, ventral view, of *P. infrequens*. 11—Mature segment, dorsal view, of *Paranoplocephala* sp. 12—Mature segment, dorsal view, of *P. variabilis*.

unilateral, sinistral, situated at about middle of margin of segment. Genital canals dorsal to longitudinal excretory canals. Testes spherical, 35 to 50 in

number; from 33 to 50  $\mu$  in diameter. Testes extend from aporal edge of vitelline gland to aporal ventral longitudinal excretory canal, but never beyond it. Cirrus sac strongly developed, pyriform, from 30 to 66  $\mu$  wide by 100 to 155  $\mu$  long; it is often constricted near middle. Cirrus spinose. Internal and external seminal vesicles well developed. Vagina opens ventral and slightly posterior to cirrus sac. Seminal receptacle well developed, extending from proximal end of cirrus sac to vitelline gland in mature segments; it becomes much larger as segments become gravid. Vitelline gland, bilobed and somewhat reniform, situated dorsal to poral half of ovary. Mehlis' gland just anterior to vitelline gland, situated in anterior depression of the latter. Tubular uterus extends ventrally past longitudinal excretory canals; saeculations gradually develop, and uterus completely fills gravid segments. Eggs measure from 30 to 40  $\mu$  in diameter. Pyriform apparatus well developed.

A whole-mount of a typical specimen has been deposited in the Helminthological Collection of the U. S. National Museum, slide number 46372.

*Paranoplocephala infrequens* is the most common cestode occurring in voles in the central part of the United States. It was found in all vole species examined except for *Microtus pennsylvanicus drummondii* (collected in Manitoba).

TABLE 1.—A comparison of the measurements of *Paranoplocephala brevis* Kirschenblatt, 1938, and *P. infrequens* (Douthitt, 1915).

	<i>P. brevis</i>	<i>P. infrequens</i>
No. of segments .....	20 to 26	25 to 51
Length .....	5.6 to 6 mm.	4 to 11.5 mm.
Max. width .....	2.1 to 2.5 mm.	1.3 to 3.5 mm.
Diameter of scolex .....	830 to 860 $\mu$	640 to 940 $\mu$
Diameter of suckers .....	315 to 365 $\mu$	298 to 340 $\mu$
Genital pores .....	unilateral	unilateral
No. of testes .....	28 to 33	33 to 50
Length of cirrus sac .....	170 to 200 $\mu$	100 to 155 $\mu$
Diameter of eggs .....	26 to 38 $\mu$	30 to 40 $\mu$

The seasonal fluctuations of this species are of particular interest (Rausch and Tiner, 1948). *Paranoplocephala infrequens* is most commonly found in the cecum of the host, although at times it occurs just anterior to the cecum in the terminal portion of the small intestine. This species also occurs in larger numbers in a single host animal than do the two above-mentioned species.

Hansen (1947) indicated certain morphological details for this species ("*Paranoplocephala troeschi*") which differed from those given by Rausch (1946). An examination of Hansen's material has revealed that he was in error as to the identification of part of his specimens, having included with those of "*P. troeschi*" measurements from another species.

Kirschenblatt (1938) described a cestode, *Paranoplocephala brevis*, from *Microtus* spp. from the Transcaucasus region of Russia. It is possible that *P. brevis* will be found to be identical with *P. infrequens*, since both morphologically and ecologically they are quite similar. Table 1 compares the measurements of the two species; certain differences may be found to disappear when a large series of *P. brevis* is studied. Further discussion of the ecology of the two species has been given in another paper (Rausch and Tiner, 1948).

#### *Paranoplocephala* sp.

*Diagnosis.*—Length from 6 to 8 mm.; maximum width, attained near the middle of the strobila, 1.5 to 2 mm. Anterior end of strobila more attenuated



than that of *P. infrequens*. Segments, from 30 to 32 in number, much wider than long (ratio of length to width of mature segments about 1:9). Scolex from 582 to 710  $\mu$  wide by 454 to 525  $\mu$  long. Suckers from 284 to 326  $\mu$  in diameter. Scolex distinct from neck, but suckers not so prominently developed. Neck well defined, about  $\frac{2}{3}$  as long as scolex. Musculature rather weakly developed. Ventral longitudinal excretory canals from 12 to 23  $\mu$  in diameter; transverse canals of a similar size. Dorsal canals from 4 to 7  $\mu$  in diameter. Genital pores unilateral, dextral, situated near middle of margin of segment. Genital ducts pass dorsal to longitudinal excretory canals. Testes spherical, from 40 to 50 in number; from 20 to 33  $\mu$  in diameter in mature segments. Testes extend from aporal edge of vitelline gland to aporal ventral longitudinal excretory canal, but not beyond it. Cirrus sac pyriform, from 156 to 185  $\mu$  long by 57 to 71  $\mu$  wide. Internal and external seminal vesicles well developed. Vagina opens posterior to cirrus sac. Seminal receptacle well developed. Ovary more sacculate than lobate, situated usually in poral half of segment. Vitelline gland dorsal to middle of ovary; reniform in shape. Mehlis' gland poral to vitelline gland. Tubular uterus extends ventrally past longitudinal excretory canals. Uterus becomes sacculate and finally fills entire gravid segment. Eggs measure from 26 to 33  $\mu$  wide by 33 to 40  $\mu$  long. Pyriform apparatus well developed.

A whole-mount of a specimen has been deposited in the Helminthological Collection of the U. S. National Museum, slide number 46374.

Although superficially this species closely resembles *Paranoplocephala infrequens*, certain differences make it doubtful that they are identical. The scolex of the present species is not so strongly developed, although Baer (personal communication) does not consider this character to be of value in this genus. In well-relaxed strobilae the skirt on the posterior margin of the segments extends much farther posterad than that of *P. infrequens*. The ovary is more poral, and the vitelline gland is at the center of the ovary, instead of above the poral half. Moreover, the genital pore in this species is dextral, rather than sinistral as it is in *P. infrequens*. We can not say whether this character is subject to such variation, but the study of material available so far would indicate that it is not. As with the foregoing species, this cestode is found in the cecum of the host. Until further material is available for study it seems best to leave the status of this worm indefinite.

*Key to the species of Paranoplocephala parasitic in North American voles.*

- |   |                        |
|---|------------------------|
| 1. Testes extend beyond aporal ventral longitudinal excretory canal .....                                   | 2                      |
| Testes do not extend beyond aporal canal .....  | <i>P. infrequens</i> . |
| 2. Testes from 60 to 80 in number; size large; ratio of length to width of mature segments about 1:12 ..... | <i>P. variabilis</i> . |
| Testes from 38 to 50 in number; size small; ratio of length to width of mature segments about 1:4 .....     | <i>P. borealis</i> .   |

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