ON THE NEMATODA-PARASITES OF THE PACIFIC SALMON

By

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(With Plates X–XIV)

The investigation of Nematoda parasitic to the Pacific salmon, *Oncorhynchus*, was initiated by ZSCHOKKE and HEITZ (1914). The fishes then studied were *O. tschawytscha*, *O. nerka*, *O. kisutch* and *O. keta* taken from the east coast of Kamchatka. The parasites found in them fell under thirteen species, of which only one species, *Ascaris* (*Porrocaecum*) *capsularis*, was warranted to be Nematoda, and the others were those belonging to Cestoda, Trematoda or Acanthocephala. This Nematoda was first mentioned by RUDOLPHI (1802), and afterwards proved to exist in the Atlantic salmon, *Salmo salar*. Hence it has a very wide range of distribution pervading in both the Pacific and the Atlantic Oceans. Furthermore in Atlantic salmon still other species of Nematoda such as *Contracaecum* and *Cystidicola* were reported to occur with less frequency. In 1932 the present writer had a good chance to examine numbers of the viscera of *O. nerka* and *O. gorbuscha* netted from the Ochotsk Sea. Three new species of *Contracaecum* were then noted which have been designated as *C. hypomesi*, *C. benimasu* and *C. ochotense*. In the next year KUITENEN-EKBAUM detected a new filiform nematode from *O. nerka* taken from British Bay, Canada. This parasite shows quite distinct features from the already known allied genus *Philometra*, so that she created a new one, *Philonema*, and nominated it *P. oncorhynchi*. Thus at present there are five species of nematodes known in *Oncorhynchus*, namely three species of *Contracaecum*, and one species each of *Porrocaecum* and *Philonema*.

Oncorhynchus being the most predominating and therefore easily available salmon in localities everywhere facing the North Pacific Ocean, there is, no doubt, still ample room left for the advancement of studies on its parasitic diseases. To meet opportunity by extending his own previous work the present writer had endeavored for years to get many samples of salmon from Kamchatka, Karafuto and Hokkaido. These samples were

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the viscera of the fish well preserved either in alcohol or formalin quite suited for the present studies.

General Consideration

Before describing each species of nematodes investigated it will be advisable to get some information about the distribution of these parasites in the Pacific salmon, and also their frequency, that is the rate of infection in the host. This will no doubt serve to clarify the present status of parasitical disease of *Oncorhynchus* caused by nematodes.

Kamchatka. In Kamchatka the material was secured from various localities on the east coast situated within N 55° to 61° and E 161° to 165°. From north to south these localities are Kavacha, Vivinckaya, Tuumlyat, Russakoff, Ozernaya and Ysti-Kamchatsk. The fish caught there were *O. nerka*, *O. gorbuscha* and *O. keta*. Although these fish were very few in number, yet surprisingly, almost all of them were found intensely affected with the parasite as is shown in the following table.

TABLE I Numbers of salmon examined and infected with parasites in different localities on east coast of Kamchatka

Locality	Fish		*O. nerka*		*O. gorbuscha*		*O. keta*	
	exam.	infect.	exam.	infect.	exam.	infect.	exam.	infect.
Kavacha	3	3	1	1	1	1	1	1
Vivinckaya	3	1	1	0	1	0	1	1
Tuumlyat	2	1	—	—	1	0	1	1
Russakoff	2	1	—	—	1	0	1	1
Ozernaya	1	0	—	—	—	—	1	0
Ysti-Kamchatsk	4	4	2	2	1	1	1	1
Total	15	10	2	3	5	2	6	5

The nematodes detected in Kamchatka were *Anisakis*, *Contracaecum*, *Metabronema* and *Philonema*. Among them *Anisakis* mostly pervades in all localities attacking 67 % of the salmon; while *Contracaecum* and *Philonema* are less being 13 % and 6 % in frequency. Of the three species of *Oncorhynchus*, *O. nerka* and *O. keta* are highly susceptible to the invasion

of the parasite, each sheltering more than 70 % in frequency. Generally the fish from the northern localities seem to incur the parasite more than those from the southern ones. Indeed, in Kavacha all salmon were not only seriously injured by the nematodes, but one of them, *O. nerka*, was found to lodge three different forms *Anisakis*, *Contracaecum* and *Metabronema*. Such a state of things is never recognizable in any other locality.

Karafuto. Here the salmon are mainly captured on the high seas within N 48° to 50° and E 144° to 145°, and 40 to 60 miles off the east coast of Chirie province. The fishing stations are Asase, Funadomari, Anaiwa, Tokoro, Karuppo, Yôman and Kaihyoto. Material was also furnished from two hatcheries at Baguntan, Motodomari province, and Tomioka, Sakaehama province on the south-east coast of the island. The preponderate species of salmon in Karafuto is *Oncorhynchus gorbuscha*, but *O. keta* is also taken at Tomioka. Occasionally so called '*tokishirazu*' was hauled up on high sea. This is generally *O. keta* which being taken out of the season such a vulgar name is usually applied. The following table is intended to show the frequency of the parasite in the hosts mentioned from the various stations in Karafuto.

TABLE 2. Numbers of salmon examined and infected with parasites from different fishing stations off coast of Chirie, and in other regions of Karafuto

Station	Fish		*O. gorbuscha*		*O. keta*	
	exam.	infect.	exam.	infect.	exam.	infect.
Asase	10	4	5	2	5	2
Funadomari	9	5	4	4	6	1
Anaiwa	29	15	20	11	9	4
Tokoro	3	2	3	2	—	—
Karuppo	26	16	15	13	11	3
Yôman	49	21	33	15	16	6
Kauhyoto	28	9	12	4	15	5
Baguntan	10	2	10	2	—	—
Tomioka	10	2	—	—	10	2
Total	174	76	102	53	72	23

The nematodes found in Karafuto were *Anisakis* and *Contracaecum*. The former is of the most common occurrence just in the fish from Kamchatka infecting *O. gorbuscha* in a higher percentage than the other host as is shown in table 7. On the other hand *Contracaecum* was recognized only in two out of forty-nine fishes. As to the host *O. gorbuscha* is more apt to harbor the parasite than *O. keta*, their frequency being 52 % and 35 % respectively. Further the fact that the fish in northern localities in Karafuto lodge many more parasites than those from other parts may also be discerned by referring to the table just mentioned. For attaining an easy conception of this matter still further the fishing stations have been classed into northern and southern sections according to whether they lie north or south of Tokoro. Then to the north the frequency of the parasite in *O. gorbuscha* was 59 %, and in *O. keta* 37 % ; while to the south it was 53 % in the former, and 23 % in the latter. Generally considered the fish that live near the coast tend to be much more affected with parasites than those from the high seas. Such a case is particularly well illustrated in *O. keta*.

TABLE 3 Position of fishing station and frequency of parasite

Distance from coast	*O. gorbuscha*	*O. keta*
1 — 20 miles	100 %	100 %
11 — 20	82	73
21 — 30	73	54
31 — 36	90	37
60 — 61	80	100

Hokkaido. The material from Hokkaido was furnished from two different sources, viz. from hatcheries on the north-east coast of Kitami province, and from the Chishima. The hatcheries near the rivers Tonbetsu, Tokushibetsu, Shokotsu, Yubetsu, Tokoro and Shari are situated at intervals of 70 to 80 miles along the coast. The fish observed were *O. gorbuscha*, *O. keta* and *O. masou*, and the parasites found in these fishes were *Anisakis* and *Contracaecum*. *Anisakis* was met with everywhere except at Tokoro, where no nematode has ever been detected so far. *Contracaecum* was rather

rare in occurrence having been found in the present investigations in only two cases, viz. one in *O. keta* from Tonbetsu, and the other in *O. masou* from Yubetsu.

TABLE 4 Numbers of salmon examined and infected by parasites in different hatcheries in the north-eastern parts of Hokkaido

Hatchery	Fish		*O. gorbuscha*		*O. keta*		*O. masou*	
	exam.	infect.	exam.	infect.	exam.	infect.	exam.	infect.
Tonbetsu	17	3	—	—	17	3	—	—
Tokushibetsu	15	7	5	3	5	0	5	4
Shokotsu	25	10	10	8	15	2	—	—
Yubetsu	30	13	—	—	10	2	20	11
Tokoro	10	0	—	—	10	0	—	—
Shari	20	1	10	0	10	1	—	—
Total	117	34	25	11	67	8	25	15

Of the fish examined *O. keta* is most abundant along the coast of Kitami province, but it is more hardy than any other salmon as shown by the fact that only 12 % were affected by the parasite. On the other hand the frequency rate was 60 % in *O. masou* and 44 % in *O. gorbuscha*. In Hokkaido just as in Kamchatka and Karafuto the fish in the north show a great tendency to harbor more parasites. This is highly pronounced in *O. gorbusch*, but less so in *O. keta*.

The salmon from Chishima came from two far distant sites, viz. the one in the north from Suribachi Bay, Paramushiri Island, and also from the high seas at N 51° to 53° and E 156° to 157°; while in the south from Rausu hatchery, Etorofu Island. The fish from the north belong to the three species of *Oncorhynchus* already named above, but also *O. kisutch* was often met with in Suribachi Bay. In Rausu, *Oncorhynchus* was usually represented by two species, *O. nerka* being entirely lacking. Instead, there were found other species of *Salvelinus*, *S. kundscha* and *S. malma*. The parasite pervading in the north was confined almost exclusively to *Anisakis*. Only on one occasion was *Philonema* perceived in *O. nerka* from the high seas. In Rausu, however, still other forms of nematodes such as *Meta-*

bronema and *Cystidicola* are found chiefly in the species of *Salvelinus*. Such a different aspect of the parasites in Rausu may be attributable partly to the kind of the fish, and partly to the unique site of its hatchery. This hatchery is situated within a short distance—about one-half kilometer—from the sea. Hence the salmon caught there have the alimentary canal full of food residue, mainly *Gammarus*. This is quite in contrast to the ordinary case, in which the fish has a stomach totally emptied or even shrivelled up from long day's fasting during up-stream migration. Consequently it seems that the fish from Rausu still retain food remnants with many forms of parasites, which otherwise might have been discharged from the body.

TABLE 5 Numbers of fish examined and infected by parasites in north and south Chishima

Locality	Fish		*O. nerka*		*O. gorbuscha*		*O. keta*		*Salvelinus malma*		*S. kundcha*	
	exam.	infect.	exam.	infect.	exam.	infect.	exam.	infect.	exam.	infect.	exam.	infect.
North Chishima	78	43	50	33	11	4	17	6	—	—	—	—
South Chishima	25	7	—	—	10	6	15	10	6	4	2	1
Total	103	50	50	33	21	10	32	16	6	4	2	1

In north Chishima the most seriously parasitized fish was *O. nerka*, 66 % of them being attacked by various nematodes. This was followed by 36 % of *O. gorbuscha* and 35 % of *O. keta*. In the south quite the reverse frequency was observed, being 60 % in the former host and 67 % in the latter.

In this connection it will be highly interesting to compare the present work with what WARD (1912) has already reported about the frequency and degree of worm-parasites in North American fresh-water fish. By degree here means an average numbers of parasite in an individual host. In his study *Oncorhynchus* together with other salmonoid fish from rivers and lakes were treated, and their parasites were enumerated in a tabulated statement. However, unfortunately, he did not mention the locality wherefrom the fish were caught, nor also the species of the parasites. Anyhow it is beyond doubt that his *Oncorhynchus* were all procured from the Pacific Ocean.

Accordingly, a comparative study of the nematode infection of the Pacific salmon on the east and west sides of the Ocean can be fairly well made. For facility in gaining an easy conception of the matter WARD's and the present results are summarized in the next table. In this table *O. tschawytscha* and *O. kisutch* are omitted on account of their rare occurrence on the west side of the Pacific.

TABLE 6 Frequency and degree of parasites in salmon on the east and west sides of Pacific Ocean

Fish	East side				West side			
	exam.	infect.	freque.	deg.	exam.	imfect.	freque.	deg.
O. nerka	247	227	92 %	11	54	36	66 %	2.0
O. gorbuscha	75	64	65	7	153	76	50	1.6
O. keta	32	11	34	3	177	43	24	1.1

On the whole the nematode infection of *Oncorhynchus* manifests a certain conformity irrespective of its origin in the Pacific. In all cases *O. nerka* is more frequently attacked by the parasite than any others, and *O. keta* stands least in this respect. Nevertheless, concerning minor details about the rate of infection there is notable discrepancy between the fish from the two sides of the Pacific. The frequency and degree of the parasite are always low in the fish on the west side. As is shown in the above table the frequency on this side is generally about two-thirds that of the east; while the degree is also less in the former rarely surpassing one-third of the latter. Consequently it will be quite safe to say that the west side of the Pacific Ocean is not so severely contaminated with the parasitic nematode as the east at least so far as *Oncorhynchus* is concerned.

Description of Species

1 *Anisakis*

The nematode of the present genus generally known as parasitic to the fish was first treated by RUDOLPHI (1802), and designated as *Ascaris capsularis* which in reality agrees in essential points to what had already been announced as *A. salaris* GMELIN (1790). However, the name *A. capsularis* was retained still longer as was noticed by BAYLIS (1915). Quite

recently YAMAGUTI (1935) after scrutinous researches of this nematode from many fishes in Japanese waters legitimately proposed that the species in question is no doubt *Anisakis* as many years ago mentioned by DUJARDIN (1845). Hence the widely adopted name, *Ascaris capsularis*, should be emended to *Anisakis salaris*. Considering YAMAGUTI's proposition tolerably fair the present writer will try to make a short note of this parasite, which infects almost all *Oncorhynchus* indiscriminately.

A. salaris (GMELIN)

Plate X, Figs. 1–2

The body is robust, 22.5 to 30.0 mm long and 0.6 to 0.8 mm broad. The head is broadly rounded measuring 0.09 mm by 0.20 mm, and is provided with a strong tooth at the anterior corner of its left ventral lip. The tail is blunt ended with a prominent spike on its tip, which is more or less retractile in nature. The skin is not thick, but distinctly striated transversely. Sometimes the cuticular membrane at the tail end is seen to dilate to form a flange. In a specimen of 22.5 mm the muscular preoesophagus is 1.82 mm long, while the thick-walled granular postoesophagus is shorter and narrower than the former usually being one-third to one-half of its length. The intestine is 19.5 mm long, and very broad often occupying the full space of the body cavity. There is no special caecum in specimens at hand, owing perhaps to the fact that they are all shorter in length than those which Baylis cited to have such structure. The rectum is 0.13 mm, and the anus opens at 0.10 mm from the tail end. The nerve ring is found at 0.50 mm from the head end. The excretory pore exists quite obviously at a point between two ventral lips, and leads to a canal which is clearly traceable running straight backwards.

The genital organ is not yet developed. However, in a female specimen of 30 mm long a trace of the vulva and vagina could be discerned with difficulty; then the vulva was seen to open at 7.5 mm from the head end.

Habitat. In body cavity and alimentary canal of all *Oncorhynchus* except *O. kisutch*.

Among nematodes parasitic to *Oncorhynchus*, *Anisakis* is a prevalent form appearing in all waters of Japan. Nevertheless, its frequency differs of course with the species of fish and also with the locality. These relations will be evident from the following table.

TABLE 7 Frequency of *Anisakis salaris* in different salmon from various localities

Locality	*O. gorbuscha*	*O. keta*	*O. nerka*	*O. masou*
Kamchatka				
Kavacha	110 %	100 %	100 %	—
Vivinckaya	0	100	0	—
Tuumlyat	0	100	—	—
Russakoff	0	100	—	—
Ozernaya	0	0	—	—
Ysti-Kamchatsk	100	100	100	—
Karafuto				
Asase	40	40	—	—
Funadomari	100	17	—	—
Anaiwa	40	44	—	—
Tokoro	67	—	—	—
Karuppo	86	27	—	—
Yōman	44	33	—	—
Kaihyoto	33	25	—	—
Baguntan	20	—	—	—
Tomioka	—	20	—	—
Hokkaido				
Tonbetsu	—	6	—	—
Tokushibetsu	60	0	—	80
Shokotsu	80	13	—	—
Yubetsu	—	20	—	50
Tokoro	—	0	—	—
Shari	0	10	—	—
Chishima	30	40	25	—

2 *Contracaecum*

Contracaecum generally found in the Pacific salmon is, on the whole, in larval form which affects the fish as the intermediate host. It remains so waiting transfer to other final host to complete the development. Now in *Oncorhynchus* studied the writer has found six species of *Contracaecum*, which can be considered as their larvae; particularly two of them are very obviously so. However, all of them except one, *C. hypomesi*, already announced show well marked characteristics even in immatured forms, which deserve to be considered as new species.

C. hypomesi FUJITA

Plate X, Figs. 3-4

The present species has a comparatively wider range of distribution than other *Contracaecum*. At present the writer has many female specimens from various localities, which manifest some variations in one or other structure of the body. For species determination it is important to know how far these variations extend. Hence the limit of variation will be described in an abridged form as follows. As to the male the specimen from Karafuto obtained on this occassion is the first instance; so its characters will be described at some length.

The female is 13 to 23 mm long and 0.40 to 0.45 mm broad. If male and female are found in the same locality the male is usually longer than the female, e. g., in Anaiwa the male was 23 mm, and the female 17 mm long. The skin is thin and smooth. The oesophagus is moderately long being 1/6 to 1/9 length of the body; but its demarkation into two antero-posterior portions is quite obscure. The oesophageal caecum is short corresponding to 1/18 to 1/25 of body length; while the intestinal caecum is 1/14 to 1/20 of the same. The anus is at 0.19 to 0.31 mm from the tail end. The nerve ring lies at about 0.50 mm, and the excretory pore at 0.56 mm, from the head end. The vulva opens at the middle to anterior one-third length of the body, and the vagina is moderately long proceeding backwards. The paired uteri are narrow at first and also run backwards in juxtaposition. Then in a short course they somewhat enlarge, and at the same time describe a pseudospiral form.

The male measures 16.80 mm long and 0.53 mm broad. The spicule is about 2 mm long, fine and winged with sharp outer end. The caudal papillae are single small conical, arranged in 25 pairs in the preanal portion, which occupy the space a little more than half length of the spicule. Of

these the middle 10 to 13 pairs are larger than the others. The postanal portion is very short and provides no papillae at all. The gubernaculum and caudal alae are entirely absent. The testis is not long but pseudospiral in form, the widest breadth of which is 1/5 to 1/6 of that of the body. Its anterior end surpasses that of the intestine. The spermatic duct lies straight and is nearly 1/4 length of the spicule.

Habitat. Male in body cavity of *Oncorhynchus gorbuscha* from Anaiwa; female in that of *O. nerka* from Kavacha; *O. gorbuscha* from Anaiwa, Yôman, Kaihyoto; *O. keta* from Russakoff.

C. crassicaudatum nov. sp.

Plate X, Figs. 5-7

The body is medium in size measuring 20 mm long and 0.54 mm broad. The head is quadriform, and 0.11 mm by 0.15 mm; the tail has an abruptly narrowed end with coarse prickles densely laid on. The skin is thin and rather smooth. The lip is outlined by laterally expanded cuticular membrane with distinct cervical papillae. The interlabia are rather inconspicuous. The oesophagus is 2.63 mm by 0.19 mm at its wide hinder portion. It is hardly distinguishable into two pre- and postoesophageal portions. Generally the preoesophagus seems to be shorter than the other. The oesophageal caecum is long and narrow measuring 1.44 mm by 0.15 mm. The intestinal one, on the other hand, is very short and moderately wide being 0.63 mm by 0.19 mm. The posterior bulb is quite distinct, and is 0.18 mm by 0.13 mm. The intestine is 16.75 mm long with the moderate breadth of 0.38 mm. The rectum is 0.28 mm long; the anus opens at 0.25 mm from the tail end. The nerve ring lies at 0.87 mm from the head end. The excretory pore is clearly seen at about 1 mm from the same end.

In the female the vulva opens at 9 mm from the head end. The vagina is 0.50 mm by 0 07 mm, and turns almost straight backwards. The uterus is long but very narrow, and is divergent. One branch at first runs forwards but almost immediately it bends backwards. Thence it begins to go along with the other branch, which from the very begining proceeds backwards. These two uteri take the same winding course until they finally arrive at a point 4.5 mm from the tail end. The oviduct and ovary are not yet distinctly brought out in the specimen at hand.

Habitat. In body cavity of *Oncorhynchus kisutch* from Suribachi Bay.

C. elongatum nov. sp.

Plate X, Figs. 8-9 and Plate XI, Fig. 10

The body is narrowed towards both the head and tail ends. Its size is 21 mm long and 0.40 mm broad. The head is more depressed than in the former species being 0.09 mm by 0.15 mm. The lip develops well with wide marginal cuticular membrane at its hinder portion. The cervical papillae are quite obvious, and the interlabia are also distinct. The oesophagus is 2 mm in total length and 0.13 mm broad, of which the longer post-oesophagus is 1.40 mm long. The bulb is well defined and is nearly 0.11 mm in diameter. The oesophageal caecum is notably short, and is 0.80 mm by 0.08 mm; while the intestinal one is long and wide being 1.00 mm by 0.11 mm. The intestine is 17.80 mm, and the rectum 0.25 mm, in length. The anus opens at 0.30 mm from the tail end. The nerve ring is at 0.52 mm from the head end, and the excretory pore is seen at 0.16 mm behind the ring.

Of female genital organs the vulva exists at almost mid-body. The vagina is 1.34 mm by 0.08 mm and is directed backwards. Its wall is very thick so that the lumen is scarcely conceivable. Of the paired and divergent uteri the anterior one, which is about 1 mm by 0.03 mm in widest portion, proceeds forwards in undulating course to almost 2 mm from the head end. On the other hand, the longer posterior half also runs windingly backwards and terminates in front of the anus. The other organs are not yet developed worth mentioning.

Habitat. In body cavity of *Oncorhynchus nerka* from Ochotsk Sea.

C. tridentatum nov. sp.

Plate XI, Figs. 11-12

The body of the female is rather robust, and is 15 mm long and 0.44 mm broad. The head is conically rounded with measurements of 0.05 mm by 0.07 mm, and the tail is elongated with a pointed end. The skin is thick and striated, particularly in the anterior portion at intervals of about 0.02 mm. At the posterior portion, however, such striation is faintly but more closely laid on. The lip is round with narrow cuticular margin, which never overlaps as in other species. However, on its anterior middle margin there is a sharply pointed tooth-like process. The cervical papillae are found distinctly, one on each lateral lip and two on the dorsal one. The interlabia are indistinct. The oesophagus is 1.46mm by 0.16mm. The oesophageal caecum is long and widens posteriorly, while the intestinal one

is rather short and narrow throughout. Their sizes are 1.38 mm by 0.15 mm, and 1.06 mm by 0.11 mm respectively. The intestine is 13 mm by 0.35 mm; the rectum is 0.11 mm long, and opens at 0.16 mm from the tail end. The nerve ring lies at 0.16 mm from the head end, and the excretory pore at 0.26 from this end.

Only the female is known at present. Its vulva is situated at 6.8 mm from the head end, that is, anterior to mid-body. The genital organs are scarcely discernible. The vagina is fairly seen as such, but is very short and directed backwards. The uterus is paired and opposed. However, its exact arrangement could not be traced.

Habitat. In body of *Oncorhynchus keta* and *O. masou* from Monbetsu, Hidaka province.

C. unidentatum nov. sp.

Plate XI, Figs. 13–14

In general appearance the present form resembles *C. tridentatum.* The body is robust more thickened towards the posterior portion and particularly so in the tail. Its size is 17 mm long and 0.48 mm broad. The tail end is sharply pointed without any prickles. The skin is thick and serrated—strikingly so towards mid-body. Of three lips the dorsal one only furnishes a tooth-like process at its anterior middle margin. The oesophagus is simple and 1.22 mm long. The oesophageal caecum is 0.86 mm by 0.15 mm, and the intestinal one 0.46 mm by 0.15 mm. The intestine is about 15 mm long, and the rectum 1/60 of this length. The anus opens at 0.36 mm from the tail end. The nerve ring lies at 0.5 mm, and the excretory pore 0.60 mm, from the head end.

The genital organ is not at all developed.

Habitat. In body cavity of *Oncorhynchus keta* from Kaihyoto.

C. robustum nov. sp.

Plate XI, Figs. 15–16

In general outline the body presents great conformity with the two preceding species. Likewise it widens posteriorly with abruptly sharpened tail end without any appendage. It is 11 mm long and 0.32 mm broad. The skin is not thick, but is striated quite definitely at intervals of 0.05 mm. This striation is well pronounced in the anterior portion of the body, and at the tail end it is conspicuously thickened. The head is round without lip and cervical papillae. The mouth opens in a slit on a capsule-like eleva-

tion bulging out of the thick anterior wall of the oesophagus. The oesophagus is 1.12 mm by 0.12 mm, of which one-third portion is represented by the preoesophagus. The oesophageal caecum is 1.15 mm by 0.10 mm, and the intestinal caecum is smaller than the oesophageal one being 0.63 mm by 0.10 mm. The blub is totally obscure. The intestine is 9.50 mm long with utmost breadth of 0.15 mm. The rectum is 0.17 mm long and opens at about 0.28 mm from the tail end. The nerve ring lies at 0.25 mm from the anterior end. The excretory pore is scarcely visible at 0.05 mm behind the ring.

The genital organ is altogether obscure.

Habitat. In intestine of *Oncorhynchus gorbuscha* from Kaihyoto.

Key to Species

The species of *Contracaecum* studied have notable characteristics by which one can easily be distinguished from the others. Hence, with a view to facilitate a ready identification of the species the following key has been constructed.

Oesophageal caecum shorter than intestinal one 1
Oesophageal caecum longer than intestinal one 2
1. Uterus and ovary divergent ..... *elongatum*
   Uterus and ovary not divergent ..... *hypomesi*
2. Lip none; tail much attenuated ..... *robustum*
   Lip three well developed; tail stout 3
3. Lip without tooth ..... *crassicaudatum*
   Lip with tooth 4
4. Tooth on all lips ..... *tridentatum*
   Tooth on dorsal lip ..... *unidentatum*

3 *Metabronema*

Metabronema was first established by YORKE and MAPLESTONE (1925) distinguished from *Haplonema*, in which it was previously comprised, on the ground of the different position of larger spicule and also the different number of caudal papillae. It is known as a fish parasite, but hitherto only a few species have been remarked, and as for its occurrence in salmonoid fish, *M. iwana* in *Salvelinus malma* from Lake Biwa already noticed by the present writer is the sole instance of the present genus. Now, fortunately, the writer has detected in *Oncorhynchus* many new species of this nematode, which show striking characteristics clearly illustrating their true nature.

M. oncorhynchi nov. sp.

Plate XI, Figs. 17–18 and Plate XII, Fig. 19

The body is slender tapering towards the acuminated tail. The size of the female is 18.5 mm long, and of the male a little less, by 0.43 mm broad in either case. The skin is thin smooth, and provides no cuticular flange. The head is 0.05 mm by 0.07 mm in size. The thick chitinous coating of the lip develops well and terminates anteriorly with bifurcated end. Laterally it projects out as a prominent process. The cervical papillae exist behind the lip. The pharynx is cylindrical, measuring 0.09 mm by 0.05 mm. The preoesophagus is shorter than the postoesophagus, their respective sizes being 0.42 mm by 0.07 mm and 1.51 mm by 0.08 mm. The intestine measures 15.38 mm long and widens posteriorly to 0.18 mm broad. The rectum is about 0.08 mm long, and the anus is situated at 0.33 mm from the tail end. The nerve ring lies at a portion somewhat anterior to the mid-point of the preoesophagus. The excretory pore is seen near the anterior end of the postoesophagus.

In the male the spicules are unequal, the longer right one slender with truncated outer end. Its length is 1.14 mm, that is twice that of the preanal row of papillae. The short spicule is wedge-shaped 0.08 mm by 0.02 mm in size. The gubernaculum is found but not prominently. The caudal papillae form 13 pairs in all laid out equidistantly and straight. They are single or coupled. In the preanal portion they are 10-paired and coupled comprising one clavate and pedunculate, and the other conical and sessile. Such couples are especially notable at middle pairs. The postanal papillae are single, small claviform and 3-paired. The caudal alae are highly obvious, their length being 0.05 mm in preanal, and much less in postanal portions.

In female the vulva is situated almost at mid-body. The vagina lies nearly straight forwards, and measures 1.22 mm by 0.06 mm with an inner wall of 0.02 mm thickness. The uterus is divergent, but its disposition is complicated differing individually. In a specimen examined the anterior uterus is about 5 mm by 0.05 mm with thick wall of 0.02 mm. It runs almost straight upwards to about 2.4 mm from the vulva, and then turns backwards to 0.85 mm below the vulva. Here it describes a fold more than once, and again ascends upwards. During this course it forms here and there node-like enlargements often 0.18 mm in diameter, which inclose a mass of eggs. The oviduct is directed forwards with a length of 0.60 mm. The ovary is 3.50 mm by 0.87 mm, and its anterior tip reaches to 2.90 mm

from the head end. The posterior uterus resembles in many respects the anterior one, but is much less folded and extends backwards to 3.16 mm from the vulva. The oviduct in this case is longer than that of the anterior one having nearly twice its length, and proceeds straight forwards. The ovary is similar in size to that of the anterior one. It runs parallel to the uterus, and terminates at 2.32 mm from the tail end. The uterian ova are oval, each measuring 34 μ by 13 μ, and they lie in one row in the uterus.

Habitat. In body cavity of young form of *Oncorhynchus masou* known as *'yamabe'* from Rausu.

M. kosugii nov, sp.

Plate XII, Figs. 20-22

The body is slender, attenuated towards both the anterior and the posterior ends. It measures 11 mm by 0.33 mm in male, and 12 mm by 0.35 mm in female. The skin is thin and smooth without any cervical flange. The head is somewhat rectangular, and 0.07 mm in diameter. The chitinous coating of the lip is pointed anteriorly, and hooked inwards. The cervical papillae are present but not distinct. The pharynx is very short being 0.09 mm by 0.03 mm. The preoesophagus is shorter and narrower than the postoesophagus, and measures 0.33 mm by 0.05 mm; while the latter is 1.41 mm by 0.09 mm. The intestine is 11 mm by 0.09 mm, and the rectum is 0.08 mm long opening at 0.24 mm from the tail end. The nerve ring lies at 0.22 mm, and the excretory pore 0.30 mm, from the head end.

Of the spicules in male the large right one is 0.6 mm long with truncated outer end. The small one is spatulate in outline, and 0.13 mm by 0.05 mm at its widest portion. The caudal papillae are single, small conical, and rather loosely arranged. In preanal portion they are 8-paired within 0.45 mm from the anus. The postanal pairs are only 2, which are situated in the anterior half of the tail. The caudal alae are narrow and 0.45 mm long in the preanal portion, but quite insignificant in the postanal.

In the female the vulva opens at 5.78 mm from the head end. The vagina is 1.70 mm by 0.03 mm, and thick-walled. It takes a rectilinear course forwards and joins with the paired uterus. The uterus and other genital organs are mostly aggregated in the posterior half of the body. The uteri have the same length of 13 mm, and are laid side by side through all their course. At first they proceed forwards to about 2.3 mm from the head end; then they bend straight backwards at the same time increasing in

breadth from 0.08 mm to 0.12 mm. Finally they connect with the thick-walled, short but convoluted oviducts. The ovaries are both equally 1.87 mm by 0.09 mm, and much folded. They extend backwards until they arrive to about 3.74 mm from the tail end. The egg with thick shell is long oval of 70 μ by 50 μ, and enclose the ovum of 50 μ by 30 μ. It has a filament on its outer opposite poles.

Habitat. In body cavity of *Salvelinus kundscha* from Rausu.

The present species is named to honor the late Mr K. Kosugi who served the author much in supplying specimens.

M. anemasu nov. sp.

Plate XII, Figs. 23-25

The body is fine with a prolonged tail. It is 21 mm long and 0.5 mm broad. The skin is thin, and quite smooth without any trace of flange. The head is conical, and measures 0.07 mm by 0.05 mm. The chitinous margin of the lip is serrated at its anterior end. The pharynx is remarkably short and narrow being 0.15 mm by 0.04 mm. The preoesophagus is thick, and the postoesophagus is slender, their respective sizes measuring 0.79 mm by 0.08 mm, and 2.21 mm by 0.06 mm. The intestine is 17.60 mm by 0.10 mm. The rectum is 0.15 mm with the anus opening at 0.45 mm from the tail end. The nerve ring is situated at 0.47 mm from the head end. The excretory pore occurs at 0.50 mm from the same position.

The male is yet unavailable. In female the vulva opens at 10 mm from the head end, that is near mid-body. The vagina is 0.75 mm long, and runs obliquely forwards. The paired uteri and ovaries are disposed almost entirely in the anterior half of the body, but the minor details concerned are very complicated. Generally considered the uterus in all cases is much prolonged describing a long loop in the body. Its anterior half has the corresponding ovary in the far distant posterior portion. So too a similar case but to a less extent may be seen in the posterior uterus and ovary. The anterior uterus is 23 mm by 0.20 mm. It ascends forwards until 4.5 mm from the head end where it turns backwards to 2.75 mm from the tail tip. Then it meets the oviduct of 0.85 mm long, which after once more bending forwards connects with the ovary. The ovary is 3.60 mm by 0.12 mm. It again proceeds forwards and terminates at 1.28 mm from the tail end. The posterior uterus is shorter than the anterior one being 15.65 mm long. At the outset it descends backwards to 6 mm from the tail end, and there it describes a loop to go forwards to 2 mm from the head

end. Here it again takes a backwards course, and at some length is succeeded by the oviduct of 0.90 mm in length. The ovary is 3 mm by 0.10 mm and stretches to about 6 mm from the tail end. The egg with shell of 6μ thickness is oblong being 90μ by 40μ in size. Its inner space is completely occupied by the ovum. The egg filament in this case is clearly seen as in the preceding species.

Habitat. In intestine of *Salvelinus kundscha* from Rausu.

The present form is called after the Japanese name of the host.

M. salvelini nov. sp.

Plate XII, Fig. 26 and Plate XIII, Figs. 27–28

The body is thin and the tail is acuminated, particularly so in female. The size in both sexes is almost the same being 10.20 mm long and 0.20 mm broad. The skin is thin and smooth. In a specimen of 10 mm long the head is 0.03 mm by 0.04 mm. The chitinous coating is thick and indentated at the anterior end. The cervical papillae are clearly seen as in other species. The pharynx is 0.07 mm long with breadth one-third of the length. The pre-and postoesophasus have totally different sizes ; the former is 0.30 mm by 0.08 mm, and the latter 0.80 mm by 0.10 mm. The intestine is 8.6 mm by 0.09 mm, and the rectum is 0.15 mm with the anus at 0.30 mm from the tail end. The nerve ring is situated at 0.20 mm, and the excretory pore 0.34 mm, from the anterior tip.

The spicules of the male organ are two but very dissimilar. The long right one is filiform sharply pointed at the outer end, and 1.10 mm long. The short one on the other hand is cuneiform, and is 0.10 mm long. The preanal papillae are single, oval, 10-paired, of which the middle 3 pairs are long. They are placed equidistantly straightwise within about 0.05 mm from the anus, i. e., nearly one-third length of long spicule. The postanal papillae are small conical and 3-paired situated on the anterior half of the tail. The caudal alae are distinct extending almost to the tail end with the size of 0.47 mm by 0.10 mm.

The female organs are paired, simple in disposition lying equally in the anterior and posterior halves of the body. The vulva is 5.10 mm from the head end, that is, behind the mid-body. The thick-walled vagina is 0.20mm by 0.02 mm, and proceeds undulately backwards. The anterior uterus is also thick-walled with very slight lumen, and is 1.70 mm long. It runs almost directly upwards except in a portion contiguous to the vagina where it curves notably. The oviduct more or less folds, but is 0.90 mm in linear

length. The ovary measures 1.43 mm by 0.04 mm, and its posterior tip reaches to a point 1.90 mm from the head end. The posterior uterus together with the oviduct is 1.75 mm long, but the latter recurves more than the anterior one. The ovary is 1.32 mm by 0.05mm, and terminates at 2.70 mm from the tail tip. The uterine egg is 79μ by 35μ, and the ovum comprised therein is 56μ by 21μ.

Habitat. In intestine of *Salvelinus kundscha* from Rausu, and *Oncorhynchus keta* from Tarandomari on the west coast of Karafuto.

M. laticauda nov. sp.

Plate XIII, Figs. 29–31

The body is short and rather attenuated anteriorly. The tail is broadly conical, its length being equal to its breadth. The size is 10.80 mm long and 0.09 mm broad at the widest portion of the postoesophageal section. The skin is moderately thick and finely striated, which is very obvious in the anterior half of the body. The head is conical, 0.04 mm in diameter, provided with distinct cervical papillae. The lip is not marked, and the chitinous margin is simple bordering only the mouth. However, at the lateral side it projects anteriorly as a tongue-like form. The pharynx is short and narrow being 0.21 mm by 0.02 mm. The preoesophagus is 0.58 mm by 0.03mm and coated inside with thick cuticle; while the postoesophagus is about four times longer than the preoesophagus. The intestine is 9.88 mm by 0.05 mm, and the rectum which is 0.09 mm long opens at 0.05 mm from the tail end. The nerve ring lies at 0.04 mm from the head end. The excretory pore is prominent situated at 0.08 mm behind the ring.

Female only is known so far. The vulva opens at 6.70 mm from the anterior tip, that is, a little behind the mid-body. The vagina is short measuring 0.16 mm by 0.03 mm, and proceeds obliquely backwards. Its wall is muscular and 0.014 mm thick, and its outside is furnished with a membraneous coating in thickness more than one half of that of the wall. This membrane extends further backwards to the thick-walled portion of the uterus. The uterus and other organs are opposed, but subequal in size. The anterior uterus is 2.34 mm and the posterior one 2.38 mm long, with 0.04 mm breadth in both cases. Their walls are equally very thick so much as 0.02 mm in a portion near the vagina. Even in the posterior narrow portion in front of the oviduct this wall is 0.015 mm thick. Anteriorly the uterus stretches nearly straight forwards and reaches to the much folded oviduct which is 0.24 mm long. The ovary is 2.35 mm by 0.04 mm, and

extends anteriorly to 1.80 mm from the head end. The posterior uterus at first proceeds forwards just as the anterior one to 0.75 mm from the vulva and then recurves backwards for 1.63 mm. Finally it connects with the oviduct of almost the same length with the anterior one. The ovary is larger than the other opposite one and is 2.90 mm by 0.05 mm. It lies straight backwards to 2.22 mm from the tail end. The eggs are not numerous lying in two rows in the uterus, and there is a less number in the vagina. The ovum measures 27μ by 14μ, and is enveloped by a thin shell. It does not show any trace of segmentation even in those in the vagina which are deposited late.

Habitat. In intestine of *Oncorhynchus nerka* from Kavacha.

Key to Species

Metabronema described thus far can be easily classified by the different arrangement of the female genital organ. The following diagnosis will be sufficient to answer the purpose.

Uterus and ovary divergent 1
Uterus and ovary not divergent 3
1. Vagina directed backwards; uterus not much folded... *salvelini*
   Vagina directed forwards 2
2. Uterus much folded, dilated here and there ..... *oncorhynchi*
   Uterus looped in long way, not dilated ..... *amemasu*
3. Vagina not thick-walled, directed forwards ..... *kosugii*
   Vagina thick-walled, directed backwards ..... *laticauda*

After studying these five new species of Metabronema it seems to the present writer that the characteristics of this genus as promulgated by YORKE and MAPLESTONE are yet problematical. This is so, as it was conceived from only one species *M. magnum*. The same opinion has already been expressed by SMEDLY who after referring to SKINKER's description of *M. canadense*, and also considering his new species *M. wardei* came to the conclusion that the identification of the genus in question rests merely on two points, viz., the four pairs of pedunculated postanal papillae of the male, and the fish host. Nevertheless as regards the postanal papillae, they are found in the majority of cases thus far studied, more than four pairs and usually not pedunculated. Furthermore the new species in many important points show tolerably different aspects from what have been believed as the genus character by the original author. At the present juncture considering the new nematodes to be *Metabronema* the diagnosis of this genus should be

emended in several points: (1) cuticular flange rarely present; (2) tail generally not coiled in male; (3) postanal papillae usually less than the preanal ones, and arranged in more than three pairs; (4) vagina generally proceeds forwards.

4 *Cystidicola*

This nematode, formerly sometimes known as Ancyracanthus, is a parasite which more generally invades the trout in Europe and America. In Japan the present writer (1922) has long ago announced a new species, *C. salvelini*, to occur in *'himemasu'*, a land-locked form of *Oncorhynchus nerka*, and *Salvelinus kundscha* in Lake Shikotsu, Hokkaido. A few years ago EKBAUM (1935) made public a short note on a new *Cystidicola* found in the air-bladder of *O. kisutch*, which she claimed to be the first instance occurring in the Pacific salmon.

C. brevicauda nov. sp.

Plate XIII, Figs. 32–34

The body is slender equally narrowed towards both anterior and posterior ends. The tail end is blunt without any appendage. The size in female is 12 mm long and 0.24 mm broad at widest portion. The skin is thin but finely striated, particularly so in the anterior portion of the body. The mouth is large, protected laterally by the chitinous wall of the lip, which anteriorly terminates in a hook. The pharynx is cylindrical, 0.15 mm long lined internally with chitinous wall continuous to that of the lip. The preoesophagus is short but muscular, and measures 0.96 mm by 0.03 mm The postoesophagus is remarkably long being 2.89 mm by 0.05 mm. The intestine is 7.90 mm by 0.09 mm at its widest middle portion. The rectum is 0.04 mm long, and the anus opens as close as 0.06 mm from the tail end. The nerve ring lies at 0.19 mm, and the excretory pore at 0.26 mm, from the head end.

The male is not yet available. The vulva is found at 7.58 mm from the head end. The vagina is short thick-walled, remarkably so in the portion just contiguous to the vulva. It is 0.30 mm by 0.03 mm, and runs obliquely backwards. The uterus and ovary are paired and opposed. They are well exhibited in the posterior half of the body. However, the corresponding anterior ones have in general respects a more complicated arrangement than the posterior. The anterior uterus is 10.25 mm by 0.80 mm. At first it proceeds forwards until it arrives at a point 6 mm from the anterior end,

and then it turns 4.2 mm backwards. Here it again takes up a forward course and connects with the oviduct. Thus the anterior half of the body cavity is seen to be almost totally occupied by the uterus. The ovary is 2 mm by 0.04 mm and lies straight with its anterior tip reaching to 3.16 mm from the head end. The posterior uterus is short but broad, and 5.50 by 0.10 mm. At the outset it describes a loop within 14 mm from the vulva, then stretches backwards almost to the tail end. Near its end it turns forwards and attaches to the oviduct. The ovary is 1.8 mm long, but more or less convoluted with the terminal end extending to 0.4 mm from the tail tip. The egg is oblong, 39 μ by 23 μ with ovum of 28 μ by 16 μ.

Habitat. In intestine of *Salvelinus malma* from Rausu.

5 *Philonema*

Philonema is a filiform nematode, and only one species has been known to occur in the Pacific salmon. Now by the present investigation three new species are added, some of which were found in the body cavity as a mass with great numbers of large-sized female.

P. kondai nov. sp.

Plate XIII, Fig. 35 and Plate XIV, Fig. 36

The body is fine with almost uniform breadth throughout except the tail portion, where it is abruptly attenuated and usually coils more than once. It is 30 mm long and 0.35 mm broad in male, and 70.0 mm long and 0.7 mm broad in female. The head is obtusely rounded without any papillae. The skin is not thick and rather smooth; sometimes faint longitudinal striations are seen closely laid on. The mouth is represented by a slit of 0.06 mm by 0.07 mm at the anterior dilated portion of the preoesophagus. The preoesophagus is 0.88 mm by 0.08 mm, of which the anterior dilated portion of 0.09 mm is coated externally by a thick wall. The postoesophagus is 0.55 mm by 0.06 mm. The intestine is about 27.50 mm by 0.20 mm, and the anus is hardly discernible in the male at 0.57 mm from the tail end. This together with the rectum are completely obliterated in the female. The nerve ring lies at 0.50 mm from the head end; the excretory pore appears at 0.15 mm behind the ring.

The spicules of the male are acicular form, equally short being only 0.35 mm long. The caudal papillae are single and conical. They are 9-paired in preanal, and 6 to 8-paired in postanal, portions. They are disposed regularly and equidistantly within a short space, but more closely so in the

preanal portion. The last pair of the postanal ones is situated at about 0.10 mm from the tail end. The gubernaculum and alae are totally lacking.

Of female organs only the uterus is seen in developed condition, while all others are altogether degenerated. The uterus is enormously enlarged throughout, and occupies almost the full space of the body cavity. It reaches anteriorly further up to the fore end of the intestine, and posteriorly to 0.36 mm from the tail end. The egg is small, being 22μ in diameter, and manifests almost the same stage of morula. There was no larval form.

Habitat. In body cavity of *Oncorhynchus keta* from Vivinckaya.

This species is named as a token of the writer's gratitude to Prof. S. KONDA of Hakodate Higher Fishery School, who kindly furnished the specimen under consideration from Kamchatka.

P. salvelini nov. sp.

Plate XIV, Figs. 37-38

The male is medium in size being 13.27 mm long and 0.40 mm broad. It has a broadly round head, and a body posteriorly narrowing to end in an acuminated tail. The skin is thin and quite smooth. The mouth is very simple, and the cervical papillae are distinct on the lateral, dorsal and ventral sides of the body. The oesophagus gradually enlarges posteriorly, and its muscular terminal end is inserted into the intestine. The preoesophagus is short and narrow being 0.40 mm by 0.10 mm, and the postoesophagus is notably long and broad measuring 1.00 mm by 0.24 mm at the posterior wide portion. The intestine is 11.30 mm long and widened anteriorly with an average breadth of 0.16 mm. The anus opens at 0.36 mm from the tail end. The nerve ring is located at 0.28 mm from the head end. The excretory pore is hardly visible at 0.33 mm from the same end.

The spicule is short just like that of *P. kondai*, and its outer end is sharply pointed. The caudal papillae are single, small conical, arranged equidistantly straightwise. The preanal ones are 9, and the postanal 8-paired. Of these the middle 2 or 3 pairs in the former, and those near the anus in the latter are more prominent than others. The caudal alae are 0.12 mm long in preanal, and 0.10 mm in postanal portion.

Habitat. In body cavity of *Salvelinus kundscha* from Rausu.

P. tenuicauda nov. sp.

Plate XIV, Figs. 39-43

The body is filiform remarkably tapering towards the tail end, which

always recurves in male. Its size is 20 mm long by 0.34 mm broad in male, and 95 mm by 0.90 mm broad at the widest anterior portion of the intestine in a large specimen of female. The skin in male is thin and not striated, while in female it is thick and striated equally all over except the mid-body. The head is conical, and the cervical papillae are few and indistinct. The oesophagus occupies five per cent of the total length of the body. The preoesophagus is short and narrow, and the postoesophagus is long and wide. Their respective sizes are 0.96 mm by 0.22 mm, and 1.60 mm by 0.32 mm. The intestine is 86 mm by 0.53 mm in female. The rectum and anus are totally obsolete, although in some specimens a trace of the anus is manifested at about 0.18 mm from the tail end. The nerve ring is at the anterior one-fourth of the preoesophagus, and the excretory pore exists a little behind the ring.

The spicule in male is quite short being 0.34 mm, but has the same breadth throughout and ends at a truncated tip. The caudal papillae are single, small conical, all lying in a linear arrangement. They are 3-paired loosely arranged both in the pre- and postanal portions. The last pairs of the postanal papillae lie at about 0.30 mm from the tail end. Neither gubernaculum nor alae are found.

Of female organs the vulva is in many specimens obliterated. In one examined it is seen to open at 10 mm from the head end. Then the vagina is thick-walled, and 1.80 mm long and directed backwards. The uterus is narrow and has a very thin wall. However, after leaving the vagina it immediately dilates wider than 3/4 of the body breadth. During its further course it is constricted here and there, and at the same time much convoluted. The oviduct is short and folded. The anterior ovary is 0.35 mm by 1.60 mm with its fore end at 1.0 mm from the head end. The posterior one has also the same length, and terminates at 1.0 mm from the tail end. The egg in morula stage is 30 μ in diameter. The larva is lanceolate in form, and measures 0.26 mm by 0.03 mm. The head is obtusely rounded, and the tail end acuminated. Traces of the oesophagus and intestine are quite distinct.

Key to Species

New species of Philonema thus described are identified with facility by the following key based mostly upon the male genital organ.

Preoesophagus shorter than postoesophagus 1

Preoesophagus longer than postoesophagus ..... *kondai*

1. Caudal papillae equally numerous in pre-and postanal

portions .... *salvelini*
Caudal papillae few in pre-and postanal portions ..... *tenuicauda*

Summary

1. The Pacific salmon, *Oncorhynchus*, usual hosts to the nematodes studied in the present work were collected from various localities of Kamchatka, Karafuto and Hokkaido. They are five species: *O. nerka*, *O. gorbuscha*, *O. kisutch*, *O. keta* and *O. masou*. At the same time two other species of *Salvelinus*, *S. malma* and *S. kundscha*, were also procured from the very limited source of Hokkaido.

2. The nematodes found in these hosts are *Anisaki*, *Contracaecum*, *Metabronema*, *Cystidicola* and *Philonema*. Among them *Anisakis* is the most prevalent form severely affecting the salmon in the localities mentioned. *Contracaecum* is another parasite occurring more extensively in Karafuto than any other regions. The remaining three forms are limited in their existence mostly to Hokkaido. Of these parasites six species of *Contracaecum*, five of *Metabronema*, three of *Philonema* and each one of *Anisakis* and *Cystidicola* are enumerated. All of them except *Anisakis* and one species of *Contracaecum* are new to science, and their characteristics are described in this paper.

3. The parasites as a whole have a tendency to occur more frequently in the northern localities than in the southern. Hence the salmon inhabiting the north Pacific harbor them to a higher degree than the others. *O. nerka* is the main representative of the northern salmon, and *O. keta* the southern one. The infection rate of parasite in the former is as high as 66 %, while in the latter it is only 24 %. Moreover the average numbers in a host are 2 in *O. nera*, but only 1.1 in *O. keta*.

4. Generally considered the nematodes make their appearance more profusely on the east side of the Pacific than on the west. Hence the salmon from that region are damaged more seriously. For instance *O. keta*, which is more or less hardy to the invasion of the parasite, shows in the east Pacific 34 % in frequency and 3 in degree. The same fish in the west is affected at as low a rate as 24% and 1.1 in the numbers. Such contrast is well pronounced in a more delicate fish as *O. nerka*. These facts evidently prove that the salmon in the west Pacific survives in a more healthy condition than that of the east.

In conclusion the writer wishes to express his thanks to Messrs. K. OGAKI, S. ISHII and M. KOBAYASHI for their kind help in the collection of specimens. Particular thanks are also due to Prof. T. INUKAI for affording facilities to carry out the work in his laboratory.

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Explanation of Figures

Abbreviations

an	anus	ph	pharynx
ao	preoesophagus	po	postoesophagus
ca	caudal alae	re	rectum
cp	cervical papillae	rv	right ventral lip
dl	dorsal lip	sc	spicule
eg	egg	sd	spermatic duct
ep	excretory pore	th	tooth
in	intestine	tp	caudal papillae
lv	left ventral lip	ut	uterus
nr	nerve ring	va	vagina
oe	oesophagus	vv	vulva
ov	ovary		

The scale of the figures is shown by millimeter.

Plate X

Figs. 1–2 *Anisakis salaris*

Fig. 1 Head portion, lateral view.

Fig. 2 Tail portion, lateral view.

Figs. 3–4 *Contracaecum hyponesi*

Fig. 3 Head portion of male, ventral view.

Fig. 4 Tail portion of same, lateral view.

Fig. 5–7 *Contracaecum crassicaudatum*

Fig. 5 Head portion of same, dorsal view.

Fig. 6 Tail portion of same, lateral view.

Fig. 7 Mid-body of female showing a portion of genitalia, lateral view.

Figs. 8–10 *Contracaecum elongatum*

Fig. 8 Head portion of female, dorsal view.

Fig. 9 Tail portion of same, lateral view.

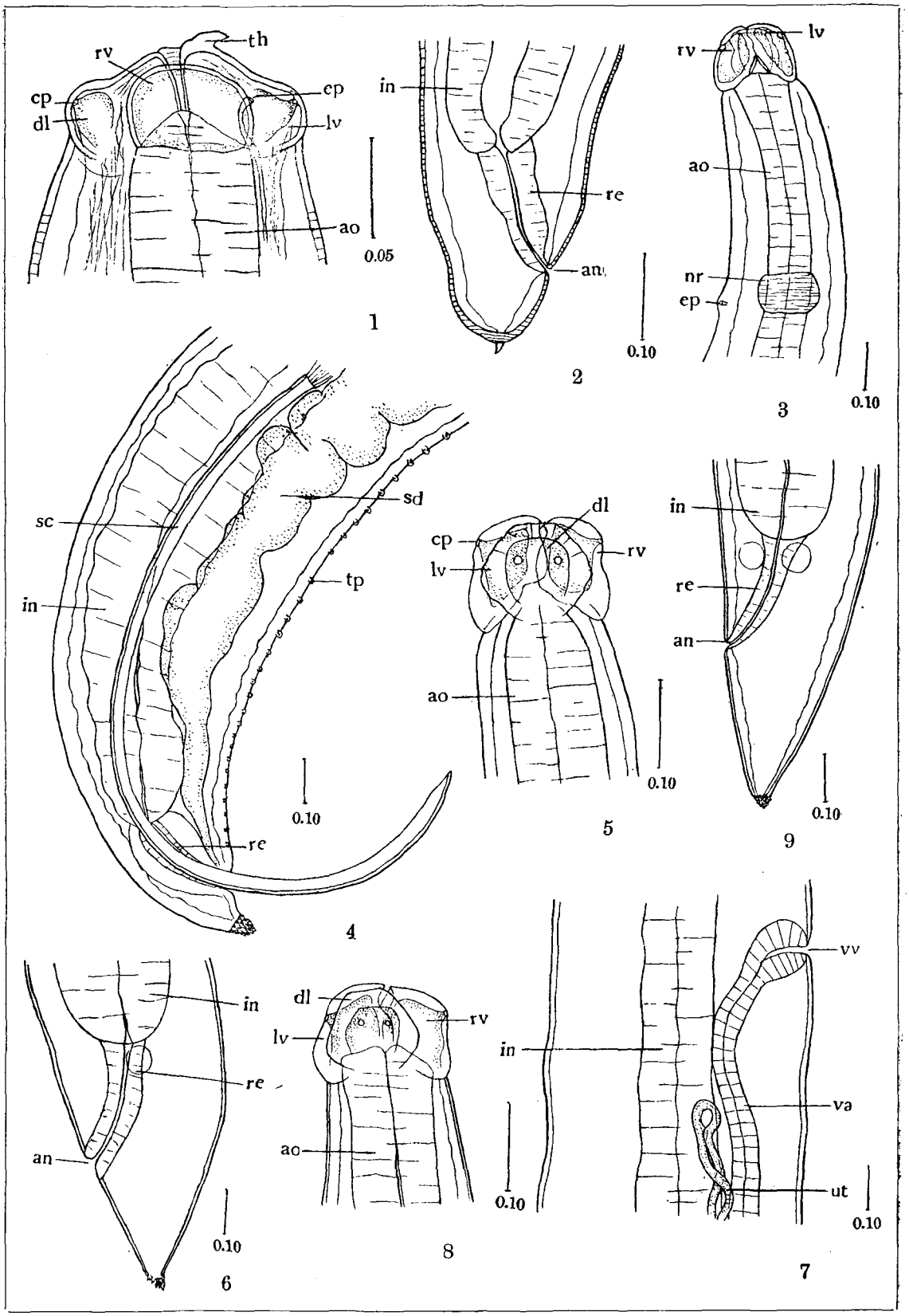
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Plate XI

Fig. 10 Mid-body of same showing a portion of genitalia, lateral view.

Figs. 11–12 *Contracaecum tridentatum*

Fig. 11 Head portion, dorsal view.

Fig. 12 Tail portion, lateral view.

Figs. 13–14 *Contracaecum monodentatum*

Fig. 13 Head portion, dorsal view.

Fig. 14 Tail portion, dorsal view.

Figs. 15–16 *Contracaecum robustum*

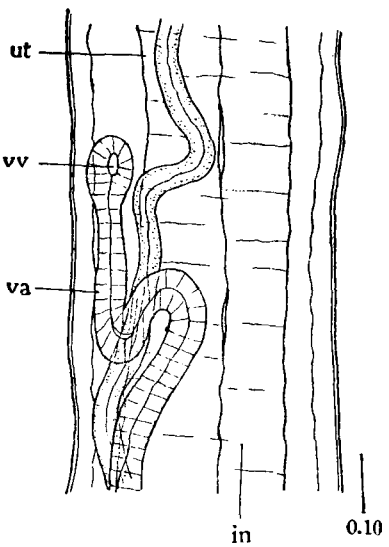
Fig. 15 Head portion, ventral view.

Fig. 16 Tail portion, lateral view.

Figa. 17–19 *Metabronema oncorhynchi*

Fig. 17 Head portoon of male, lateral view.

Fig. 18 Tail portion of same, lateral view.



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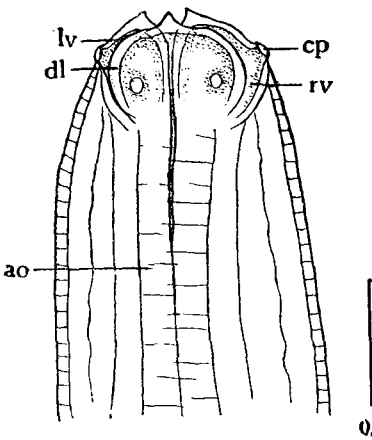

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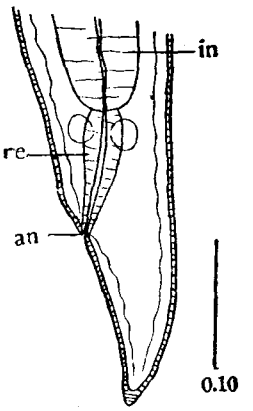

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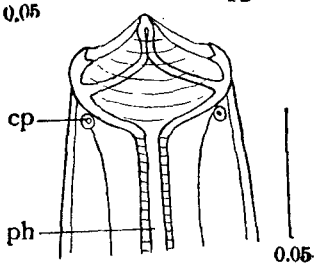

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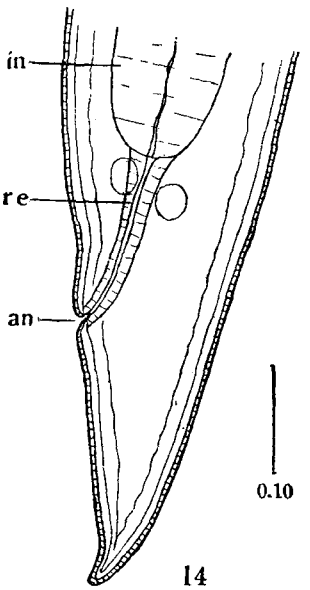

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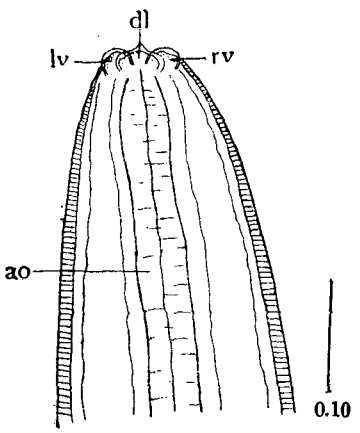

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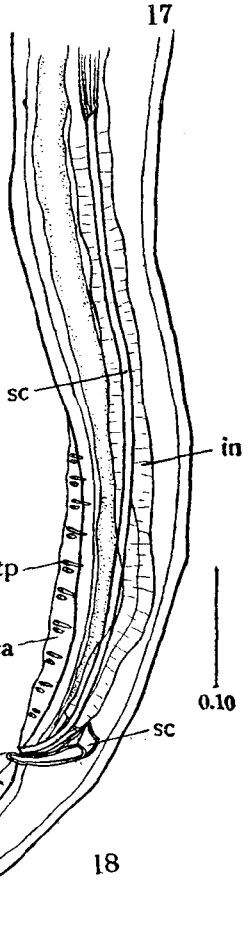

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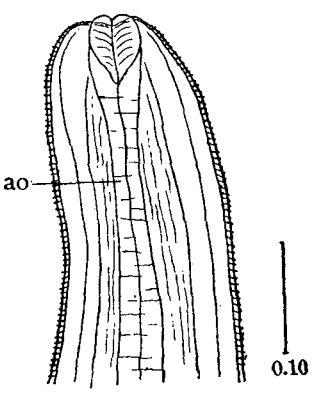

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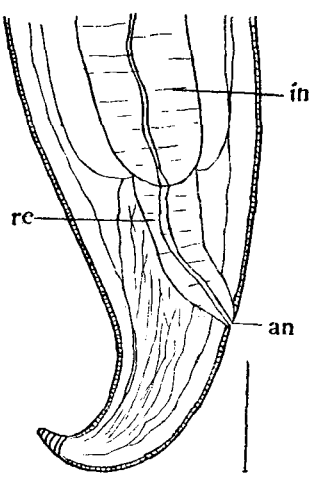

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Plate XII

Fig. 19 Mid-body of female showing a portion of genitalia, lateral view.

Figs. 20–22 *Metabronema kosugii*

Fig. 20 Head portion of male, lateral view.

Fig. 21 Tail portion of same, lateral view.

Fig. 22 Mid-body of female showing a portion of genitalia, lateral view.

Figs. 23–25 *Metabronema amemasu*

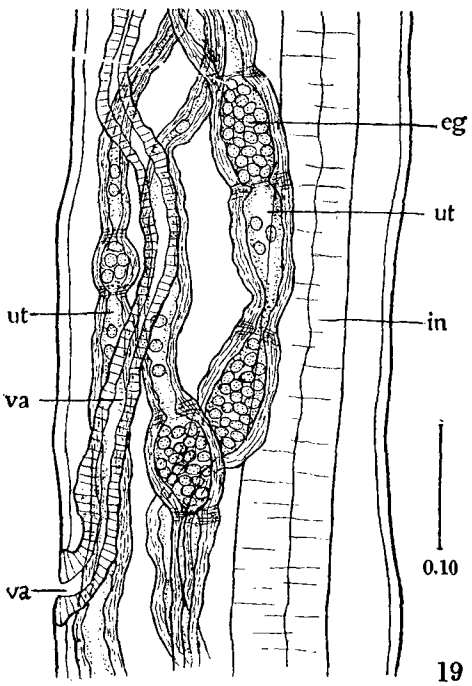
Fig. 23 Head portion of female, ventral view.

Fig. 24 Tail portion of same, lateral view.

Fig. 25 Mid-body of same showing a portion of genitalia, lateral view.

Figs. 26–28 *Metabronema salvelini*

Fig. 26 Head portion of female, lateral view.



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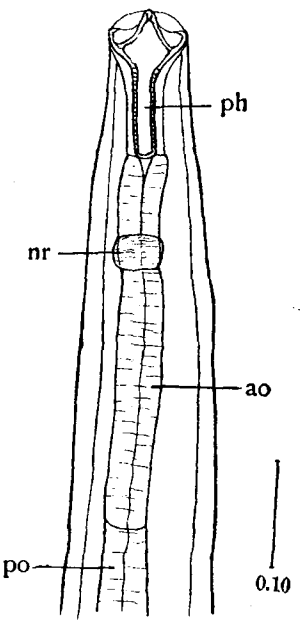

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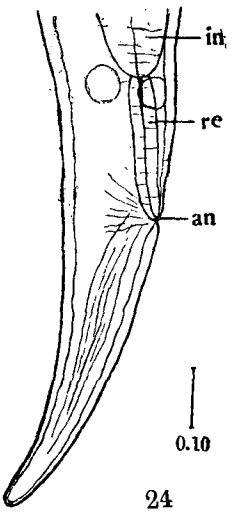

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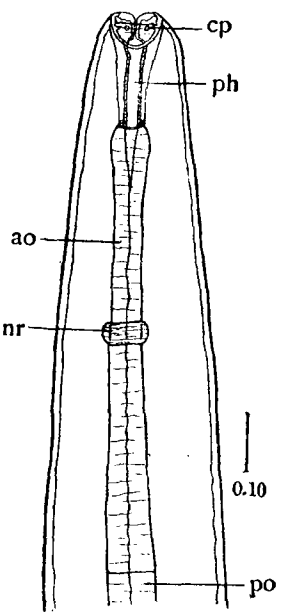

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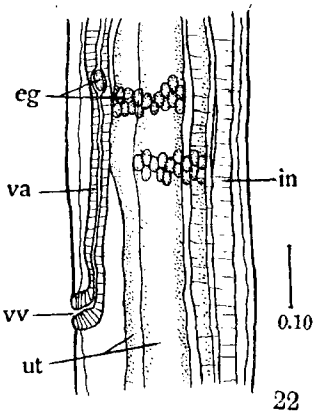

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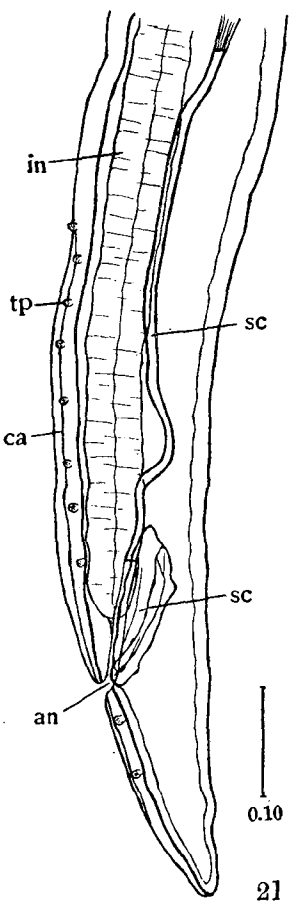

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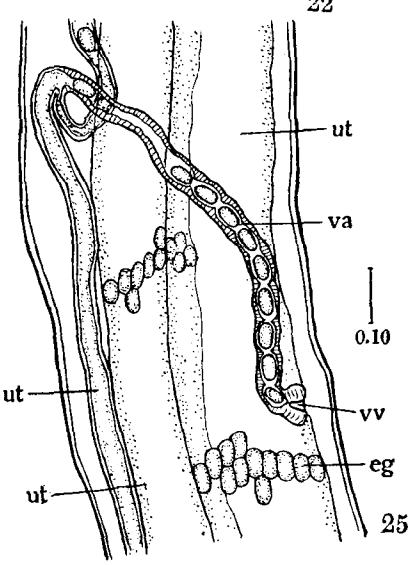

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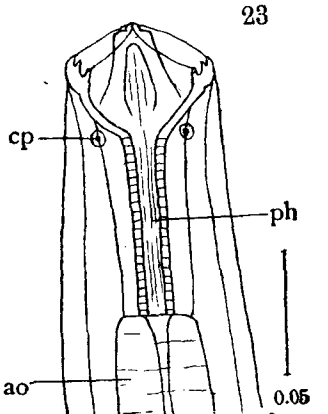

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Plate XIII

Fig. 27 Tail portion of male, ventral view.

Fig. 28 Mid-body of female showing a portion of genitalia, lateral view.

Figs. 29–31 *Metabronema laticauda*

Fig. 29 Head portion of female, lateral view.

Fig. 30 Tail portion of same, lateral view.

Fig. 31 Mid-body of same showing a portion of genitalia, lateral view.

Figs. 32–34 *Cystidicola brevicauda*

Fig. 32 Head portion of female, ventral view.

Fig. 33 Tail portion of same, lateral view.

Fig. 34 Mid-body of same showing a portion of genitalia, lateral view.

Figs. 35–36 *Philonema kondai*

Fig. 35 Head portion of female, lateral view.

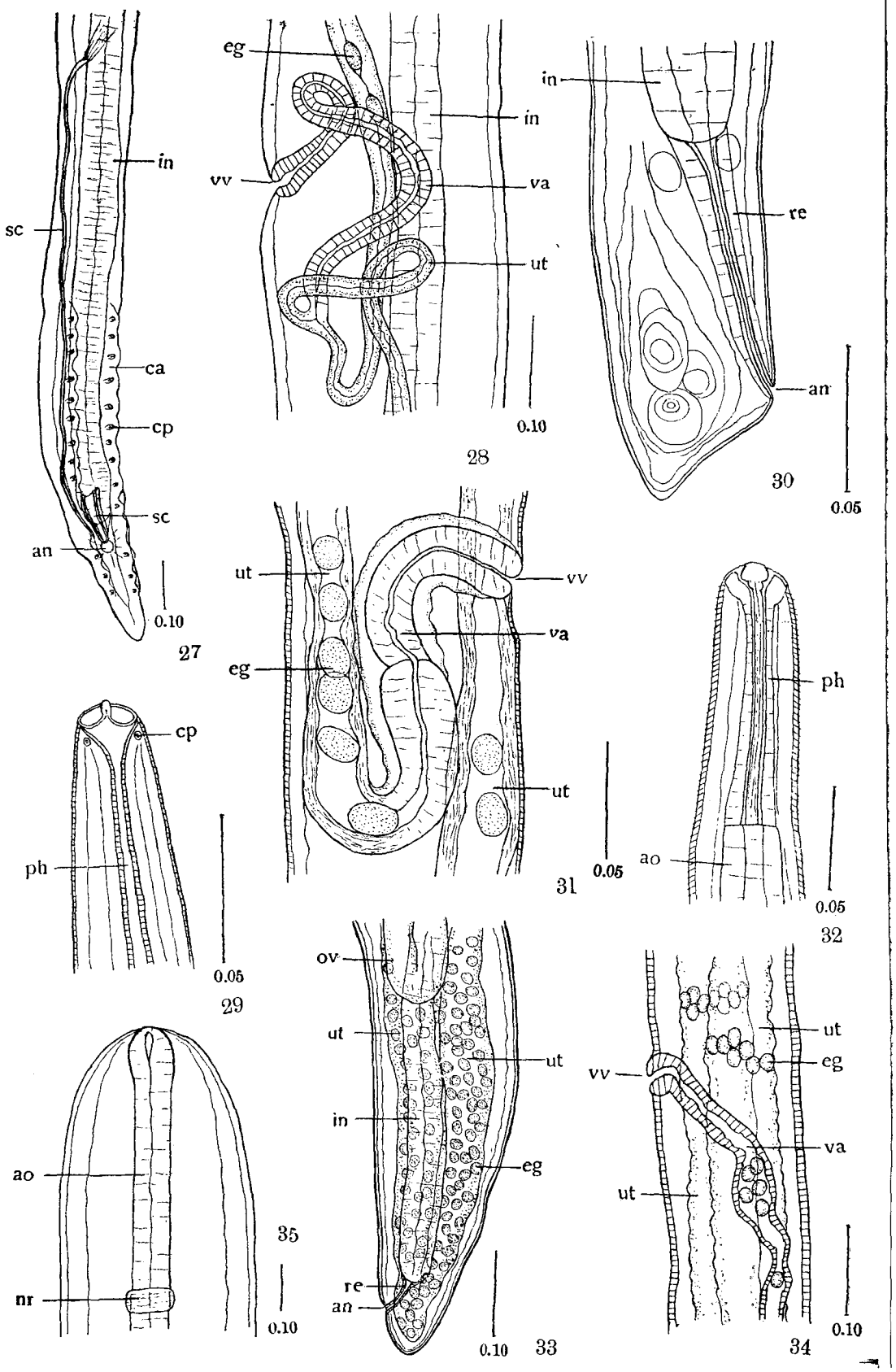
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Plate XIV

Fig. 36 Tail portion of male, lateral view.

Figs. 37–38 *Philonema salvelini*

Fig. 37 Head portion of female, dorsal view.

Fig. 38 Tail portion of male, lateral view.

Figs. 39–43 *Philonema tenuicauda*

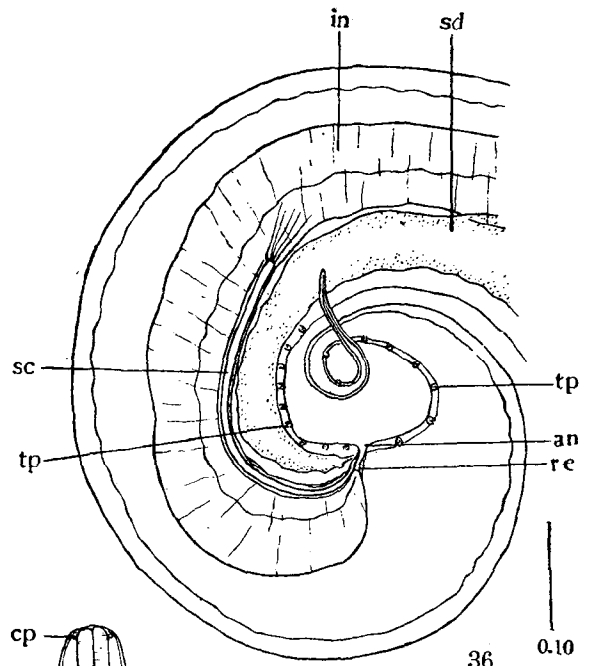
Fig. 39 Head portion of female, ventral view.

Fig. 40 Tail portion of same, lateral view.

Fig. 41 Tail portion of male, lateral view.

Fig. 42 Mid-body of same showing genitalia not yet degenerated, lateral view.

Fig. 34 A larva.



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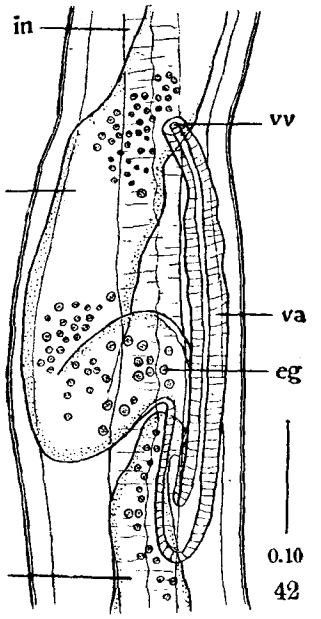

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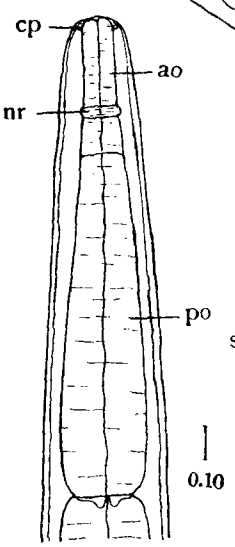

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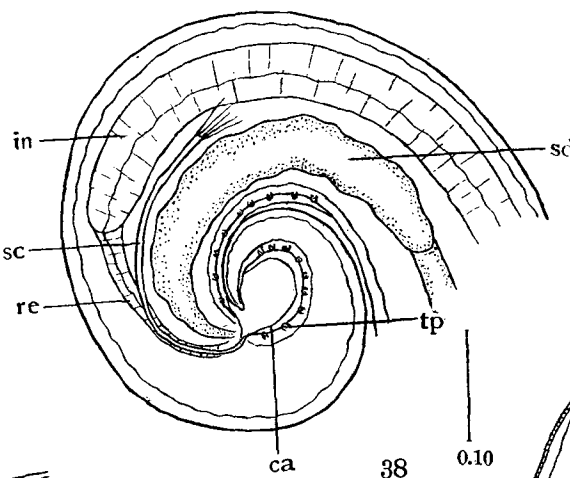

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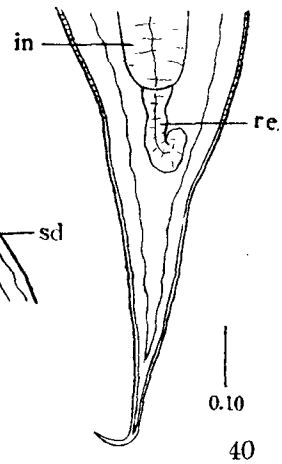

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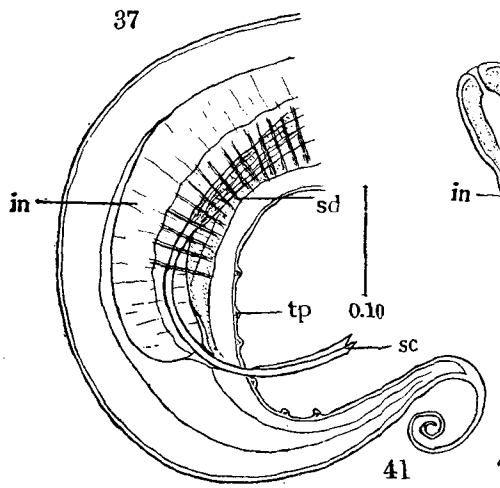

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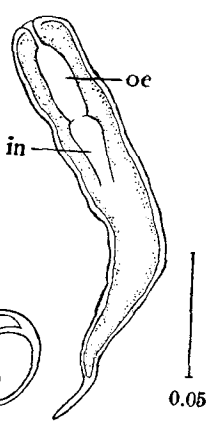

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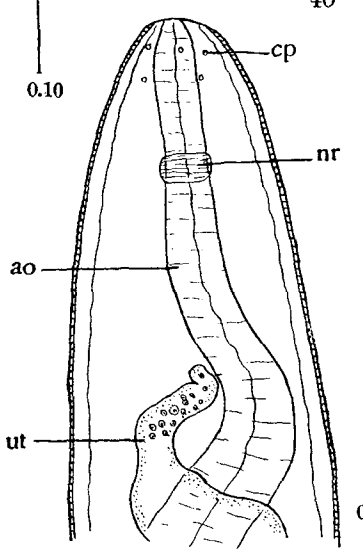

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