A NEW SPECIES OF CESTODE PARASITE (TÆNIA BALANICEPS) OF THE DOG AND OF THE LYNX, WITH A NOTE ON PROTEOCEPHALUS PUNICUS.

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The tapeworms of the dog have received considerable attention from scientists, and the great amount of work on the commoner forms led at an early date to a number of valuable discoveries which have given these forms permanent scientific importance. From an economic standpoint the tapeworms of the dog are likewise of great importance, as several species have an intermediate stage which develops in man and the domestic animals, often with serious or fatal consequences.

The tapeworm described in this paper was first found in a dog which had been fed larval *Multiceps serialis* in Fallon, Nevada, in the spring of 1908 and shipped to this laboratory. Apparently the dog received an overdose of *Multiceps*—it had been fed six clusters—and the infection with the strobilate *Multiceps serialis* did not develop. When the dog arrived in Washington, thirteen days after being fed the first four clusters of *Multiceps*, the feces already showed numerous cestode eggs. These could hardly be attributed to strobilate forms resulting from the ingestion of the *Multiceps* larva, as the brief period of thirteen days would be too short a time for the adult worm to have developed, judging from the experiments of Baillet (1863) and from the time required for the development of other dog tapeworms of nearly the same size. In subsequent investigations on the life history of the parasite, the larval form failed to develop on feeding the eggs to the rabbit, a point which also indicates that the tapeworms present did not include *M. serialis*.

Two weeks after the dog's arrival a proglottid was found in the feces. A little more than a month later a chain of thirty-six attached proglottids was found in the feces and an examination of these showed that the tapeworm belonged to an undescribed species. For over six months proglottids, either singly or in chains, were collected from time to time from the feces. One specimen having a

head attached is hereby designated as the type-specimen and has been entered in the Helminthological Collection of the U. S. National Museum as No. 7314. A specimen without the head is designated as the paratype and has been entered in the same collection as No. 7315. The longest specimen collected is headless and is 24 cm. long.

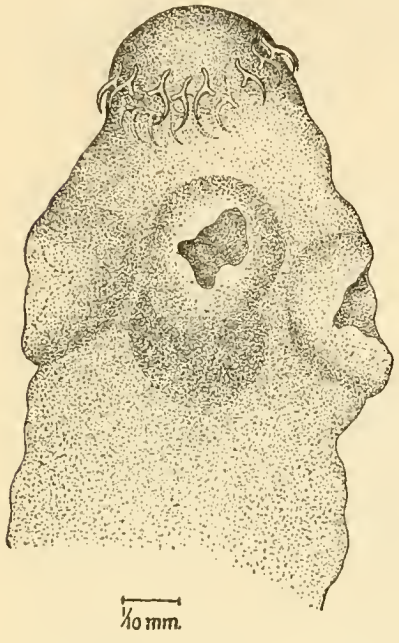

FIG. 1.—HEAD OF DOG TAPEWORM.

While proglottids were still being found in the feces of this dog, a post-mortem examination of a lynx, *Lynx rufus maculatus*, from southern New Mexico disclosed the existence of a very recent tapeworm infection indicated by the presence of a number of tapeworm heads with a neck, but no segments as yet developed. The heads were apparently of the same species as the one obtained from the dog. In fact, certain peculiar characteristics leave little room for doubt on this point. Not only is the general shape of the head the same, but the form and dimensions of the hooks and the suckers are the same and there is the same tendency to lose the large hooks. It is further evident from a study of the tapeworms from both hosts that the parasite is a new species of the genus *Tænia* and the name *Tænia balaniceps* is here proposed for it.

FIG. 2.—HEAD OF LYNX TAPEWORM.

As the specific name indicates, the shape of the head resembles to some extent that of an acorn, due to the very prominent rostellum which projects anterior of the suckers much as the seed of the acorn projects from its cup. The rostellum, being a protrusible muscular organ, is not of constant dimensions. In the head of the tapeworm collected from the dog and mounted in balsam (fig. 1), the distance from the anterior edge of the sucker to the tip of the rostellum is 300 μ and the maximum breadth of the head is 668 μ. The entire length of the head in this specimen can not be accurately measured owing to the contracted condition of the neck. In a specimen collected from the lynx and mounted in glycerine (fig. 2), the distance

from the anterior edge of the sucker to the tip of the rostellum is 370 μ, the entire length of the head being 735 μ and the maximum breadth being 676 μ. In another specimen, mounted in glycerine and viewed *en face*, the breadth was 534 by 752 μ. The bulb of the suckers has a diameter of 215 to 265 μ in mounted specimens. The muscular bulb bearing the hooks has a diameter of 307 μ. The hooks are located on the anterior end of the rostellum at some distance from the suckers. In the specimen from the dog, the small hooks, fifteen in number, are all that are present. A marked hiatus shows where another is missing from the original circlet of sixteen. In examining specimens of the lynx tapeworms, no large hooks were found in the first specimens studied. Later, heads were found with an occasional large hook present, though it appears that the attachment of the large hooks is very weak. One perfect specimen had only twenty-eight hooks, making the apparent range of twenty-eight to thirty-two in number of hooks.

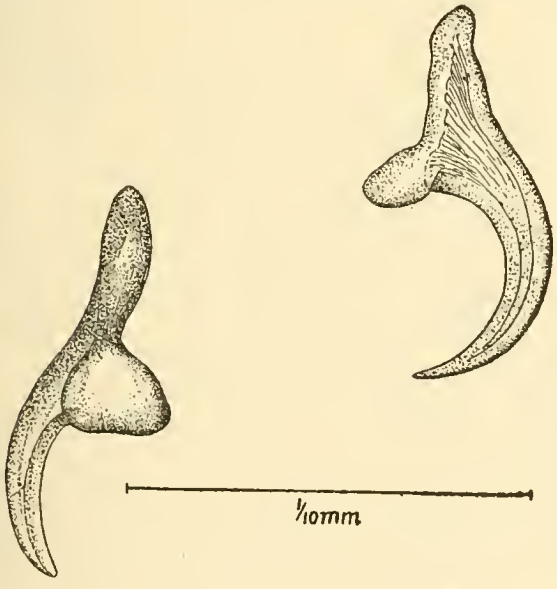

FIG. 3.—SMALL HOOKS OF DOG TAPEWORM.

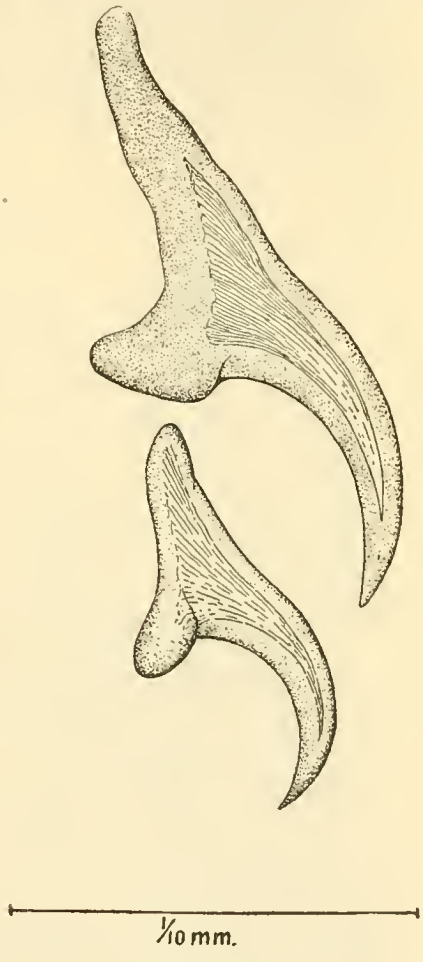

FIG. 4.—LARGE AND SMALL HOOKS OF LYNX TAPEWORM.

The small hook has a strongly curved blade, a very short posterior root or handle, and a broad, almost cordiform, anterior root or guard. (See figs. 3 and 4.) The hook length from tip of the blade to the distal end of the posterior root is 93 to 95 μ in the tapeworm from the dog, and 93 to 98 μ in the tapeworm from the lynx. In the large hook as found in the tapeworm from the lynx, the blade is less curved than in the small hook, the anterior root or guard is of almost the same dimensions as in the small hook, but the straight posterior root or handle is longer, so that the total length of the large hook is 145 μ. (See fig. 4.)

The primordia of the genital organs appear a short distance back of the head. The testes, genital canals, shell-gland, and the main trunk of the uterus are clearly defined in toto mounts before the ovaries and yolk-gland can be detected.

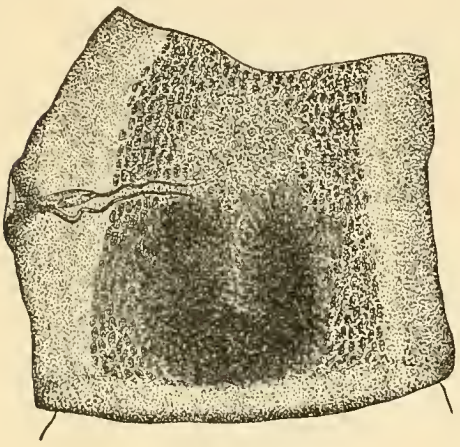

FIG. 5.—MATURE PROGLOTTID.

In the type-specimen, mounted in balsam, mature proglottids measure 2 mm. long by 2 to 2.5 mm. wide.

In the mature proglottids the testes occur on the median side of the lateral excretory canals. (See fig. 5.) There are no testes in the middle line of the proglottids, except at the anterior end, where a band unites the two lateral fields. The vas deferens forms a series of involved loops in passing through that portion of the proglottid where the testes are located. At the plane of the ventral excretory canal, or just past it, the vas deferens opens into a tubular cirrus pouch 300 to 370 μ long and with an average length just between these two extremes, or 335 μ. The diameter of the cirrus pouch also varies considerably, the maximum diameter noted being about 110 μ. There is no vesicula seminalis present. The length of the cirrus varies from 418 to 518 μ, and the maximum diameter noted was about 33 μ. The lumen measured about 8 μ. The cirrus was often found extruded from the genital pore to a distance of 134 to 175 μ.

FIG. 6.—GRAVID PROGLOTTID SHOWING UNUSUAL UTERINE BRANCHING.

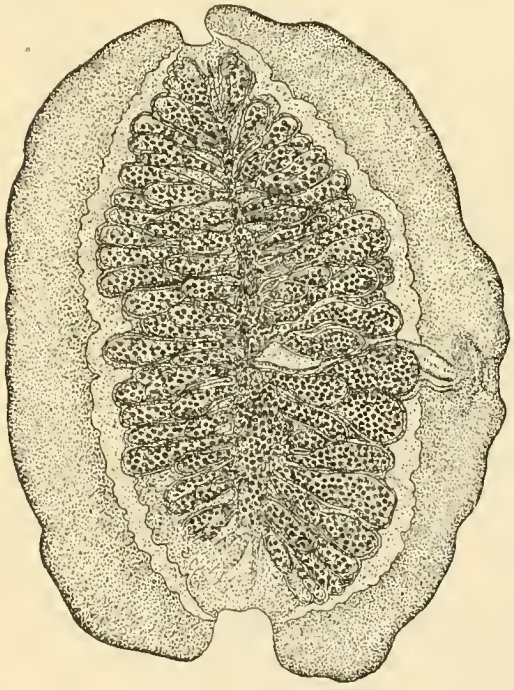

FIG. 7.—GRAVID PROGLOTTID.

The marginal genital pores have an irregular alternate arrangement. They are especially prominent in proglottids full of developing eggs. One such proglottid 1.25 mm. long has a genital pore 0.48 mm. in antero-posterior diameter. Such proglottids in the paratype specimen are 1.25 to 1.5 mm. long by 2.5 to 3 mm. broad.

The female reproductive system shows no notable peculiarities in the mature proglottid. From the genital pore the vagina swings in a wide curve to the neighborhood of the shell-gland, where it opens into a small receptaculum seminis. Around the shell-gland the ovaries are arranged in somewhat crescentic fashion, and the vitelline gland lies partly posterior to the median portion of the ovaries. The uterus outline in the mature proglottid is not shown in figure 5, owing to its failure to stain differentially.

Gravid proglottids, collected from the feces and mounted in glycerine jelly, measure 5.5 to 8 mm. long by 2 to 2.5 mm. broad. One mounted in balsam measures 10.5 by 4 mm. broad. In the gravid proglottid the uterus develops a form somewhat different from that typical of the genus *Tænia*. Originating as a median longitudinal stem, it develops at times branches of unusual form, quite unlike the more uniform and regular branches of the commoner mammalian cestodes of the genus *Tænia*. An illustration of this unusual branching is given in figure 6. Usually the median stem enlarges greatly, and the numerous club-shaped lateral branches are so closely approximated and at times so united that the ultimate result resembles a lobed sac filling the proglottid between the lateral and transverse excretory canals and the muscular layers. (See fig. 7.) A striking peculiarity is the formation in many proglottids of a uterine lobe which at the genital pore extends out over the lateral excretory canals to a variable distance. (See fig. 8.) In two cases noted, this lobe extended to within 134 μ of the tip of the genital pore. The lobe in question occupies a position close to the cirrus pouch and vagina, and these appear to be compressed or crowded aside by this uterine growth. The appearance of the segments suggests that there is an area of weakness in the vicinity of the genital pore, and that the growing uterus has profited by this weakness to make an excessive growth at the point occupied by the now useless and partly atrophied genital canals. A large number of the proglottids obtained from the feces of the dog showed the uterus empty or

FIG. 8.—MARGIN OF PROGLOTTIDS WITH DEVELOPING EGGS IN UTERO.

with perhaps a few lobes filled with eggs or containing only a few eggs. This suggests that we have here a condition similar to that in *Calliobothrium* and allied genera, where the uterus ruptures on the dorsal or ventral side. A further suggestion of this is found in some sections where a uterine lobe extends past the limiting musculature of the inner parenchyma and reaches clear to the cuticula. The eggs in this lobe are not yet completely developed. Eggs were observed to escape from one end of a loose proglottid as it crept about with a leech-like movement, but this method of releasing eggs is common enough in other *Tænia* forms in which a similar large number of fresh gravid proglottids do not show a uterus nearly or quite empty.

The eggs are ovoid in shape, the long diameter varying from 29 to 37 μ and the short diameter from 27 to 33 μ, the average dimensions being 35 by 31 μ. The shell is about 4 μ thick.

In some cases the genital canals pass to the genital pore dorsad of the main nerve and the main or ventral excretory canal and ventrad of the dorsal excretory canal. Where this happens the main nerve trunk and the ventral excretory canal lie side by side in almost the same plane. In other cases the genital canals pass between the main nerve trunk and the ventral excretory canal, in which case the nerve trunk rises to pass dorsad of the canals at that point.

The excretory system is notable for the great development of the transverse canal. In the gravid proglottids this occupies a position between two proglottids instead of being in the posterior part of the anterior proglottid. This condition is indicated in figure 8, showing a toto mount and shown in sagittal section in figure 9. The valve in the ventral canal, located at the posterior end of the proglottid is so well developed that in toto mounts of gravid proglottids there appears to be no connection between the transverse canal and the ventral canal of the same proglottid. This is indicated in figure 8. Where the two canals join the transverse canal is dilated to form a sort of reservoir. The valve-guarded aperture of the transverse canal opening into this from the anterior end has a diameter usually only a third or fourth as great as that of the unguarded aperture of the lateral canal of the following proglottid. The lateral canal, where it passes back from the transverse canal, in gravid proglottids turns toward the median part of the proglottid, forming a sharp angle with the transverse canal. (See fig. 8.)

The worm has a well-developed layer of transverse muscles and several discontinuous and ill-defined layers of longitudinal muscles.

Calcareous corpuscles are abundant and of variable shape. Some of the larger measure about 20 μ in the long diameter.

In an attempt to determine the life-history, proglottids showing the hexacanth embryo were fed at various times to six rabbits, two

white mice, and one field mouse, *Microtus pennsylvanicus*, these being animals closely related to those which would probably form part of the food of the dog and lynx from which the tapeworms were obtained. The rabbit was especially indicated as a possible host in that the remains of a rabbit were found in the cage with the lynx when it arrived in Washington, and the infection in the case of the lynx was evidently of very recent occurrence. The rabbits were killed and examined at intervals of from one week to three months eighteen days after feeding, the white mice after an interval of one month, and the field mouse after an interval of two months thirteen days. Care was taken to use proglottids that had been kept moist for some time as well as fresh ones and it seems fairly certain that the eggs were capable of infecting the proper intermediate host. Nevertheless, no signs of infection were found in any of the experiment animals. During a visit to Fallon, Nevada, the writer was struck by the abundance of rodent burrows in that locality, and it seems not unlikely that the intermediate hosts of the tapeworm belong to one or several of the numerous species of rodents around Fallon.

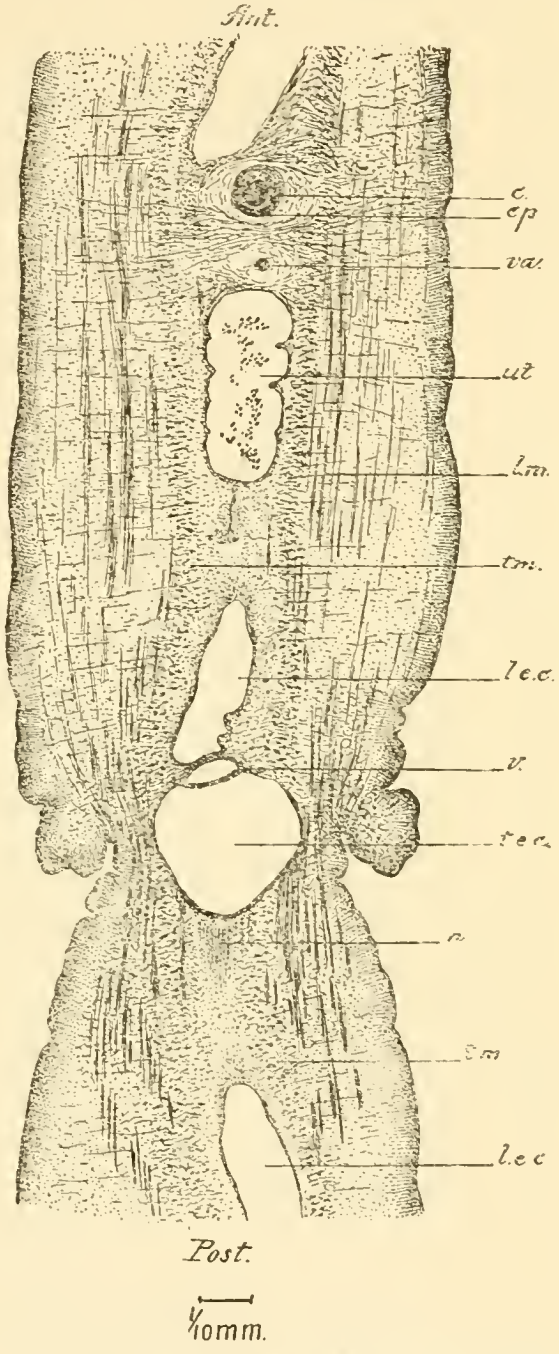

FIG. 9.—SAGITTAL SECTION SHOWING CROSS SECTION OF TRANSVERSE CANAL BETWEEN ADJACENT PROGLOTTIDS. *c*, CIRRUS; *c. p.*, CIRRUS POUCH; *l. e. c.*, LONGITUDINAL EXCRETORY CANAL; *l. m.*, LONGITUDINAL MUSCLES; *n*, NERVE; *t. e. c.*, TRANSVERSE EXCRETORY CANAL; *t. m.*, TRANSVERSE MUSCLES; *ut.*, UTERUS; *v*, VALVE; *va.*, VAGINA.

The salient characteristics of *Tænia balaniceps* are as follows: A prominent rostellum with the hooks set well forward of the suckers; large hooks which display a tendency to fall off readily; a uterus which forms so many lateral branches which become approximated or fused that the uterus becomes practically a lobed pouch,

one lobe often projecting over the lateral excretory canals near the genital pore; and, in the region of the gravid proglottids, a large transverse excretory canal occupying a position directly between proglottids.

In compiling a key to the dog tapeworms, an examination of Kholodkovski's (1908) description and figures of *Tænia punica* from the dog showed that the cestode in question probably belongs in the genus *Proteocephalus* Weinland. The head, the uterine stem, the position of the ovaries at right angles to the uterine stem, and the position of the testes and the genital canals all indicate this. The granular strand of uncertain nature which Kholodkovski noted in the position of the excretory canals can hardly be anything other than the vitellaria, in the location usual for species of the genus *Proteocephalus*. Kholodkovski states that the vitellarium is very small, but it seems likely that he has mistaken something else for the vitellarium. A comparison of the figures with mounted specimens of worms of the genus *Proteocephalus* leaves no reasonable doubt on this point, and it is the opinion of the writer and Dr. B. H. Ransom, with whom the point was discussed, that it is more likely that the dog from which the tapeworms were obtained had just eaten the true host, some fish, reptile, or batrachian, than that the dog was the true host by virtue of a normal, even though unusual, infection with larval form. Fuhrmann appears to have overlooked the unusual features of this worm in his review of Kholodkovski (1909), and states that the anatomy is that of species of *Tænia*.

The desirability of removing this species from the genus *Tænia* at once raises the question as to whether it shall take the generic name *Proteocephalus* Weinland (1858) or *Icthyotænia* Lönnberg (1894). The writer and Doctor Ransom have gone over the literature of this subject and base a preference for the name *Proteocephalus* on the following points.

Weinland (1858) proposes the genus *Proteocephalus* in a footnote in the following terms:

> *Proteocephalus* Weinl. . . . The shape of the head in this genus is extremely variable. There is no proboscis, nor hooklets. The eggs are provided with two shells, the outer shell being mucilaginous. These Tænioids live in reptiles and fishes. The type of the genus is *Tænia ambigua*, Dujardin. Here belong *Tænia filicollis* and *T. dispar*.

Lönnberg (1894) proposed for the fish tapeworms the generic name *Ichthyotænia*, noting for this genus the following characteristics: The vagina opens beside and anterior to the cirrus pouch, and the vitellaria are peripheral and follicular. As type of the genus he names the following species in the order given: *Icthyotænia filicollis* (Rudolphi), *I. ocellata* (Rudolphi), *I. longicollis* (Rudolphi), *I. torulosa* (Batsch), and *I. coryphicephala* (Monticelli).

It is obvious that if these two genera are strictly synonymous, *Proteocephalus* must be retained by virtue of many years priority. Whether they are synonymous depends on the application of Weinland's *Proteocephalus*. Unfortunately, Weinland selected as a type species *Tænia ambigua* Dujardin. This has been stated by Lühe (1899) to be at present a species inquierenda. In the same article, Lühe raises the point that he himself has created the new genus *Nematotænia* and taken as its type *Tænia dispar*, the last of the three species mentioned by Weinland. *Proteocephalus* is left then with a type species, *Tænia ambigua*, now regarded by Lühe as a species inquierenda, and the included species *Tænia filicollis*, which latter species Lühe (1899) regards as identical with *Icthyotænia ocellata* (Rudolphi) Lönnberg. Unless *Icthyotænia* applies to forms generically different from those of *Proteocephalus* it must fall into synonymy by virtue of the law of priority. A consideration of Dujardin's (1845) descriptions of *Tænia ambigua* and *Tænia filicollis* (*Icthyotænia ocellata*) does not warrant us in considering the two species generically different, and unless this can be shown, the generic characters of *Proteocephalus* may be taken from the better known *Tænia filicollis* in the absence of adequate data regarding *T. ambigua*, since Weinland mentions *T. filicollis* as belonging in the genus *Proteocephalus*. In other words, unless sufficient data exist to warrant a belief that the type species and the included species of a given genus are generically different, they should be considered as generically identical and the characters of the genus regarded as fixed by the included species in the absence of the type material. Lühe (1899) apparently believes that such data exist in the case of *Tænia dispar* and proposes for it the generic name *Nematotænia*. The only distinguishing character suggested in proposing the name, the circular cross section of the proglottids, is one already noted by Dujardin (1845). No such adequate difference has been shown to exist in the case of *Tænia ambigua* and *T. filicollis* and in our opinion such differences are not indicated in Dujardin's descriptions.

Lönnberg (1894), in proposing the name *Icthyotænia* for certain fish tapeworms, was apparently unaware of the existence of the generic name *Proteocephalus* and gave it no consideration. In making *T. filicollis* the first of his so-called type species, he made *Icthyotænia* a synonym of *Proteocephalus*, unless it can be shown that good reason exists for considering *T. ambigua*, the type of *Proteocephalus*, generically distinct from the included species *T. filicollis*, which is type of *Icthyotænia*. Railliet (1899) states that *T. ambigua* falls clearly in the genus *Icthyotænia*, and that *Proteocephalus* should be retained on the grounds of priority. The only evident reason why Braun (1900) and others should make *Proteocephalus* a syno-

nym of *Icthyotænia* is by following Lühe (1899) in considering *Proteocephalus* preoccupied, and hence unavailable. Otherwise *Icthyotænia* is a synonym of *Proteocephalus*, or the two genera are distinct and valid, with characters fixed by the type species *T. filicollis* and *T. ambigua*, respectively. Even Lühe (1899), in commenting on *T. ambigua* as a species inquierenda, has not seriously proposed that two different genera are involved in this question of synonymy. Riggenbach (1896) has listed *Icthyotænia ambigua* and *I. filicollis* among his species of *Icthyotænia*. Benedict (1900) bases his preference for *Proteocephalus* on this action of Riggenbach's. Larue (1909) notes that Lühe has given certain reasons for retaining *Icthyotænia*, but he uses *Proteocephalus* on the grounds of priority without further discussion.

Lühe (1899) has objected to the generic name *Proteocephalus* Weinland (1858) on the grounds that de Blainville (1828) proposed the name *Proteocephala* for a cestode family. Stiles (1901) has rejected Lühe's conclusions on the grounds that *Proteocephalus* and *Proteocephala* are not identical and hence not homonyms and that the prior use of a name to distinguish a family does not preclude its later use as a generic name, a point on which we agree with Stiles.

Lühe (1899) and Braun (1900) regard *Tetracotylus* Monticelli, 1892, as a synonym of *Icthyotænia*, Lühe giving as his reason that *Tetracotylus* is preoccupied by virtue of the earlier name *Tetracotyle* Filippi, 1854. Here again we agree with Stiles (1901) that these two names are not homonyms, but we regard *Tetracotylus* as a synonym of the earlier *Proteocephalus*. Monticelli (1892) does not designate a type species. Braun (1900) states that *Tetracotylus* is based on *Tænia coryphicephala*, which is the species Monticelli describes most thoroughly. This action of Braun is tantamount to the designation of a type-species, and *T. coryphicephala* is here considered as type-species of *Tetracotylus* by Braun's designation. Braun, however, regards *Tetracotylus* as synonymous with *Icthyotænia*, which makes it a synonym of *Proteocephalus* for reasons already given in this article. Monticelli gives a list of three new and seventeen old species as belonging in his new genus *Tetracotylus*, and includes among the old species *Tænia ambigua* Dujardin and *T. filicollis* Rudolphi, the first being the type of Weinland's *Proteocephalus* and the second an included species. No records are available showing that *Tetracotylus* has been accepted on the grounds that *T. coryphicephala* belongs to a genus different from the one to which *T. ambigua* and *T. filicollis* must be referred, and it is held here to be a synonym of *Proteocephalus*.

Tænia punica Kholodkovski, 1908, should therefore be known as *Proteocephalus punicus* (Kholodkovski, 1908) Hall, 1910, a combination proposed here for the first time and used in the following key to the tapeworms of the dog. The key is intended to show the rela-

tion of *Tænia balaniceps* to other dog tapeworms, and hence the species of *Dibothriocephalus* and *Mesocestoides* are not given.

1. Head armed with two slit-like suckers ..... *Dibothriocephalus.*
   Head armed with four cup-like suckers ..... 2.
2. Head armed with hooks; genital pores marginal ..... 3.
   Head not armed with hooks ..... 12.
3. Head small, armed with four rows of hooks; two genital pores in each segment, one on each side ..... *Dipylidium caninum.*
   Head armed with two rows of hooks; one genital pore in each segment ..... 4.
4. Entire body of tapeworm less than 1 centimeter long and with only three or four segments ..... *Echinococcus granulosus.*
   Body at least several centimeters long and with numerous segments ..... 5.
5. Gravid uterus with branches so numerous and so closely approximated as to give the outline of a lobed sac, one lobe often crossing the lateral excretory canal. *Tænia balaniceps.*
   Gravid uterus forms a system of fairly distinct lateral branches, none of them crossing the lateral canal ..... 6.
6. Large hooks 225 to 250 μ long ..... *Tænia pisiformis.*
   Large hooks not over 220 μ long ..... 7.
7. Mature segments broader than long ..... 8.
   Mature segments longer than broad ..... 9.
8. Head small, genital pore unusually large and prominent ..... *Tænia krabbei.*
   Head large, 1 millimeter broad, genital pore not prominent .... *Tænia hydatigena.*
9. Guard of small hook twisted so that its flat surface tends to lie in the plane of the blade and handle ..... *Tænia brachysoma.*
   Guard of small hook not twisted ..... 10.
10. Adult strobila not over 20 centimeters long; large hooks 95 to 140 μ long. *Tænia brauni.*
    Adult strobila 40 to 100 centimeters long ..... 11.
11. Large hooks 150 to 170 μ long; eggs spherical and 31 to 36 μ in diameter. *Multiceps multiceps.*
    Large hooks 135 to 156 μ long; eggs ovoid and 33 to 41 μ long by 26 to 31 μ wide. *Multiceps serialis.*
12. Genital pores ventro-median ..... *Mesocestoides.*
    Genital pores marginal ..... *Proteocephalus punicus.*

Tænia erythraea has been erroneously included as a tapeworm of the dog by von Linstow (1905); Setti (1897) described it from *Canis mesomelas.*

The only tapeworms which the writer has found recorded from the lynx are *Tænia laticollis* Rudolphi, *Tænia monostephanos* v. Linstow, and a species of *Mesocestoides.* *Tænia laticollis* can readily be distinguished from *T. balaniceps* from the fact that the former has very large hooks, the smaller ones measuring 128 μ in length and the larger 239 μ, according to von Linstow (1905). *Tænia monostephanos* can readily be distinguished from the fact that it has a single circlet of hooks all of the same size instead of the customary double circlet of large and small hooks. *Mesocestoides* differs from *T. balaniceps* in that the head is unarmed and the genital pores are ventro-median, as indicated in the above key.

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