A PARASITOLOGICAL SURVEY OF THE GENUS CITELLUS IN WESTERN CANADA.

By J. A. McLeod. B. Sc. (MAN., 1931)

A Thesis presented to the Committee on Post-graduate Studies, University of Manitoba, in candidacy for a Master of Science Degree. April 1933.

ABSTRACT.

The results are given of a parasitological survey of 236 ground rodents (Genus Citellus) from the province of Manitoba. The survey yielded five ectoparasites, all previously recorded. It also yielded four sprcies of Nematodes, three of which are regarded as new to science, an Acanthocephalan and two species of Cestodes which were previously unrecorded. No Trematodes or intracellular Protozoans were found.

The importance of the Arthropod parasites as transmitters of disease is cited. The pathogenicity of the enteric parasites and the correlation between the incidence of infection and host abundance is discussed.

A PARASITOLOGICAL SURVEY OF THE GENUS CITELLUS IN WESTERN CANADA.

Among the worst enemies of the prairie farmer in Western Canada are the various species of Citellus a type of burrowing rodent commonly referred to as the Ground Squirrel or the Gopher. These animals are most difficult to keep in check and they cause an immense amount of damage to cultivated crops. The annual loss to agriculture in the State of North Dakota, for example, has been estimated at more than one million dollars. (Reference No. 26.) In Manitoba the gopher population in ~~such~~ certain areas as have been surveyed, has been estimated at 20 animals per acre. (Reference No. 20.) and the damage caused has been conservatively estimated at fifty cents per rodent each year. The loss per acre thus occasioned may mean all the difference between a comfortable profit and a heavy loss on the years crops. In addition to the direct loss inflicted by gophers upon crop growth, the mounds of earth thrown up during their tunnelling operations increase considerably the expense of working the land and gathering the harvest.

There is further the possibility of such common rodents serving as alternate hosts, or as the direct carriers of organisms pathogenic to higher animals. Citellus beechyi in California has been shown to be susceptible to Pasteurella pestis of bubonic plague, and to be capable of acting as host to murine species of Ceratophyllus through whose agency the disease is conveyed to man. Whilst the possible establishment of bubonic plague in the Canadian prairie areas would seem

to be remote, the similarity of climatic conditions in Western Canada to those in the endemic areas of bubomic plague in Manchuria and the fact that the latter disease is essentially one of ground rodents through whose ectoparasites the disease is conveyed to man, must not be overlooked.

The effect from a parasitological standpoint of the practice used by some mink ranchers, of feeding fur bearing animals upon small mammalia has not been experimentally investigated, but is another point worthy of consideration.

Now there can be little doubt that artifical methods of controlling ground rodents - trapping, poisoning, burrow fumigation - have not in the past yielded results commensurate with the immense expense involved. In Manitoba a sum of approximately $5000.00 has been spent as a bounty upon gophers, and an approximate total of 100,000 gophers has been destroyed in one year, but there is no evidence that any serious diminution has been thereby brought about in the gopher population.

It would seem to the writer that a type of animal so destructive and so potential in destructive possibilities would well repay the trouble of a minute and thorough investigation of the natural factors in it's environment which oppose it's biotic potential either by maintaining a high degree of mortality among immature animals or by influencing the fertility of the mature animals. Such natural factors opposing it's biotic potential are temperature values outside the effective range, pathogenic bacteria and fungi, pathogenic helminths, predatory enemies, and so forth.

It is well known that ground rodents are particularly susceptible to cyclic fluctuations of population density. The

factors inducing such fluctuations are obscurely known. Climatic extremes undoubtedly play a part. Overcrowding reduces the potential fertility. Bacterial and helminth parasitism may be pathogenic. Boughton (4) has shown that in the case of the Western Canadian Snowshoe Rabbit population, endemic helminth infestation may become epidemic under conditions of overcrowding and of adverse climatic conditions, and that epidemic mortality from helminth infestation can be an important factor in bringing about local fluctuations of population density.

The evidence that epidemic mortality is prevalent among gophers is by no means so complete as in the case of rabbits, field mice and lemmings. The presence of an epidemic is less easily detected among such deep burrowing forms than among non-burrowing forms since a gopher usually dies in it's burrow. A continuous record of gopher abundance over the whole of Manitoba is not available, but such evidence as the writer has been able to collect from farmers and naturalists in the area suggests strongly that there exist peak years of abundance followed by a sharp decline in population density. The peaks however are not synonymous over the area but vary by one year or more between different localities. In the case of localities studied the maxima of abundance appear to be as follows.

C. tridecemlineatus.	1897-99.	1912.	1917.	1923.	1927.	1932.
C. franklini		1912.	1917.	1923.	1927.	1932.
C. richardsoni.		1912.	1917.	1923.	1927.	1932.

The aim of the investigation reported below therefore has been that of surveying the parasitic fauna of the species

of gophers present in Manitoba with a view to ascertaining which members of that fauna have the potentiality of gopher destruction, and which members of the fauna have the potentiality of spreading from the gopher to man and higher animals. The report is based upon an examination of 236 individuals, representing three species of Citellus common in the Southern half of Manitoba, carried out during the period May to October 1932, a year which appears to be a peak year of gopher abundance.

METHODS.

Three species of Citellus were included in the survey. C. franklini is an indigenous form, comprising about 2% of the Manitoba gopher population (20) and more abundant in the eastern area of the province where it is to be found among uncultivated shrubby land, feeding on plant foliage and seeds upon insects, upon eggs and nestlings of birds. It is popularly called the Scrub Gopher.

C. tridecemlineatus another indigenous form, represents about 8% of the gopher population (20) and is most plentiful in the eastern and northern edge of the prairie region, being essentially an open prairie or pasture land form; it feeds chiefly upon the foliage and seeds of wild and cultivated plants and upon grasshoppers and crickets.

C. richardsoni the predominant gopher of Manitoba, is an immigrant from the southwest, entering the province about 1900. It rapidly spread over the cultivated areas but at present is located most densely in the dry agricultural southwest area of the province.

Most of the animals examined during the survey were obtained from as many scattered points as possible, but as the

total area covered was approximately 80,000 square miles, it was not possible to conduct examinations at regular intervals of time. Most of the animals were obtained alive, were etherised in the laboratory, the fur combed for ectoparasites, and a routine post-mortem examination performed.

The helminthological technique used was the standard technique recommended by other authors. Intestinal helminths were obtained by a decantation method, were washed briefly in warm water, and fixed in 70% alcohol at 75 degrees centigrade, a method found satisfactory both for nematodes and cestodes, followed by preservation in 70% alcohol plus glycerine. Nematode preparations were made by clearing in glycerine alcohol at room temperature and mounting in glycerine jelly. Cestode material was stained with Delafields haematoxylin and cleared in beechwood creosote. This latter clearing agent was found most satisfactory also for the ectoparasitic fauna.

Taxonomy.

The survey yielded five ectoparasites and seven endoparasites, which may be listed briefly as follows:-

ARTHROPODA.

Ixodidae	Dermacentor venustus (Banks).
Dermanyssidae	Liponyssus occidentalis (Ewing).
	Liponyssus montanus (Ewing).
Pulicidae	Ceratophyllus bruneri (Baker).
Haematopinidae	Linognathoides montanus (Osborne).

CESTODA.

Dilepididae	Prochoanotaenia spermophili n.sp.
Hymenolepididae	Weinlandia citelli n.sp.

NEMATODA.

Strongylidae	Warrenius bifurcatus (Sleggs).
Spiruridae	Rictularia citelli n.sp.
	Spirura infundibuliformis n.sp.
	Physaloptera spinicauda n.sp.

ACANTHOCEPHALA.

Moniliformidae	Moniliformis spiradentatis n.sp.

The absence of Trematoda and larval Cestoda is noteworthy but it may be noted that Boughton found no Trematoda and only two larval Cestoda in Lepus americanus.

All five species of ectoparasites were common to the three species of Citellus examined. Of the helminthes, some were restricted to one Citellus species, others to two, and one occurred in all three host species. The helminthes were all parasites of the stomach or of the anterior half of the duodenum; the caecum, large intestine, liver, lungs and muscles were free from parasites. About 40% of the gophers examined showed disease of the wall of the stomach or intestine but although a considerable number of such lesions were sectioned and examined, no causative Protozoan was found. Several specimens showed splenic enlargement, but time did not permit the preparation and examination of blood smears of such individuals and the writer was unaware at the time that a trypanosone had been recorded from Citellus richardsoni.

Owing to the difficulty in obtaining material from a particular area at any definite time it is impossible to give an exact comparison of the infection in all the localities from month to month.

However some generalized statements will be given later in this paper. Table 1. is a record of the incidence of infection for each species of parasite for both young and adult of all three species of hosts. The young of C. tridecemlineatus and C. franklini are found to be uninfected up to the age of eight weeks, but those of C. richardsoni are heavily infected, in some cases at an early age.

TABLE 1.

RELATIVE ABUNDANCE OF DIFFERENT PARASITES

PARASITE	C.tridecem		C.franklini		C.richardsoni	
	No exam.	%inf.	No exam.	%inf.	No exam.	% inf.
Rictulari citelli	71.	21.1	11.	18.1	154.	
Spirura infundibulformis	71.	19.4	11.		154.	.6
Physaloptera spinicauda	71.	15.4	11.	18.1	154.	
Moniliformis spiradentatis	71.	8.4	11.		154.	
Warrenius bifurcatus	71.		11.		154.	61.9
Weinlandia citelli	71.	14.	11.	9.	154.	2.9
Prochoanotaenia spermophili	71.	2.8	11.		154.	1.9

Males and females are exposed to infection to a like extent and although there is a slight variation in the infection of the two sexes, as shown in Table 2. below, it is not sufficiently great to be of any particular significance. The mean and maximum number of parasites per host is however of considerable importance and will be discussed later.

TABLE 2.

THE RELATIVE INFECTION OF THE TWO SEXES AND THE NUMBER OF PARASITES PER HOST

Citellus tridecemlineatus.

Parasite.	No. of males examined	No. of females examined	% inf. males	% inf. females	Mean No. of worms	Max. No. of worms
Rictularia citelli	29.	42.	24.1	19.	4.	8.
Spirura infundibuliformis	29.	42.	20.7	19.	18.	48.
Physaloptera spinicauda	29.	42.	17.2	19.	2.	4.
Moniliformis spiradentatis	29.	42.	10.4	7.1	7.	19.
Weinlandia citelli	29.	42.	13.7	14.2	5.	15.
Prochoanotaenia spermophili	29.	42.	6.8		1.	1.

Citellus franklini.

Rictularia citelli	6.	5.	16.6	20.	3.	4.
Physaloptera spinicauda	6.	5.	16.6	40.	4.	7.
Weinlandia citelli	6.	5.		20.	17.	17.

Citellus richardsoni

Warrenius bifurcatus	69.	85.	62.6	60.	24.	83.
Spirura infundibuliformis	69.	85.		3.3	2.	3.
Weinlandia citelli	69.	85.		3.5	8.	20.
Prochoanotaenia spermophili	69.	85.		2.3	8.	17.

DERMACENTOR VENUSTUS. (Banks).
Dermacentor andersoni (Stiles).

Typical Ixodid or hard-shelled ticks of medium large size measuring up to 6 mm. in length in the adult. It is recorded as being the causative agent of tick paralysis as well as the transmitter of certain diseases of man and animals, such as Tularemia and Rocky Mountain Spotted Fever.

Male. Has a well developed scutum covering the entire dorsal surface of the body, which is chesnut brown with sparsely scattered white spots and unequal punctuations. Scutum bears thirteen festoons on the posteria margin. Mouth parts project forward beyond the anterior margin so as to be visible from the dorsal side. Eyes rather flat and at the sides, level with the second legs. The palps are much longer than broad and the second segment is without retrograde spur. Coxa 1. with two long well developed contiguous spurs, the external being conical. Coxa 11. and 111. with two short spurs. Coxa 1V. is much longer than broad with a spur at the antero-external angle. The spiracle is situated at the side of the body behind leg 1V. and the postero-external extension of the peritreme is well developed.

Female. Scutum small and pale, being only slightly longer than broad and having a posteria border a little sinuous. The eyes as in the male, are located at the sides, about the middle of the length of the scutum opposite the second pair of legs.

The species venustus is distinguished from the closely related species occidentalis and albipictus by the shape of the spiracle and the well developed postero-external extension of the peritreme.

Localities. Montana, Wyoming, U.S.A., Manitoba, British Columbia, Can.

CERATOPHYLLUS BRUNERI. (Baker).
Ceratophyllus. (Curtis 1832).

Specific diagnosis:- Siphonaptera of medium size with the three thoracic segments not strongly constricted and their epiphyses extending over but one abdominal segment. Pronotal comb with 18 ctenidia, genal comb absent and gena without recurved process. Head bluntly rounded anteriorly. Eyes present, genal row with one bristle. Labial palpi with four pseudojoints and reach to about the distal end of the femora. Maxillary palpi shorter than the anterior coxa. Legs slender.

Female:- Third joint of the antenna nine pseudojoints distinct on the posterior side, but indistinct on the anterior. Second joint of the antenna with a row of fine hairs which extend almost to the outer end of joint lll. Gena without recurved process but style present. Abdominal tergites with only two rows of bristles. Three antipygidial bristles present. Body of gravid female never swollen so as to expose extensive areas of connective membrane.

Male:- Body slightly smaller than female with the posterior end curved dorsally. Third joint of the antenna distinctly divided into nine pseudojoints. Gena without recurved process, style absent. Abdominal tergites with only two rows of bristles. Three antipygidial bristles, claspers short, smooth on the ventral margin, and bristles are in a small group of five near the upper end.

Host and locality. Citellus sp. Montana, Citellus tridecemlineatus, Citellus franklini, and Citellus richardsoni, Manitoba.

LIPONYSSUS OCCIDENTALIS. (Ewing).
Liponyssus (Kolenati).

Female:- Small with large dorsal shield. Palpi moderate; chelicera stout. Dorsal shield extending across the body at the shoulders, lateral margins behind the shoulders convex. Peritreme very long and very sinuous, reaching to the anterior coxa. Sternal plate about three times as broad as long, barely reaching to the third coxae, and with the anterior margin strongly arched; anterior setae situated on the anterior margin; middle setae situated on a line between the anterior and posterior setae, the latter being almost at the tip of the posterior angles. Anal plate egg-shaped in outline; anus small, almost circular with a uniform rim and situated in front of the middle transverse line; paired setae situated near the level of the anterior margin of anus. Posterior setae situated more than their length behind the anus; caudal area forming a lobe-like projection of the anal plate. Legs moderate. Body length 0.61 mm. Width about 0.31 mm.

Male. Unknown.

Hosts. C. richardsoni and C. tridecemlineatus.

Locality. Montana and Manitoba.

LIPONYSSUS MONTANUS. (Ewing).

Female. Large, the body length being about 1.02 mm. and the width about .60 mm. Palpi large; chelicera shearlike but the hooked tips of both arms rather blunt. Dorsal shield medium, lateral margins behind the shoulders very slightly convex. Peritreme long and sinuous and extending to opposite coxa 1. Sternal plate with posterior corners broadly rounded and not extended. Anal plate very

large, broadly rounded in front and somewhat truncate behind, anus subcircular with a uniform rim, and situated almost centrally; paired setae situated far forward, being at the level of the anterior margin of the anus; median setae situated about it's length behind the anus; caudal area crescentic, scobiate. Legs long; anterior pair longer than the second pair and about equal to the third pair. Last pair reaching to about the tip of the abdomen.

Male. Unknown.

Host. C. richardsoni and C. tridecemlineatus.

Locality. Montana and Manitoba.

LINOGNATHOIDES MONTANUS (Osborne 1912).

Lingognathoides (Cummings).

Specific diagnosis. First pair of legs smaller than either the second or third pairs. Abdomen with only slight rudiments of pleural plates on it's segments. Six pairs of sbdominal spiracles present which open on the flat body surface and not on tubercles. Abdomen clothed in normal setae with never more than a single transverse row on a typical segment. Antennae five segmented, the second being the longest and the last two being quite distinct. Temples more or less swollen but without postero-lateral angles.

Male. Body about .84 mm. long by about .4 mm. in greatest body width. Head large, about the size of the thorax; temples slightly swollen; clypeal region pointed; forehead knoblike. Legs stout with well developed single claws on the tarsi of the first pair. Abdomen broad with a single transverse row

of short setae on each segment. Posterior end broadly rounded. Color, light brown.

Female. Body length about 1.15 mm. by about .4 mm. in greatest body width. Head, antennae and legs similar in size and shape to those of the male. Abdomen large and rectangular, ending bluntly, and bearing on each segment a single transverse row of long coarse setae. Body color, dark brown.

Host. Species of Citellus.

Locality. Practically all over the North American Continent.

WARRENIUS BIFURCATUS. (Hall 1916). (Sleggs 1925).

Generic diagnosis. Warrenius. Head simple, no lips evident, bursa is deeply incised dorsally to form two large lateral lobes and a small dorsal lobe. The dorsal lateral and venteral ray systems are well defined and separated from one another, the rays of each system being more closely related to one another than to the rays of the other systems. The dorsal lobe is supported by the dorsal ray which branches dicotomously. The external dorsal rays are slender wavy rays lying in the lateral lobes, the tip of which are some distance from the bursal margin. The recurved tip turns toward the dorsal ray and is closer to this than to the postero-lateral. The postero-lateral and medio-lateral rays originate in a common stem. The latero-lateral and ventro-lateral rays originate as branches of a common stem and diverge from their origin to their termination near the bursal margin. They are usually large for ventral rays. The spicules are well developed; uteri divergent;

vulva in the posterior half of the body. Ovijector well developed.

Specific diagnosis. bifurcatus.

The worms are whitish in color after fixation but the intestine is red when the worm is alive. The male is considerably shorter and not so stout as the female and may exhibit two or three flat coils or may be coiled in a flat spiral. The female is very strongly coiled in a flat spiral, the extremeties of the body being frequently hidden within the ends of the coil. The posterior end of the female bears a minute curved cuticular spine. Cuticle is finely striated transversely and presents also about 24 longitudinal striae running the full length of the body. No buccal capsule is present. Diameter of head in female exclusive of cuticular inflation, about 48μ. Diameter of head in male exclusive of cuticular inflation, about 36μ. Length of oesophagus in female about 75μ. Length of oesophagus in male about 600μ. The nerve ring is situated about one-third of the way along the oesophagus from the anterior end of the body. The oesophagus is dilated posteriorly and separated from the mesenteron by a constriction. The excretory pore is about two-thirds of the way along the oesophagus.

Male. Length 7-12 mm. Greatest body width 215μ. Right spicule bifurcates in a horizontal plane, left in a vertical. Right lateral lobe of the bursa is about one and one-half times as long as the left.

Female. Length 15-18 mm. Greatest body width 315-335μ. Distance of anus from posterior end ranges from 88-120μ. Vulva is a transverse crescentic slit about 2.6 mm. from the posterior end.

Eggs. Very numerous in a gravid female; 12-16 segmented and enclosed in a thin shell.

Host. Citellus richardsoni. in stomach and duodenum.

Locality. Manitoba and Saskatchewan, Canada.

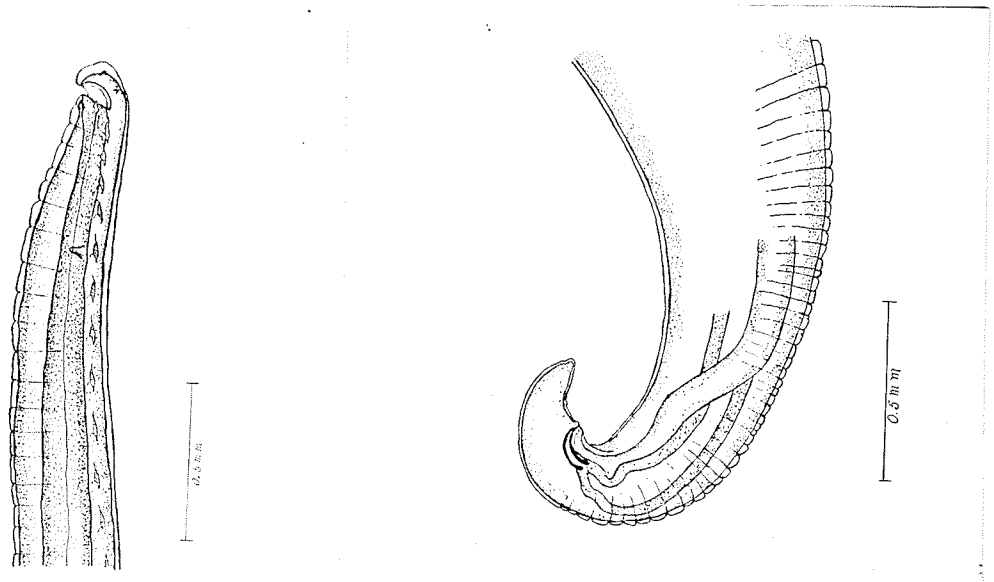
RICTULARIA CITELLI n.sp. (Figures 1. and 11.)

Rictularia.(Froelich 1802).

Specific diagnosis. Buccal capsule well developed and narrow with it's aperture more or less distinctly dorsal and with it's base armed with teeth and spines. Along practically the entire ventral surface on each side, there is a row of cuticular combs or spines. Vulva anterior, near the posterior end of the oesophagus. Oviparous, the eggs containing a well developed embryo when oviposited.

Female. Rather stout worms, measuring from 30 to 60 mm. in length; of a pinkish color when alive but turning almost white on fixation. The following body measurements were found to be constant for gravid females measuring 44 mm in length. The head including cuticle is 235μ in diameter and the body increases in thickness gradually until a point one fifth of it's length from the posterior end it is 910μ in diameter. This diameter is held or only slightly reduced to a point a short distance from the caudal end where attenuation takes place sharply, the body ending in a fine point. Cuticle about 12μ thick in the head region and is definitely annulated along the neck. There is a pair of stout lateral cervical papillae about 630μ from the anterior end. The first cuticular spine in each row is situated

posterior and slightly ventral to the mouth, there being 28 spines in each row from the head region to the vulva. Spines are finely striated and rather indistinct in mounted specimens, only a few being visible posterior to the vulva. Mouth is somewhat reniform in shape and is bounded by two subequal lips. The posterior lip nears a short conical tooth on each side of it's apex while the anterior one is smooth, semicircular and forms the helmet-like termination of the body. The œsophagus is simple, slightly dilated in the middle region and ends posteriorly in a hemispherical projection into the intestine. The vulva is a short transverse slit near the posterior end of the œsophagus and is bounded by prominent lips formed of cuticle overlying finger-like projections of the body wall. The body is slightly expanded on each side of the vulva. The vagina is long and bifurcates in the posterior region to form two convergent uteri which terminate in filiform ovaries.



A. B.

Fig.1. Rictularia citelli. A. Anterior extremity, lateral view. B. Male posterior extremity lateral view.

Eggs. 47-52μ in length by 34-38μ in width, very numerous, ellipitical in shape with thick shells and each contains a coiled larva.

Male. Like many of the species of this genus, the males of Rictularia citelli are rare, there being only a single male found in the fifty specimens examined. This specimen measuring 14 mm in length, resembled the female in body shape, presence of cervical papillae, mouth structures and cuticular annulations. There were 28 combs in each row from the head region to the transition point, posterior to which the rows of combs extended almost to the caudal end. The posterior end of the body is obtusely conical, ending in a blunt point and is sharply curved ventrally. The anus is situated on a slight elevation 227μ from the end of the tail. The spicules are equal, small and curved, measuring 117μ in length. Gubernaculum is absent.

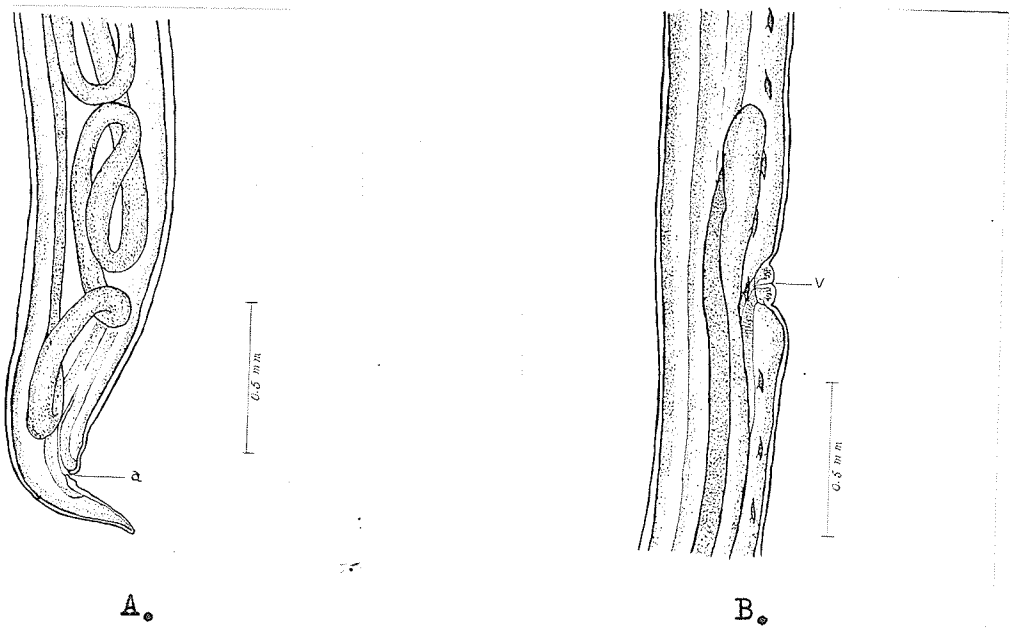


Fig.2. Rictularia citelli. Female. A. Posterior extremity, lateral view. B. Body in region of vulva, v. vulva.

The possession of two lips and a definite buccal cavity along with a short muscular and long glandular region of the aesophagus, simple intestine and vulva opening in the midbody region, places this nematode in the superfamily Spiruroidea. The absence of projecting processes on the head and the presnece of two longitudinal rows of spines on the ventral surface identifies it as a member of the genus Rictularia. The shape and position of the cervical papillae and the number of cuticular spines between the head region and the transition point serve to distinguish this from other species and is considered sufficient grounds for the creation of a new species.

Type Host. C. tridecemilineatus and C. franklini, (in stomach and duodenum.)
Type Locality. Manitoba, Canada.

SPIRURA INFUNDIBULIFORMIS. n.sp. (Figs.111. and 1V.)

Spirura (Blanchard 1849).

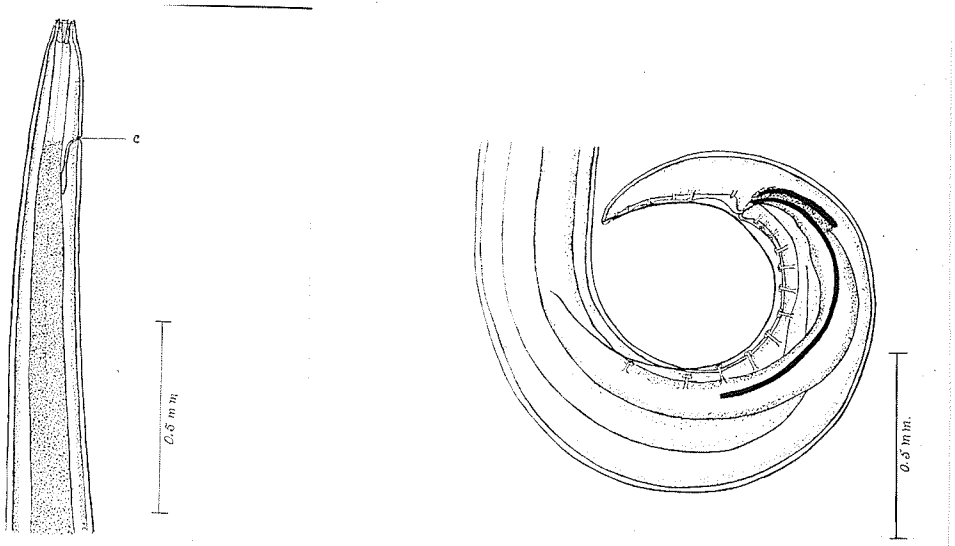
Specific diagnosis. Posterior portion of the body decidedly thicker than the anterior portion. Cuticle densely striated transversely. At a distance one-seventh to one-twelfth of the total body length from the anterior end, is a prominent cuticular boss or struma. The anterior is bluntly rounded. Mouth with two rather inconspicuous lips each bearing three papillae and surrounded by chitinous projections of the vestibule. Vestibule, well marked, wide and cylindrical when seen laterally. Oesophagus narrow and cylindrical, one-sixth as long as the body.

Male. 28 to 34 mm long with a gradual increase in body width from the narrow head to a point just anterior to the tail.

Body widths for specimens measuring 31 mm in length are as follows:- Head 79μ. mid-cervical region 210μ. posterior to boss 253μ. mid-body region 250μ. and posterior region 367μ. The mouth width is 42μ. and the length of the buccal capsule 87u. Cervical pore opens 402μ. from the anterior end and the boss or struma is situated 2.4 mm from the anterior end. The oesophagus is narrow, about one-sixth as long as the body and is divided into an anterior muscular portion that reaches just posterior to the cervical pore, and a long glandular posterior portion. The anterior end of the body is bent toward the ventral side at an angle of about 45 degrees just posterior tp the boss. The caudal end is sharply coiled ventrally. Two curved very unequal narrow spicules are present, the right being 770μ. in length, while the left is 297μ. A gubernaculum is present. The caudal end bears two long narrow alae which meet behind at the tip of the tail but do not meet on the ventral side anterior to the anus. These alae are supported by twelve pairs of pedunculated pre-anal papillae and six pairs of short post-anal papillae, the last two pairs of which are close to the posterior extremity.

Female. 20 to 41 mm in length and decidedly thicker near the posterior end. The diameters in specimens 40 mm long are as follows:- Head 96μ. anterior end of oesophagus 175μ. mid-oesophageal region 367μ. behind struma 437μ. mid-body 542μ. anterior to tail 542μ. The oesophagus is one-sixth as long as the body, and the boss is situated 2.17 mm from the anterior end. The posterior end of the body is straight and conical with an obtuse termination.

The anus opens at a distance of 420μ. from the posterior end. The vulva is situated on the ventral side about five-eighths of the body length from the anterior end and is a prominent transverse slit with conspicuous lips, the cuticle being slightly thickened for a distance on each side of the aperture. There is a short vagina connecting with an infundibuliform ovijector which has a chitinous lining inside the muscular wall. This chitinous lining is thrown up into folds, forming oblique valves on the wall with their free ends directed toward the vagina. The short common trunk of the uterus divides to form two divergent uteri.



A. B.

Fig. 3. Spirura infundibuliformis. A. Anterior extremity dorsal view. c. cervical pore. B. Posterior extremity of male lateral view.

Eggs are roundly elliptical in shape and have thick smooth shells. They are very numerous in gravid females and measure from 36 to 39μ. in length by 27 to 30μ. in breadth.

The identity of this nematode as a member of the super-family

Spiruroidea is established by the possession of two indefinite simple lips, definite vestibule and long oesophagus followed by a simple intestine and the opening of the vulva near the middle of the body. The presence of a cuticular boss and a definite nerve ring along with well developed candal alae in the male supported by castiform papillae places it in the genus Spirura. This species resembles to a considerable extent the species talpae. (Gmelin 1790.) (Blanchard 1849.) The females differ in body size, the number and size of the eggs produced and in the posterior body termination. This species terminates in an obtuse cone, the concave surface posterior to the anus, so pronounced in the species talpae, being absent. Apart from body size the males differ only in the number of papillae supporting the caudal alae. This species has twelve pairs of preanal and six pairs of post-anal papillae, while the species talpae has four pairs of pre-anal and five pairs of post-anal papillae.

In the opinion of the writer the nematode described represents a hitherto unrecorded species and the specific name infundibuliformis is suggested.

Type Host. C. tridecemlineatus and C. richardsoni (in stomach and duodenum.)

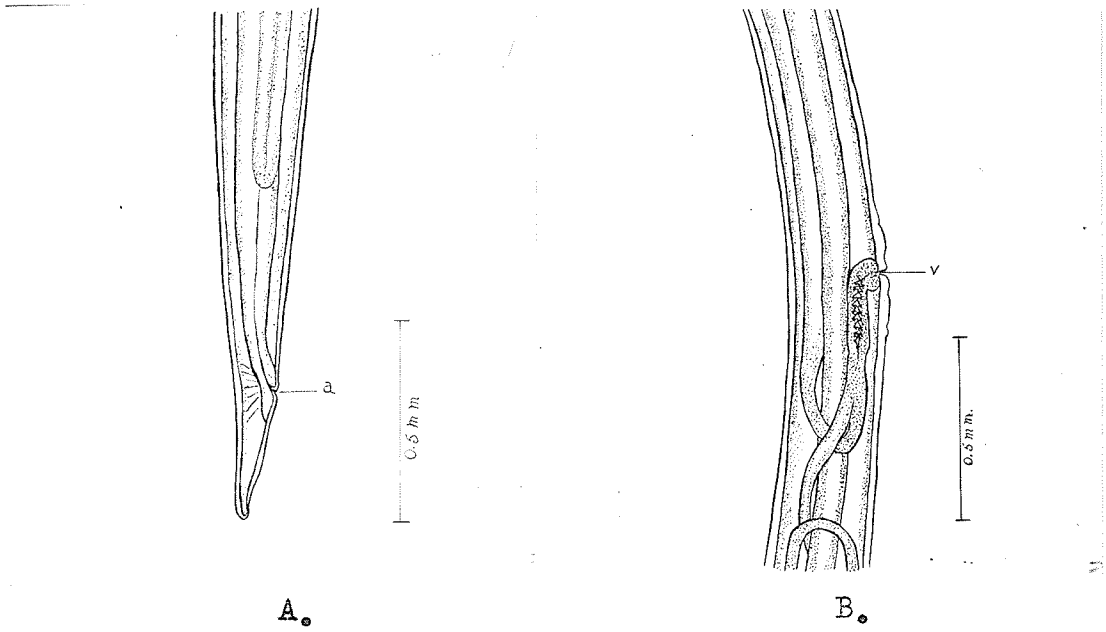
Type Locality. Province of Manitoba, Canada.

PHYSALOPTERA SPINICAUDA. N.SP. (Figs. V. and VI.)

Physaloptera. (Rudolphi 1819.) (Travossos 1919.)

Specific diagnosis. Large relatively thick worms with two large simple triangular lateral lips each armed with two teeth and bearing a papilla at it's apex. Cuticle may be reflected over

the head to form a cephalic collarette or may be retracted and thrown into folds in the anterior cervical region. Cervical papillae anterior to the nerve ring; buccal cavity is short and a definite vestibule is absent. Oesophagus divided into a short muscular anterior part and a long glandular posterior part. Cuticle densely striated transversely.



A. B.

Fig. 4. Spirura infundibuliformis. A. Posterior extremity of female, lateral view. a. anus. B. Body in region of vulva. v. vulva.

Male. Length from 15 to 20 mm., the body being slightly attenuated at the anterior end. Head round, continuous with the body and bearing two triangular lateral lips each of which terminate in a short papilla. Each lip bears on it's inner surface near the base of the papilla, two short teeth. In specimens measuring 18 mm in length the cuticle was thrown up so as to form a cephalic collarette 52μ. in length and 28μ. in diameter. The head was 210μ. wide with a definite buccal cavity but a vestibule is absent. Two lateral cervical papillae are

present about 700μ. from the anterior end, the left being slightly posterior to the other. The oesophagus is broad and about one-fifth as long as the entire body, the anterior one-sixth, being muscular with a diameter of about 105μ., and the longer posterior glandular portion with a diameter of about 297μ. at it's greatest breadth. A distinct nerve ring is present about 437μ. from the anterior end. The body is cylindrical and of uniform thickness being about 612μ. The caudal end is conical and slightly flattened on the ventral side, ending in a blunt point and is curved ventrally. The large caudal alae which meet anteriorly are supported by four long costiform papillae, two pre-anal and two post-anal. A single sessile median papillae is present about 245μ. from the posterior body termination. A gubernaculum is absent and the two subequal spicules measure 437 μ. and 700μ. The anus is situated on an elevation 875μ. from the posterior end and the curved ventral surface of the caudal region bears numerous longitudinal rows of very fine cuticular projections.

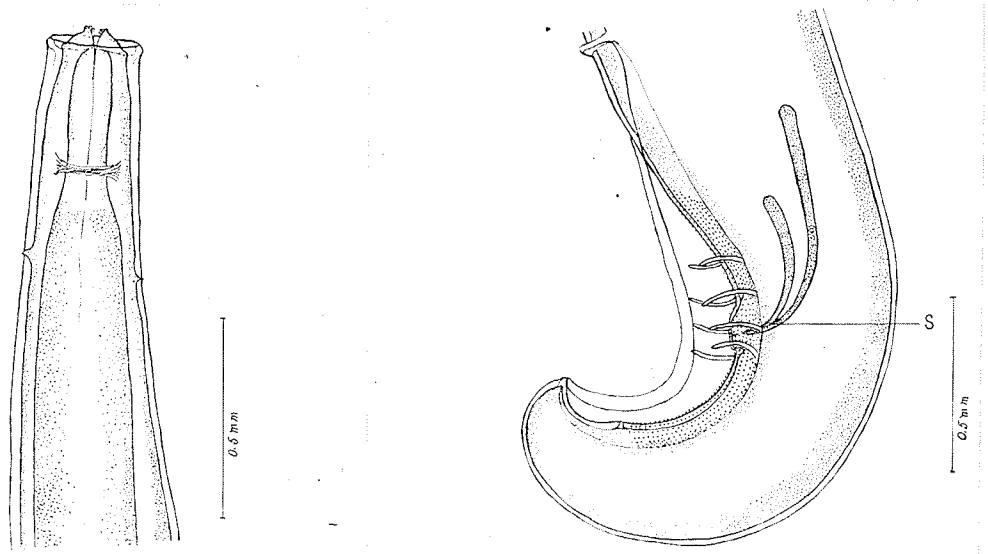


Fig.5. Physaloptera spinicauda A. Anterior extremity, dorsal view B. Posterior extremity of Male lateral view s. spicule.

Female. Length from 18 to 50 mm. Generally resemble the male with regard to body shape. The cuticle is densely striated transversely and in larger specimens measuring 50 mm. in length and 1.2 mm. in diameter, the cuticle is so dense that ordinary clearing methods do not render it sufficiently transparent to show the internal organs on microscopic examination. Smaller non-gravid females measuring about 20 mm. in length show the head and cervical structure of the male. The vulva is a very small inconspicuous circular opening on the ventral side of the end of the anterior one-third of the body. There is a narrow tubular vagina of considerable length with a sphincter muscle at it's outer end. Two divergent uteri are present which in the non-gravid female both lie as much coiled tubes posterior to the vulva. In the gravid female the anterior uterus reaches to within a short distance of the oesophagus. The tail is acute and ends bluntly, being flattened dorsoventrally. The anus is situated on a prominent ventral elevation and the intestine is large.

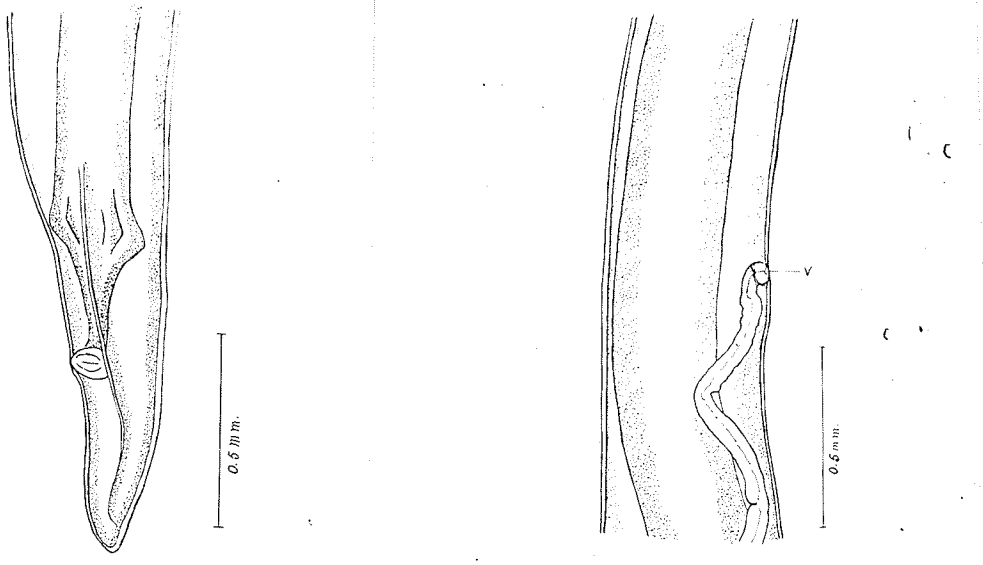
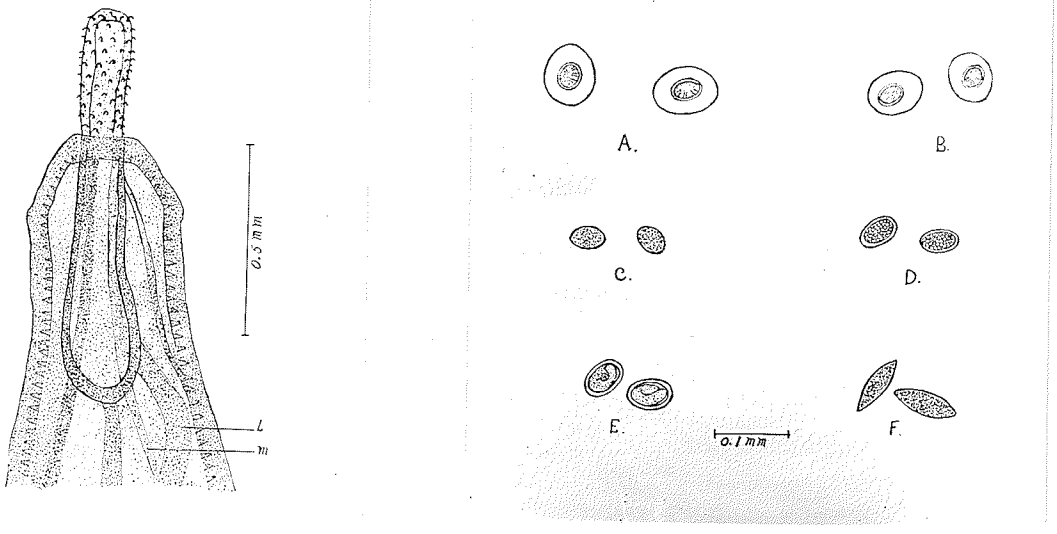


Fig. 6. Physaloptera spinicauda. A. Posterior extremity of female ventro-lateral view. B. Body in region of the vulva. v. vulva.

Eggs. Roundly elliptical, measuring 41 to 44μ. in length by 28 to 32μ. in breadth. They are very numerous, thick shelled and embryonated when deposited. The presance of two large triangular lateral lips and a cephalic collarette and absence of a vestibule along with large caudal alae supported by long costiform papillae in the males of this species is considered sufficient reason for placing it in the genus Physaloptera of the superfamily Spiruroidea. It differs however from P. citelli, the only recorded species from citellus, in general body size and in the possession of only two head papillae. This is considered sufficient grounds for the creation of a species for which the name spinicauda is suggested.

Type Host. C. tridecemlineatus and C. franklini (in stomach and intestine.)

Type Locality. Manitoba, Canada.



A. B.

Fig. 7. A. Moniliformis spiradentatis, Anterior extremity, dorsal view. m. muscles, l. limnisci. B. Eggs. a. Weinlandia citelli, b. Prochoanotaenia spermaphili, c. Physaloptera spinicauda. d. Spirura infundibuliformis. e. Rictularia citelli. f. Moniliformis spiradentatis.

MONILIFORMIS SPIRADENTATIS. N.Sp. (Fig. 7.)

Moniliformis. (Travossos 1915.) (Van Cleave 1924.)

Specific diagnosis. Echinorhynchidea of medium to large size. Body without spines and divided into a large number of pseudosegments. Neck absent, proboscis well developed, sub-cylindrical and armed with numerous rows of hooks which are small and have only a single posteriorly directed root. Limnisci filiform, with numerous nuclei. Testes ellipsoidal, situated quite posteriorly; prostatic glands eight, almost spherical, compressed.

These worms are very variable in size even from a single host. The males ranging in length from 35 to 110 mm. while the females range from 45 to 190 mm. in length. The body widths also very greatly, being from .73 mm. in the smallest males and females to 1.2 mm. and 2 mm. respectively for the larger specimens. In fully developed worms the body is somewhat flattened and except at the two extremities is marked out into a large number of pseudosegments; the posterior end is considerably broader than the anterior in large specimens. The proboscis is relatively short, cylindrical and with a broadly rounded end, the length being .40 to .42 mm. with a greatest breadth of about .16 mm. A short portion of the proximal end of the proboscis is bare but the remainder bears eight spirally arranged irregular rows of hooks, there being 14-17 hooks in each row. Each hook is recurved, from 31-36μ. in length and has but a single root. Proboscis receptacle is a double walled muscular sac with retractors passing through the posterior extremity. Outer wall of the receptacle is disposed in spiral bands.

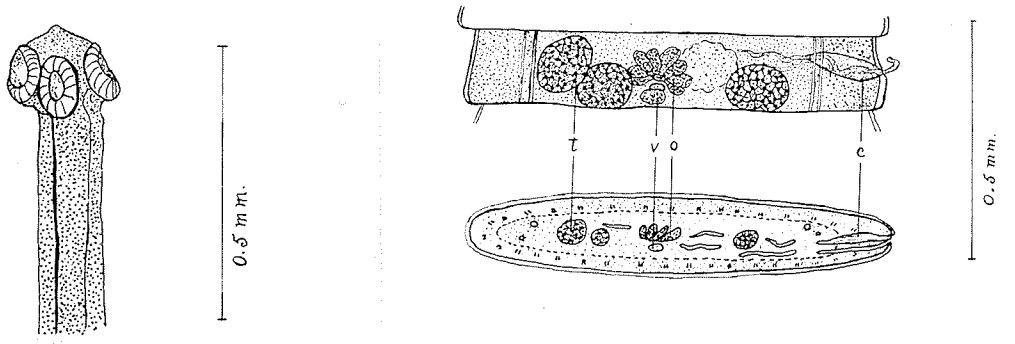
The limnisci are narrow and of variable length, being contorted and about one-seventh as long as the body. Testes are situated in the posterior part of the worm where they fill almost the entire body cavity, one being posterior to the other and close to it. They measure from 1.3 to 1.6 mm. long by .38 to .61 mm. in breadth. Each testis is an elongated slightly curved body, somewhat flattened dorsoventrally. The prostatic glands are situated posterior to the testes very near the end of the body. They are eight in number and form an elongate group measuring .8 to .84 mm. long and .35 to .38 mm. in greatest breadth.

Eggs are present in large numbers in small females measuring 45 mm. in length as well as the largest specimens. They are elongately oval with sharply rounded ends and measure 59 to 65μ. in length to 20.8 to 22μ. in width and have thin wrinkled shells in the large females. In younger females the shells are thicker and smooth giving the eggs a width 26 to 28μ. Eggs do not contain larvae but are embryonated when deposited.

The above described Acanthocephala possess the characters of the genus Moniliformis. (Travassos 1915.) sub-order Echinorhynchidea, such as smooth body divided into a large number of pseudosegments, absence of neck, well developed proboscis armed with numerous rows of hooks and retractible into a double walled proboscis-sheathe, testes posterior and ellipsoidal, prostate glands eight, compressed and not in the form of a single syncytial mass. It resembles the species Moniliformis moniliformis, (Bremser 1811.) in

general body shape and the arrangement of the various organs, but there are a number of marked differences. There are sufficient differences in the relative body measurements, the number and arrangement of the proboscid hooks and the size and shape of the testes to warrant the creation of a new species in the opinion of the writer and the name spiradentatis is suggested.

Type Host. C. tridecemlineatus. (in stomach and intestine.)
Type Locality. Manitoba, Canada.



A. B.

Fig. 8. Weinlandia citelli. A. Scolex and neck, ventro-lateral view. B. Proglottis. t. Testes. v. Vitellarium. o. Ovary. c. Cirrus sac.

WEINLANDIA CITELLI N.Sp. (Fig. 8.)

Type species, Weinlandia macrostrobilodes. (Mayhew 1925.)
Length 15 cm. and it's greatest width 2.8 mm. The anterior portion is very much attenuated, the width just back of the scolex being 175μ. while 27 mm. behind, where the sexual organs are first fully formed it is 277μ. Increase in width is gradual

and the first gravid proglottid measures 1.3 mm. with a continual increase toward the posterior end until a maximum width of 2.8 mm. is reached. There is scarcely any neck since the slight constrictions indicating the beginning of strobilization are evident about 180μ. behind the scolex. The length of the anterior proglottids are about one-eighth of the width but after the sex organs begin to develop there is an increase in length with regard to width so that at a point where they are .94 mm. wide the length of each proglottid is 157μ. In the mid-body region gravid segments of width 1.57 mm. measure 330μ. in length. The genital pores are unilateral and on the right side.

The scolex is but little wider than the anterior end of the strobila and with the suckers measures 245μ. in width by 157μ. dorsoventrally. The suckers are elliptical and measure 113μ. in length and 87μ. in breadth with a prominent rim about 21μ. in width. The rostellum is a rather indefinite triangular structure at the anterior termination about 38μ. long when extended.

Three testes are present, two lie at the posterior margin of the proglottid about equidistant from the ovary, one being poral and the other antiporal. The third is anterior and lateral to the posterior antiporal testis and may lie somewhat dorsal or ventral to it in some segments. The testes are oval or spherical in shape and in segments 927μ. in width measure 143μ. long and about 113μ. wide. The vas efferentia are very small tubes not readily discernible in in-toto mounts but they appear to arise from the anterior margins of the testes. Those from the two antiporal testes unite to form a common duct which is joined

by the one from the poral side. The cirrus sac is one of the most conspicuous structures of the proglottid and is a fusiform slightly curved structure opening a little posterior to the middle of the proglottid on the right side. It is about 157u. in length and is directed slightly anterior and curved toward the median line.

The cirrus is a thin rod-like structure arising at the inner end of the cirrus sac and terminating in a clavate expansion which curves sharply anteriorly after passing through the opening.

The vagina is an indistinct somewhat twisted tube which runs anteriorly from the shell gland for a short distance, and then turns laterally passing with the vas deferens below the excretory vessels.

The ovary is deeply divided into eight oval or spherical lobes forming a crescent shaped mass in the middle of the non-gravid proglottid. The vitelline gland is compact, almost spherical and lies in the concavity on the posterior side of ovary, while the shell gland is also rounded and ventrally placed beneath the vitelline gland.

The uterus in non-gravid proglottids is a small irregular sac situated anteriorly and to the left of the ovary. In gravid proglottids it extends almost to the margins of the proglottids with a fimbriate margin, the folds being so deep in some places as to form a number of lobes. It lies anterior to the ovary and testes but posterior and median to the cirrus sac.

There are two excretory vessels on either side of the strobila. They are very narrow, almost straight tubes, the dorsal

being slightly larger and median to the ventral. Both lie near the inner end of the cirrus sac.

Eggs oval to almost spherical in shape measuring 78-86μ. in length by 59-65μ. in width. There is a thin outer shell and thick albuminous layer about one quarter of the diameter of the egg in thickness, surrounding the inner shell and hexacanth embryo.

The presence of three relatively large testes in each proglottid, sac-like uterus, unarmed rostellum and unilateral cervical pores is proof that the cestode described above is a member of the family Hymenalepididae (Ariola 1899.) The arrangement of the three testes, two being posterior and the third being anterior and lateral to the posterior antiporal testis supports the opinion that it is a member of the genus Weinlandia (Mayhew 1925.) Twenty-seven species of this genus have been recorded by Mayhew (21) from birds but none from rodents of the genus Citellus so far as the writer is aware. There appears to be a definite host specifity among members of this family, and it is considered unlikely that an avian species would also be found in a mammal since the only recorded case, that of H. lanceolata (Zschoppe 1902.) a parasite of the goose being found in man was regarded as erroneous by Fuhrmann (1908). The only Hymenclepid recorded from Citellus sp. to the author's knowledge, is H.megaloon. Linstow (19) which differs from the above species in the possession of a conical scolex with shallow bothria and three testes arranged in a posterior row. On these grounds it is considered as a hitherto unrecorded species and the specific name citelli is suggested.

Type Host. C. tridecemlineatus. C. richardsoni and C. franklini, (in stomach and intestine).

Type Locality. Manitoba, Canada.

PROCHOANTAENIA SPERMOPHILI.N.SP. (Fig. 9.)

Prochoanotaenia (Meggit).

Small worms of 10 cm. in greatest length and is somewhat attenuated but the increase in body width is more or less gradual. Behind the scolex the body width is 334μ. while in the midbody region sexually mature but non-gravid segments measure about 720μ. in greatest width. Gravid segments at the posterior end measure about 1 mm. in width. Distinct strobilization begins almost directly behind the scolex leaving a neck of only about 740μ. in length. The anterior proglottids are narrower at their anterior ends being about three quarters of the width of the posterior end of the strobilae. They are about two-thirds as long as their posterior width. In sexually mature but non-gravid segments the posterior width is about 710μ and the anterior width about 595μ. the length being about 635μ. Gravid segments are about the same width at each end but are slightly expanded in the mid-region. Those with a width of 1.08 mm. have a length of about 1.45 mm. The genital pores are irregularly alternate, usually in groups of twos or threes.

The scolex is somewhat narrower than the neck and anterior end of the strobila, and with the suckers measures about 332μ. in width by 227μ. in thickness. The suckers are on the dorsal and ventral surfaces, and are prominent circular cups 122μ. in diameter with openings about 66μ in diameter. The rostellum which is mounted specimens was only in a partly

distended condition measured 105μ. in length. It is a fungiform structure, the expanded end bearing a single circle of 16-18 very fine hooks each with a single root. The rostellum is retractible into a dagger shaped muscular bulb 315μ in length by 105μ in greatest width.

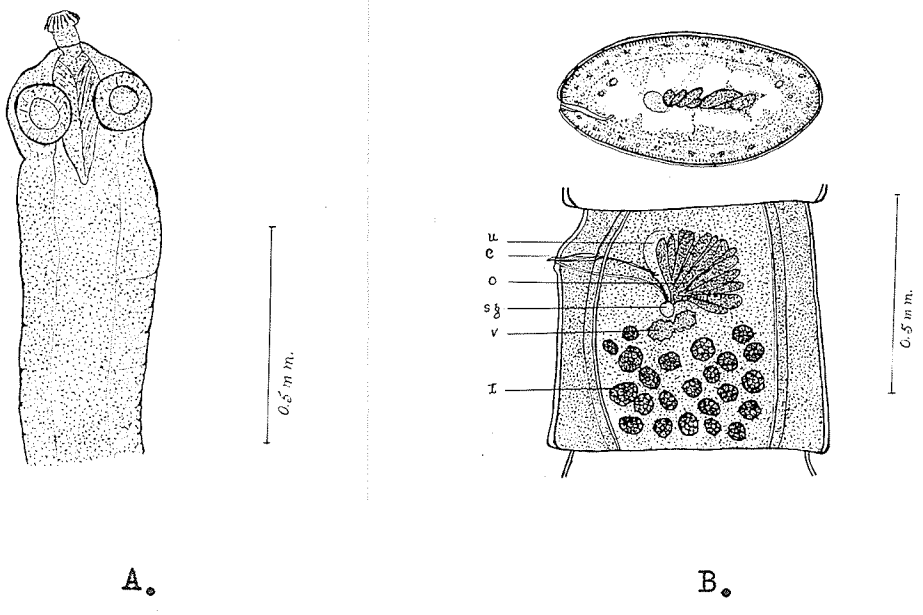
Testes are about 70μ in diameter in proglottids 780μ wide and from oval to spherical in shape. There are from 20-25 in each proglottid and all are post-ovarial in position. The vas deferens is first discernible just anterior to the ovary where it runs anteriorly for a short distance and then follows a convoluted course laterally, passes ventral to the longitudinal excretory vessels and enters at the base of the cirrus sac. The cirrus is fairly conspicuous and is a clavate shaped structure extending obliquely inward about 140μ. In sexually mature segments it opens on a prominent lateral elevation about one quarter of the length of the segment from the anterior end. The cirrus is slightly convoluted and the blunt outer end projects through the opening in gravid segments.

The vagina is an indistinct arched tube running in an anterio-lateral direction. It's outer end is almost parallel with the cirrus sac and opens immediately posterior to it. Like the vas defferens it passes ventral to the longitudinal excretory canals.

The ovary is divided into ten to fourteen finger-like lobes radially arranged in a semicircle. It lies in the anterior one-half of the segment and is somewhat antiporal in position.

The vitelline gland is a compact uni- or bilobed structure almost median in position and with an anterior angle or concavity close to which lies the spherical shell gland.

The uterus is an irregular sac anterior to the shell gland and dorsal to the ovary in sexually mature but non-gravid segments, but is replaced by egg capsules in gravid ones. The excretory vessels run parallel to the lateral margins and are about one-fifth of the width of the segment from them.



A. B.

Fig. 9. Prochoanotaenia spermophili. A. Scolex and neck, dorsal view. B. Proglottis. u. Uterus. c. Cirrus. o. Ovary. sg. shell gland. v. vitellarium, t. testes.

Eggs. Very numerous in gravid segments and are held in egg capsules. They are oval in shape with a length of 56 to 62μ and a width of 42 to 46μ. There is a thin smooth outer shell and a thick albuminous layer surrounding the inner shell and embryo which is from 31 to 33μ in diameter.

The possession of marginal genital pores, post-ovarial position of the vitelline gland, non T shaped rostellar

hooks and the post ovarial arrangement of the numerous testes identifies the above cestode as a member of the family Dilepididae. The presence of an unstable uterus which is replaced by egg capsules places it in the sub-family Dipylidinae. That it belongs to the genus Prochoanotaenia (Meggit) is supported by the possession of a single set of genitalia, absence of spines on the neck, position of the genital ducts below the longitudinal excretory vessels, alternate genital pores and a rostellum with a single row of hooks. A search of the literature reveals the most closely related species from small mammalia to be Taenia blanchardi, recorded by Mola (24) from Talpa europaea. This differs from the above material in the armature of the rostellum, and the relative size of the suckers. It also differs in that the ovary is arranged around the vitellaria while in the above the vitellaria lies posterior to the ovary. To the writer's knowledge no member of this genus has been recorded from Citellus and the specific name spermophili is suggested.

Type Host. C. tridecemlineatus and C. richardsoni.

Type Locality. Manitoba, Canada.

THE BIOLOGY AND PATHOGENICITY OF CITELLINE PARASITES.

Up to the present time in Manitoba, no outbreaks of any disease that can be ascribed directly or indirectly to the agency of the ectoparasites encountered in this survey, have been brought to the attention of scientific investigators. That such have never been reported does not necessarily mean that they do not exist but more likely that they do not reach such proportions as to warrant a thorough investigation. Little doubt exists in the opinion of the writer that many such cases of disease in wild and domestic animals in the past if fully investigated would involve one or more of these predatory parasites.

Dermacentor venustus a tick which is a highly potential transmitter and causative agent of disease was found to be plentiful on members of the genus Citellus in the area surveyed, particularly in the spring and early summer. Although the incidence of infection was never high, not more than six individuals being found on one host, this parasite is very abundant and the percentage of infection is accordingly great. Reports of investigators in British Columbia, Montana and Idaho where Dermacentor venustus is common, state that the adult is usually found on larger animals such as the sheep, deer, cattle, etc., while the nymphs and larvae are parasitic on rodents such as the ground squirrel. The writer found however that adults as well were quite common on gophers presumably in the absence of the larger and more suitable hosts. The life-cycle requires about two and one-half years to complete under favorable conditions and involves three feeding stages which usually occur in the spring or early summer. Before the eggs are produced the female requires a large blood meal and to obtain this she will attack almost any animal including man. Not only does she inflict

during the process of feeding a severe wound which may be followed by ulceration, but secretes into the tissues a substance which is toxic to the host. Should this injection take place close to nerve centres, as along the spine or at the base of the skull, and such is not uncommon, paralysis and even death may ensue.

Dermacentor venustus has been shown to be the transmitter as well as the physiological host of Tularemia and Rocky Mountain Spotted Fever, two malignant diseases of man and animals. These diseases have always been confined to regions where this tick is abundant since it's host relations, feeding as it does during the early stages of it's development on rodents which serve as reservoirs for the disease and as adults on man and larger animals makes it pre-eminently suited for the role it plays. The adult not only remains infective from one year to another but the virus is transmitted through the egg to the larva and nymph.

With a large gopher population as a potential reservoir and the widespread occurrence of such a potential transmitter as Dermacentor venustus, The outbreak of an epidemic in this province would appear to depend only on the introduction of the virus in an infected animal or tick. If such were the case the disease would be far more widespread than it is at the present time. However in recent years it has appeared in districts far removed from endemic areas so that geographic position as well as natural factors place an outbreak in Manitoba well within the limits of possibility.

Ceratophyllus bruneri was found to infect almost one hundred percent of the gophers examined as the nesting habit and thick fur of the host greatly facilitates the high rate of reproduction and spread of fleas. No direct pathological conditions result

from the bite of this insect but Bubonic plague and pneumonic plague of man, common in numerous parts of the world owe their persistence to the presence of animal reservoirs in the form of small rodents and transmission from one host to another to the fleas of these rodents. Climatic conditions in Western Canada are sufficiently near to those of the endemic areas of pneumonic plague to encourage this disease if once introduced.

It is not known to what extent gophers are infected with Trypanosoma citelli but Ceratophllus bruneri may play a considerable part in it's dissemination. Likewise it may be intimately concerned as the intermediate host of Weinlandia citelli, a common tapeworm of gophers since a number of the members of this genus have their larval stages in insects. The microscopic examination of the stomach and intestinal contents of a large number of gophers showed that they commonly ingest numerous fleas.

The lice and mites of gophers although quite common are not considered to be of any importance either in the pro duction of pathalogical conditions in the host or in the transmission of disease.

Warrenius bifurcatus ranks first as a pathogenic organism of all the gopher parasites listed in this report, not only because it occurs in large numbers but because of it's feeding habits and toxin producing powers. As many as eighty of these worms were found in one host with their heads buried deep in the submucosa or inner muscle layer of the pyloric end of the stomach and duodenum. They are definitely blood feeders and tissue mutilators and their presence in appreciable numbers is always accompanied by a necrotic and hemorrhagic

condition of the digestive tract. Where this worm attacks the wall of the duodenum there appears to be a destruction of the villi in the region around where the head is buried as shown in figure (10). Surrounding this is a circle of cronically inflammed tissue with a great thickening of the submucosa and concentration of leucocytes. Infected areas of the stomach show a similar inflammed condition with lesions and open ulcers, although general observations did not reveal more than an unhealthy state of the host, loss of blood and the presence of toxins must reduce it's fertility and physical condition considerably.

Fig.10. Section of wall of duodenum showing portions of worm embedded.

Little is known of it's life cycle but that of most members of this family are direct and infection is either active or by the ingestion of larvae with food.

The incidence and percentage of infection of Rictularia citelli as shown in table 2. are not great, being eight at the most in one host but it's relative size greatly increases it's detrimental possibilities. The presence of plates and spines in the buccal cavity would indicate that it might possibly be a tissue feeder but apart from poor general physical condition, possibly due to the interception of food

or production of toxins by the worm no pathalogical condition was observed due to it's presence in the host. It's life cycle is not known.

Spirura infundibuliformis was found in numbers as high as forty-eight in one host. They are usually found at the cardiac end of the stomach surrounding the opening of the oesophagus and are hooked through a loop of the mucosa and sub-mucosa, the boss or struma of the cervical region serving to prevent the worm from being dislodged. There is no great evidence that they are tissue feeders or toxin producers, but there is an inflammed condition of the tissue surrounding the point of attachment. They must interfere mechanically with the passage of food, and the movement of the stomach walls. Not only do they intercept the host's food and possibly produce harmful toxins, but the wounds provide favorable openings for secondary infection. The life cycle is unknown.

Physalopteria spinicauda may be considered as an unimportant nematode parasite from the point of view of pathogenicity. It may be able to attach itself to the gut wall by means of the hooked teeth on the inner sides of the lips, but was always found in a free condition. The maximum number found in one gopher was seven. It's only known importance is in the reduction of the hosts vitality by the robbing of food destined for the host's tissues and the possible production of toxins. It's life history is unknown.

Moniliformis spiradentatis occurs in Citellus tridecemlineatus to the extent of 8.4 percent with a maximum number of 19 worms in one host. This worm is found in the stomach and

duodenum with it's proboscis buried in the wall and on account of it's extremely large size no doubt is a serious impediment to the passage of food material and the normal functioning of these organs. Wounds made by the armed proboscis provide favorable points for the entrance of secondary infections and the worm itself must require considerable food. Specimens heavily infected with this Acanthocephalan showed general poor physical condition. The life history is not definitely known, but it is thought to have a larval stage in an insect. The infection of C. tridecemlineatus is possibly correlated with it's habit of feeding on grasshoppers and crickets.

Prochoanotaenia spermophili does not cause any visible lesions in the host and occurs in a low percentage of two species of Citellus as shown in Table 2. As many as seventeen worms were found in one host but it's small size renders almost impossible any great mechanical interference with the host's organs or the interception of any appreciable amount of food. It's life history is unknown.

Weinlandia citelli possesses considerable pathogenic possibilities. It is found in numbers up to twenty in the duodenum of a single host and because of it's large size are almost completely block the lumen as shown in Fig. 11. Where several worms are present in one region of the intestine or folded a number of times on themselves the wall becomes stretched and thin with a general emaciated appearance. Hymenolepids are among the greatest toxin producing cestodes so that the presence of these worms may seriously affect the health of the host in this way. Specimens infected with this

worm showed a general unhealthy state. The egg producing power of Weinlandia citelli is great and the percentage of infection is accordingly large. The life history is not known but as previously stated the larval stage may take place in the flea.

Fig.11. Transverse section of intestine with worms in situ.

PARASITISM AND HOST ABUNDANCE.

The abundance of animals is influenced beyond doubt by three primary environmental factors, namely temperature and weather conditions, proper food supply, and the nature of other organisms with which they come in contact or associate. The influence of these factors either singly or combined may be manifest directly in the longevity of the animal or indirectly in it's fertility or powers of reproduction. If these conditions are variable, increase in favorable years must be great if the species is to survive during the adverse ones.

Although Western Canada is subject to considerable seasonal extremes of temperature and weather conditions, members of the genus Citellus due to their hibernating habit are well adapted to withstand winter conditions unless interfered with from some other source. Food during their active

season is present in much larger quantities as a rule than that required to support their numbers even in years of maximum abundance. It must rest then with the associated organisms to at least initiate the condition that so regularly depletes their number.

Gophers living as they do in what is now agricultural areas are practically free from the attacks of such natural predators as the Coyote, Fox, Badger, Hawk, Owl, etc., This condition would allow for the rapid multiplication and existence of large numbers of these rodents were it not for the intervention of disease due to parasites and perhaps bacteria. Parasitic infection as shown by Boughton (4) is dependent on a number of factors such as the rate of egg production, life-cycle stages, the presence of a secondary host if such be necessary and the chance of gaining entrance to the hosts. He has also shown that moisture and soil conditions play an important part in the hatching of the eggs. With the increased numbers and overcrowding of the hosts the probability of infection is more than proportionately increased not alone because of the greater chance of them coming in contact with the eggs or larvae but overcrowding and inter-breeding produces a strain of host with much lowered resistance. Chandler (8) has shown that animals possess a specific resistance to parasitic infection as well as bacterial and also that this resistance varies with the individual. This is further supported by the fact that wild and domestic animals under unfavorable food and weather conditions show much heavier parasitic infection than they would otherwise.

During the course of this survey it was observed that young specimens and either pregnant or lactating females showed the heaviest infection.

Of the Helminths listed in this report Warrenius bifurcatus may be considered the most important with regard to the health of the host, because of the high percentage and incidence of infection and it's pathogenicity. It is only found in C. richardsoni but this particular species represents 90% of the gopher population. The presence of any of the others with perhaps the exception of Physaloptera spinicauda, in the numbers found in this survey has been previously shown to have serious effect on the health of the host. This detrimental influence is much increased by the fact that the worms are metabiotic and several species can infect the same host, in fact the greatest number of a single species was often found in the presence of other parasites. For example a single specimen of C. tridecemlineatus showed infection as follows:- Weinlandia citelli 8, Moniliformis spiradentatis 19, and Spirura infundibuliformis 48. A single specimen of C. richardsoni also showed Warrenius bifurcatus 62, W. citelli 20, and Prochoanotaenia spermophili 14. The presence of one parasite appears to lower the host resistance and facilitate the existence of others.

Unfortunately it has not been possible to carry out examinations during the winter months to determine the change in infection due to hibernation. Figures gathered during the survey show the maximum incidence of infection to be in

June and July with slightly lower and about equal infections in the spring and fall. It is assumed from this that in the fall abundant food and increased age of the young raise the host resistance and infection drops. That infections in the spring and fall are approximately equal and that an equal percentage of mature worms were found on the first examinations supports the belief that the parasites winter over in the host without decrease in numbers in the fall and reinfection in the spring.

The facts gathered during this survey carried out under endemic conditions indicate that,

1. Overcrowding and interbreeding result in lowered resistance and heavy parasitic infection.
2. These parasites are sufficiently pathogenic and because of their high egg producing powers and direct life-cycle or presence of a secondary host in abundance, can occur in large enough numbers to seriously impair the health if not kill the host.
3. The mortality is greatest in the early spring or shortly after the gophers have come out of hibernation, when food is scarce and the weather unfavorable.
4. Death is due directly to parasites or to a mild type of virus to which the host would be immune in the absence of parasites.
5. Gopher abundance reaches a maximum approximately every five years and a combination of the above factors result in epidemic disease with a high mortality rate.

ACKNOWLEDGMENTS.

This survey was carried out under the direction of Prof. R. A. Wardle, to whom the author wishes to express his sincere thanks not only for permission to use his private literature files but also for many helpful suggestions, kind criticisms and for assistance in the preparation of the manuscripts. Thanks are also due Mr. Stuart Criddle, Treesbank, Man., and members of the Dept's of Zoology and Biology, Manitoba University, for valuable assistance.

Financial assistance was received from the National Research Council of Canada, supplemented by the resources of the Department of Zoology, University of Manitoba.

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