T H E S I S

on

SALMON POISONING IN DOGS

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SALMON POISONING IN DOGS

Part I

I N T R O D U C T I O N

This is a report of studies with salmon poisoning in dogs and other animals, including studies of the life cycle of the parasite which causes this trouble. There are many factors of this problem which have not been solved.

Geographic distribution.

This disease is known to exist in western Oregon, northwestern California, and southwestern Washington. It apparently does not occur in British Columbia or Alaska although both salmon and trout are plentiful in these districts. This trouble has not been reported from any other part of the world.

Animals affected.

Salmon poisoning has been produced experimentally in dogs and coyotes and has been diagnosed in foxes.

History and Bibliography.

The history of this disease dates back as far as we have any record of dogs inhabiting this section of the country. Dr. Allen Bonebrake (1) reports that he first saw it in northern California in 1862. There have been numerous theories advanced by veterinarians and laymen explaining this problem. None of them has stood the test

of time. Some veterinarians have claimed that such a disease did not exist, and that symptoms attributed to salmon poisoning were the result of known diseases.

Search of the literature and correspondence with veterinarians and others brought very little definite information. Dr. E. F. Pernot, (2) reporting some studies made in Oregon, stated that salmon poisoning in dogs was caused by an amoeba which could be found in the salmon. Calomel was recommended as a curative treatment.

Part II.

STUDIES OF THE DISEASE

The initial experiments were for the purpose of determining whether salmon would produce symptoms and death when eaten by the dog and if so, to determine what kinds of fish would cause the trouble.

The first efforts to produce salmon poisoning failed. Beginning June 23, 1924 four dogs were fed salt water salmon which had been taken from salt water and obtained from a local butchershop. These dogs remained normal.

The next step was to feed salmon that had been taken from fresh water. These same four dogs all

developed symptoms and succumbed after eating this fresh water fish. Their symptoms and the course of the disease were later established as being typical of salmon poisoning. At that time the parasite associated with this trouble had not been found and it was not possible to confirm the diagnosis on autopsy. During the fall of 1924, five more dogs developed typical symptoms and died after eating fresh water salmon.

ETIOLOGY.

On December 13, 1924, large numbers of a small intestinal fluke were found on autopsy in the intestinal content of one of these dogs. A part of the salmon, which had been eaten by this dog, was still on hand. A microscopic examination of the muscle tissue of this fish revealed an encysted moving fluke. On January 10, 1925, twenty-five (25) salmon were taken from a small fresh water stream located in western Oregon and encysted flukes were found in the muscle tissue of all of them. The description and identification of this parasite is given under the life cycle.

It has been shown that this intestinal fluke is definitely associated with salmon poisoning in dogs. One hundred and forty-six (146) dogs have been used in these studies and of these 89 have died and a diagnosis made by finding the fluke or the fluke eggs.

Table (I) gives a summary of the experimental dogs and their termination.

Summary of Experimental Dogs.

Table I

	Total	No Symptoms	Symptoms	Deaths	Diagnosed Salmon Pois.	No Diagnosis	Recovered
Dogs fed parasitized fish	114	14	100	98	89	9	2
Dogs injected intraperitoneally with ground up flukes	4	1	3	3	0	3	0
Dogs injected intramuscularly with ground up flukes	1	1	0	0	0	0	0
Neither fed nor injected	14	14					
Dogs which escaped or died from other causes before studies were completed	15						
Totals	148		103	101	89	12	2
Less duplicates	2						
Total	146						

The cystic parasites found in the fish developed, after six (6) to ten (10) days, into the mature flukes which were found in the intestines of the dog. This was demonstrated in three ways. First, the capsule of the cyst was ruptured mechanically. This liberated the young living fluke, the morphology of which appeared the same as in the mature fluke. Second, dogs were destroyed at intervals during the period of development of the flukes. All of the stages of development were seen in this way. After the encysted flukes had escaped from their membranes, their development was merely a matter of growth until they reached maturity and began to produce eggs. Table II shows the intervals at which these animals were destroyed. Third, cats were fed parasitized fish. The young living flukes were liberated and they began to develop but did not reach maturity and excrete eggs. The cat, therefore, provided a suitable means of growing immature flukes for study. Table III gives the data on these cats.

Stages of Development of Fluke Cysts to Maturity in Dogs

Table II

Dog No.	Dates Fed parasitized fish	Death	No. days after eating fish	Remarks on autopsy
13	1-12-25 1-14-25 1-13-25 1-16-25	Destroyed 1-19-25	7-6-5 & 3	Flukes in various stages of development. Some appeared identical to cysts found in salmon except that the young fluke was liberated from its membrane. Later stages showed a little larger flukes. Still later stages showed the immature fluke in vigorous activity but these did not contain any eggs. Mature flukes were found containing eggs. Eggs were abundant free in the intestinal content.
16	1-20-25	Died 1-30-25 Complications present	10	Numerous living flukes and fluke eggs found in small intestine. All mature and producing eggs.
41	2-19-25 may have eaten fish on 2-20-25 and 2-21-25	Died 3-2-25	11 Possibly 9-10	No mature flukes were found but fluke eggs were found in the intestinal content. A few immature flukes were present. Animal had been given 3½ cc dose of carbon tetra chloride followed by a dose of Epsom Salts
45	2-12-25	Died 2-28-25	16	No mature flukes were found but fluke eggs were found in the intestinal content. A few immature flukes were present. Animal had been given 4 cc carbon tetra chloride followed by a dose of Epsom Salts.

Table II Continued

52	3-6-25 3-7-25 3-8-25 3-9-25	Destroyed 3-17-25	11-10-9 & 8	Mature flukes and fluke eggs found, also immature flukes showing vigorour movement and not producing eggs were found.
90	11-21-25	Destroyed 11-29-25	8	Numerous immature living flukes found, estimated as 2/3 mature in size but producing eggs. Fluke eggs found free in intestinal content.
137	3-25-27	Destroyed 3-29-27	4	Immature flukes showing vigorous movement found but none were producing eggs. No fluke eggs found in intestinal content.

Note that there was some variation in the time required for the fluke cysts to develop into the mature flukes.

Development of flukes in cats.

Table III

Case No.	Dates fed parasitized fish	Kind of fish fed	Death	Interval between eating fish and death	Remarks on autopsy
27	6 P.M. 2-5-25	Salmon # 12	Destroyed 2-7-25 (11 A.M.)	41 hours	Very immature flukes found in intestine. None were producing eggs.
28	2-5-25	"	Destroyed 2-10-25	112 hours	Immature flukes were found moving very vigorously. These flukes were quite near the size of mature flukes. One fluke was seen that contained one egg. No others had produced any eggs.
33	2-5-25	"	Destroyed 2-13-25	8 days	Immature flukes showing vigorous movement were present. An occasional fluke had one or sometimes two eggs in its body but no eggs were found that had been excreted by the flukes into the intestinal content.
47	2-5-25	"	Destroyed 2-24-25	19 days	Only a very few flukes were present. They were not mature and no eggs were found either inside the flukes or in the intestinal content. Only one living fluke was observed and its movement was very slight. Others were dead and slightly disintegrated. Apparently most of the ingested parasites had passed out of the intestinal tract.

Table III Continued

62	3-30-25	Parasitized trout	Destroyed 4-1-25	42 hours	No developing flukes were found.
65	4-7-25	"	Destroyed 4-10-25	3 days	"
85	7-13-25 7-15-25 7-16-25 7-18-25	"	Destroyed 7-24-25	11-9-8 & 6 days	"

Note that no parasites developed in three cats that had been fed trout.

Period of Incubation.

The dogs usually showed visible symptoms in six (6) or seven (7) days after eating parasitized fish. In a few cases the symptoms were noticed on the fifth (5th) day and in others as late as the twelfth (12th) day. This interval was apparently the time required for the flukes to develop to maturity. In all dogs that were destroyed as soon as symptoms were noticed mature flukes were present. Further evidence of this was in the constant finding of fluke eggs in the feces as soon as the animals were visibly sick.

Symptoms.

Table I shows that symptoms have been observed in one hundred dogs after being fed parasitized fish. The onset was very sudden with rapid rise in temperature to 105° to 107° F. This was accompanied by marked depression and decrease or, in most cases, complete loss of appetite. There was also a very marked thirst. The high temperature usually continued for twenty-four to forty-eight hours after which it was gradually lowered. In many cases a purulent discharge from the eyes was noticed. There was frequently an edematous swelling of the face, especially around the eyelids, which made the eyeballs have a sunken appearance. A diarrhea usually developed in from three (3) to six (6) days after the

first symptoms were noted. The feces were blood tinged when diarrhea first appeared and in the later stages of most cases were practically all blood. This bloody discharge contained fluke eggs in great numbers when the dogs had ingested any considerable number of flukes. Both red and white blood cell counts were made on four different days during the course of the symptoms in one case. No abnormality in numbers of blood cells was found. The animals became very weak, thin and emaciated and were frequently unable to stand in the last stages. In about six (6) days the temperature was usually subnormal and death occurred twenty-four to forty-eight hours later. In average cases the first visible symptoms were noted in one (1) week and death occurred in two (2) weeks after the parasitized fish had been eaten. An occasional dog recovered. Those that did recover always showed these severe symptoms before any improvement was noticed. They were in such an extremely weakened condition that a long period of convalesence was necessary.

Case No. 86 is typical of the 98 dogs that died after eating parasitized fish. Note that symptoms were first observed on the sixth (6th) day after being fed salmon. Death occurred eight (8) days later or fourteen (14) days after ingestion of parasites.

Case No. 86 Black-mature-long-haired dog.

11-12-25: Examination of feces, by use of centrifuge, for fluke eggs was negative.

11-13-25: Examination of feces, by use of centrifuge, for fluke eggs was negative.

11-14-25: Fed large amount of dog-salmon (sore-back which was obtained from the Wilson River in Tillamook County, Oregon. This fish contained numerous living fluke cysts.

11-19-25: 5 P.M. Temp. 103.4° F. Examination of feces for fluke eggs was negative. Animal apparently normal.

11-20-25: Six (6) days after eating parasitized fish. 10 A.M. Temp. 105.1° F. Fluke eggs easily found in feces from thermometer without centrifuging. 4 P.M. Temp. 105.6° F.

11-21-25: 10 A.M. Temp. 105.6° F. Depressed. Loss of appetite.

11-22-25: 10 A.M. Temp. 104.2° F. Marked depression - loss of appetite.

11-23-25: 8:30 A.M. Temp. 103.6° F. Marked depression - loss of appetite.

11-24-25: Temp. 103° F. Slight pus discharge from eyes - Edematous swelling of face.

Case No. 86 Continued

11-25-25: Temp. 101.6° F. Same symptoms

11-26-25: Temp. 100.4° F. Extreme weakness. Vomited -
: Refused feed

11-27-25: Temp. 99.8 F. Same symptoms

11-28-25: Fourteen (14) days after eating parasitized
: fish. Dead. Autopsy. Hemorrhagic inflam-
: mation of mucosa extending throughout the
: entire length of intestinal tract being most
: marked in the first part of the ileum. Ac-
: cumulation of blood tinged serous fluid in
: bowel. Numerous mature living flukes present.
: Fluke eggs were found free in the intestinal
: content. Iliocecal lymph node markedly en-
: larged. The lungs, liver, kidneys of this
: dog were normal on microscopic examination.

Case No. 136 is typical of cases that recover. Note that there was complete loss of appetite and typical symptoms of salmon poisoning for eight (8) days before the dog began to recover.

Case No. 136. Light-colored collie - mature.

1-13-27 : Stray dog - history unknown.

1-14-27 : Given 50 fluke cysts in gelatin capsule.

3-25-27 : Fed trout containing moving flukes.

4-8-27 : Refused feed.

4-13-27 : Typical symptoms of salmon poisoning.

4-16-27 : Much improved and appetite partially regained.

4-18-27 : Apparently normal - appetite normal.

5-17-27 : Given large number of fluke cysts in capsule

10-4-27 : Destroyed

Diagnosis.

Diagnosis has been made in three ways. First, in the living animal showing symptoms the eggs of the fluke were detected through a microscopic examination of the feces. This was usually not difficult. It has been done repeatedly by making a direct smear of fecal material. In cases that had a minimum infestation it was necessary to centrifugalize feces to find eggs. This method of diagnosis has proven satisfactory any

time after symptoms had developed. Eggs have not been found before symptoms developed. Examinations for fluke eggs in the feces of sixteen (16) dogs that were not affected with salmon poisoning were negative. Description of these eggs is given under the life cycle of the parasite. See Figure I.

Second, the mature flukes were found in the intestines on autopsy. They could be seen with the naked eye after becoming familiar with the. In most cases they were present in large numbers, but in some cases death resulted from small numbers of the flukes, and then it was usually necessary to centrifugalize or sediment the intestinal content in order to find the flukes. A description of the fluke is given under discussion of the life cycle. Figure I.

Third, the diagnosis has been confirmed and the relation of the fluke to this disease established by finding the mature parasites imbedded in the mucosa of the duodenum. See Figure II.

Prognosis.

The prognosis was always unfavorable. Four (4) dogs (Table X) developed typical symptoms and died after ingestion of only one hundred (100) encysted flukes. Table I shows that of one hundred and fourteen (114) dogs fed parasitized fish, ninety-eight (98) have died, two (2) have recovered, and fourteen (14) were immune.

Postmortem Findings.

Of the one hundred and forty-six (146) dogs used in these studies, ninety-two (92) autopsies have been held. Table IV gives a summary of autopsies.

Summary of Autopsies

Table IV

Group	Flukes or Fluke Eggs: Found	Not found	Total
1. Death after eating parasitized fish	71	3	74
2. Immune dogs	0	6	6
3. Death from other causes and normal dogs destroyed	0	12	12
Totals	71	21	92

The postmortem findings were extremely significant. As has been stated before, the mature flukes and fluke eggs were found in the intestines. Seventy-four (74) autopsies were held on dogs that succumbed as a result of salmon poisoning. Flukes and fluke eggs were found in 71 of these. In three (3) cases they could not be demonstrated. Of these three negative autopsies, two were cases of minimum infestation and the third was a dog that had received 1 cc of carbon tetra chloride per day for eight days between ingestion of the flukes and the time that its first symptoms developed.

In most cases, there was a marked hemorrhagic inflammation extending from the pylorus of the stomach to the anus. This enteritis was so severe in the average case that blood was found in the lumen of the bowel. The extent and degree of this inflammation was usually in proportion to the number of parasites ingested. That is, the inflammation was severe in cases of maximum infestation and either absent or very mild in cases of minimum infestation. It generally accompanied the presence of the parasite, but in some cases was present in parts of the intestine, where the flukes were not numerous enough to be found. In 5 dogs, 2 mature and 3 puppies, an intussusception of the terminal part of the small intestine was found. A marked swelling of the ileo-cecal lymph gland was present in many cases, and in some this glad was definitely purulent. In a few there was a moderate swelling of several of the mesenteric lymph glands. No other gross pathology was found in any part of the body.

Six (6) autopsies were of dogs that had been affected with salmon poisoning, had recovered and were permanently immune. Examination of these dogs for flukes and fluke eggs was negative. Some of these had recovered many months previous to autopsy, but still showed a slight

hemorrhagic inflammation of the intestines.

Twelve (12) dogs were autopsied that did not have salmon poisoning. These included dogs that were normal, and dogs that had succumbed from other diseases such as dog distemper. Flukes were not found in any of these autopsies.

Microscopic Pathology

As has been mentioned under diagnosis, a study of the microscopic pathology showed that the mature parasite burrowed into the mucous membrane of the duodenum. See Figure II. They always burrowed in head first and often became completely imbedded in the mucosa. They were not found to have penetrated into the sub-mucosa or muscular layers of the intestine. Microscopic sections of the intestines have only been completed in 9 autopsies.

Data on Microscopic Sections of Intestines.

Table V.

	Cause of Death	Flukes imbedded in duodenum	Flukes imbedded in other parts of intestine	Flukes not found imbedded
5 dogs	Salmon poisoning	3	0	2 Minimum infestation
1 coyote	"	1	0	0
2 dogs	Destroyed immune to salmon pois.	0	0	2
1 dog	Destroyed-Normal	0	0	1
9	Total	4	0	5

The flukes were found imbedded in intestines of three dogs and one coyote. They were not found in five (5) dogs. Two of these had received minimum infestations, two were immune and the fifth was a normal dog. In this small number of studies, they have not been found imbedded in any part of the intestinal tract other than the duodenum. In dog No. 53 they were found in each of twenty (20) slides prepared from the duodenum and in none of twelve (12) slides prepared from the jejunum. All sections of intestines of dogs that died of salmon poisoning showed a necrosis of the surface of the mucosa. This was present in all parts of the intestinal tract.

Sections of the kidneys, liver, lymph glands and lungs have been made in one(1) autopsy. They did not show any pathology except a mild cloudy swelling of some of the cells of these organs which might be expected in any animal that had experienced such a high body temperature.

The technic for preparing these sections was the usual method using formalin as a hardening fluid, paraffin to imbed the tissues and hematoxylin and eosin for stains.

Immunity and Susceptibility

Natural Immunity

No experimental evidence of natural immunity has been demonstrated. Four litters totaling 21 pups were raised and used in these studies. These were the only ones of the experimental dogs on which a definite history was available. Two of these litters, totaling 15 pups, were from an immune mother. All of these twenty-one(21) pups were susceptible. (Table VI).

Of the eighty-seven (87) dogs with unknown histories seventy-nine (79) proved to be susceptible. There was no evidence that sex, age, breed, physical condition, care, or rations affected susceptibility. The presence or absence of other intestinal parasites did not have any influence. Some of these dogs consistently refused to eat fish but they developed salmon poisoning after a forced feed on parasitized fish.

Acquired Immunity

A definite, permanent immunity was present in dogs that recovered. Of the one hundred (100) susceptible dogs, fifteen (15) were destroyed during the course of the disease while eighty-three (83) died and 2 sick dogs recovered. (Table VI). After their recovery parasitized fish, which caused salmon poisoning in susceptible check dogs, was

repeatedly eaten by these dogs with impunity. Fourteen (14) other immune dogs were used in these studies. The origin of the immunity in eight (8) of these was unknown. Six (6) of them were reported to have recovered from salmon poisoning.

Data on Immunity

Table VI

Group :		Total	Immune	% Immune	Susceptible	% Susceptible	Died	Destroyed during course of disease	Recovered	% Recovered
1	Dogs fed parasitized fish-History unknown	87	8	9.19	79	90.81	62	15	2	2.4
2	Dogs fed parasitized fish-Reported to have recovered from salmon poisoning	6	6	100	0	0	0	0	0	0
3	Dogs fed parasitized fish-Definite history, no salmon poisoning	21	0	0	21	100	21	0	0	0
	Totals	114	14	12.28	100	87.72	83	15	2	2.4

In addition to the 16 immune dogs listed in Table VI many dogs that inhabit the coast country and eat fish regularly were observed. The owners usually reported that such dogs had previously recovered from salmon poisoning. Rarely they reported that a dog had eaten these fish all its life but had never been affected.

The factors involved in the development of this immunity have not been explained. Sufficient data have been accumulated to demonstrate that it was an active, acquired, permanent immunity. Defibrinated blood of immune dog No. 35 was given to three (3) susceptible dogs, Nos. 53, 57, and 69, in an effort to transfer the immunity. The usual aseptic precautions were observed in collecting, defibrinating and injecting this blood. Phenol (0.5%) was added as a preservative and it was stored in a refrigerator at about 45° F. See Table VII. The blood serum was given dogs Nos. 53 and 69 before symptoms developed. It was given dog No. 57 after symptoms developed. In dogs No.s 57 and 69, death occurred at the usual time and in the same manner as if the blood serum had not been administered. Dog No. 53 developed a severe peritonitis and died 8 days after eating the fish but showed typical lesions of salmon poisoning.

Data on Immune Serum

Table VII

Dog No.	Date fed parasitized fish	Date Given Serum	Source of Serum	Interval	Amt. of serum given	Date of Death	Interval between eating fish and death	Cause of death
53	4-24-25	Norm. 4-29-26	Immune Dog No. 35	5 days	140 cc intraperitoneal	5-2-25	8 days	Salmon poisoning complicated with severe peritonitis
57	3-28-25	Sick t. 104 2 F 4-6-25	"	9 days	100 cc intramuscular	4-19-25	13 days	Salmon poisoning
69	4-28-25	Norm. 4-29-25	"	1 day	105 cc intraperitoneal	5-12-25	14 days	" "

Following the demonstration of a definite acquired immunity attempts were made to find a specific exciting etiologic factor of the disease.

Bacteriological Studies.

An attempt ot transmit the disease by transfusion of blood was negative. Dog No.90 was destroyed at the peak of a typical case of salmon poisoning when the temperature was 105.7° F. Eight (8) cc of fresh blood was collected and injected intraperitoneally into dog No. 91. Dog No. 91 remained normal and after sixteen (16) days was proven susceptible by feeding parasitized fish.

Attempts were made to isolate a bacterium from affected dogs with negative results. See Table VIII.

Bacteriological Studies

Table VIII

Autopsy Case No.	Kinds of media used	Tissues Cultured	Growth	Type of bacteria
43	Loeffler's blood serum	ileo-cecal lymph gland	0	None
69	Plain nutrient agar	ileo-cecal lymph gland	0	None
86	Plain nutrient agar	ileo-cecal lymph gland	+	Non-pathogenic
88	Plain nutrient agar	ileo-cecal lymph gland	0	None
90	Blood agar Loeffler's blood serum. Plain nutrient agar.	spleen, heart blood, liver pericardial fluid, ileo-cecal lymph gland	0	None
106	Blood agar glycerin agar nutrient agar	ileo-cecal lymph gland	0	None

Note: The organisms isolated from the purulent ileo-cecal lymph gland of dog No. 86 were injected subcutaneously into dog No. 96 with no symptoms resulting. No. 96 was later fed parasitized fish and succumbed with a positive diagnosis of salmon poisoning.

Toxin Studies

Attempts were made to demonstrate the presence of endotoxins or exotoxins originating in these mature flukes. See Table IX. Of the four (4) dogs which were given intraperitoneal injections of ground up mature flukes three died. The only dog which received a subcutaneous injection of this material lived. The results of experiments in which intestinal content was administered through a stomach tube were negative.

Toxin Studies

Table IX.

Dog No.	Material used	How administered	Results	Remarks
13	Washed flukes	Fed with meat	No symptoms	Later proven susceptible to salmon poisoning
58	100 cc of bloody intestinal content containing flukes	Thru stomach tube	" "	"
59	Washed ground up flukes	" " "	" "	"
105	4 cc of suspension of washed, ground up flukes in tap water.	Subcutaneous injection	" "	Later died after eating parasitized fish but no flukes or eggs were found on autopsy
111	7 cc of suspension of washed ground up flukes in tap water	Intraperitoneal injection	Death after 22 days	Had shown temperature 104.5° F. with marked febrile symptoms - No autopsy
106	4 cc of suspension of washed, ground up flukes in tap water	" "	No symptoms	Later proven susceptible to salmon poisoning

Table IX Continued

158	6 cc of suspension of washed ground up flukes in tap water	Intraperitoneal injection		Death after: 23 days	No autopsy
159	6 cc of suspension of washed ground up flukes in tap water	"	"	Death after 17 days	Autopsy showed marked enlargement of ileocecal lymph gland, a 6" intersusception of terminal part of small intestine. Slight hemorrhage of ileocecal valve mucosa. No other significant pathology.
Immune Check 132	6 cc of suspension of washed ground up flukes in tap water	"	"	No symptoms	This dog did not show any evidence of peritonitis and is still alive.

Anaphalaxis Studies

Ground up mature flukes were placed in the conjunctiva of the eye of an immune dog, No. 58, with negative results.

Dr. W. T. Johnson's (3) work with coccidiosis suggested that it might be possible to determine a minimum lethal number of parasites and then immunize dogs through repeated feeding of parasites in sublethal numbers. See Table X.

Minimum Infestation and Increasing Numbers of Fluke Cysts

Table X

Case Number	Date	Number of cysts given	Results	Date Given Lethal Number of cysts	Results	Remarks
102	2-4-26	1	No symptoms	3-27-26	Died after 14 days	Diagnosis of salmon poisoning
103	2-26-26	5	" "	3-27-26	" " 15	"
96	2-26-26	20	" "	3-27-26	" " 16	"
110	4-10-26	100	Died after 19 days			"
123	10-17-26	100	" " 17 "			"
124	10-17-26	100	" " 16 "			"
125	10-17-26	100	" " 15 "			"
128	12-2-26	50	No symptoms			
	12-29-26	50	" "			
	1-3-27	50	Died after 10 days			Diagnosis of salmon poisoning
112	4-15-26	100	No symptoms			
	5-3-26	300	" "	6-12-26	Died after 16 da.	"

Table X Continued

115	5-3-26	100	No symptoms			
	6-2-26	300	?	6-7-26 6-12-26	Died 6-21-26	Not known whether death due to 300 cysts or lethal dose
117	5-17-26	100	No symptoms			
	6-2-26	300	?	6-7-26 6-12-26	Died 6-18-26	"
119	5-17-26	100	No symptoms			
	6-2-26	300	?	6-7-26 6-12-26	Died 6-19-26	"
88	11-21-25	300	Died after 15 days			Diagnosis of salmon poisoning
114	4-26-26	100	No symptoms			
	5-3-26	100	" "			
	6-2-26	300	" "	6-7-26 6-12-26	Died 6-24-26	"
120	5-17-26	100	" "			
	7-26-26	300	" "			
	8-21-26	600	Died after 16 days			"

Table X Continued

118	5-17-26	100	No symptoms			
	6-12-26	300	" "			
	7-26-26	550	" "			
	8-21-26	1200	" "	10-17-26	No symptoms	
				12-2-26	" "	Destroyed 3-27-27. Immune, origin unknown
132	12-31-26	50	" "			
	1-3-27	50	" "			
	1-14-27	100	" "			Gave birth to 9 pups on 3-7-27
	5-16-27	100	" "			
	5-27-27	200	" "			
	6-6-27	200	" "			
	6-16-27	400	" "			
	6-24-27	400	" "			
	7-16-27	800	" "			
	8-7-27	800	" "	8-17-27	No symptoms	Immune, origin unknown
(7 dogs) 141-146 inclusive & 150						This group is known never to have eaten fish.
	5-17-27	25	" "			
	5-27-27	25	" "			
	6-6-27	50	" "			
	6-16-27	50	" "			
	6-24-27	100	" "			
	7-5-27	150	" "			

Table X Continued

7-16-27	200	No symptoms	
7-27-27	200	" "	
8-7-27	400	" "	
8-17-27	400	" " except in 150 which died after 14 days	Diagnosis of salmon poisoning
8-31-27	800	Died after 13 to 18 days	"

4 checks
147 - 148
149 - 151

Kept in kennels with Nos. 141-146 inclusive & 150

Nos. 147-148-151 died of fright disease. No. 149 was affected and recovered. This occurred late in August 1927

Eleven (11) susceptible dogs (Nos. 102, 103, 96, 128, 141 to 146 inclusive and 150) received initial doses of from one (1) to fifty (50) fluke cysts without developing symptoms of salmon poisoning. Of the ten (10) susceptible dogs receiving initial doses of one hundred (100) cysts four (4) (Nos. 110, 123, 124, and 125) died while six (6) (Nos. 112, 114, 115, 117, 119, and 120) failed to develop symptoms. Three (3) (Nos. 123, 124, and 125) of the four (4) that died were fed during the fall and one (1) (Nos. 110) during the spring. The six (6) that did not develop symptoms were fed during either spring or early summer. Only one (1) dog (No. 88) received an initial dose of three hundred (300) cysts. It died.

Seven (7) (Nos. 141 to 146 inclusive and No. 150) which received initial doses of twenty-five (25) cysts with increased numbers thereafter developed no symptoms until after four hundred (400) parasites were given. One (1) dog (No. 150) died after receiving this number of cysts while the other six (6) (Nos. 141-146 inclusive) died following the administration of eight hundred (800) cysts. All seven (7) of these dogs together with their four (4) checks (Nos. 147, 148, 149 and 151) suffered from fright disease a few days prior to their deaths. Checks No. 147, 148 and 151 died presumably from this

disease at the time that dogs No. 141 to 146 were dying presumably from salmon poisoning.

Control

No satisfactory method of controlling this disease has been found except to prevent susceptible dogs from eating parasitized fish. Some of the dog owners in the coast section make a practice of feeding fish to small puppies. In this way they raise only an occasional puppy but these are immune. A dog that has not had salmon poisoning is of very little value in these districts while one that is immune will have a relatively high monetary value, regardless of its breeding. No accurate data as to the number of puppies that will recover are available.

There have been numerous treatments recommended but none is universally used. A considerable number have been tried in these studies and found of no merit, at least under experimental conditions. See Table XI.

Medicinal Treatment Studies

Table XI

Dog No.	Date fed parasitized Fish	Date Symptoms appeared	Date Treated	Interval between eating fish & treat.	Interval between appear. of syms. & treat.	Date of Death	Interval between eating fish & death	Treatment given
				Miscellaneous Drugs				
17	1-27-25	2-2-25	2-4-25	8 days	2 days	2-9-25	13 days	12 cc fluid extract aspidium. 10 grams powdered arecanut in 1 oz. of honey. Animal vomited in 5 minutes
18	1-25-25	1-31-25	2-1-25	7 days	6 days	2-9-25	15 days	25 drops oleoresin of aspidium in castor oil
19	?	Temp. 105°F. 1-25-25	1-26-25	?	1 day	2-1-25	?	3 grams powdered arecanut - 10 drops oleoresin aspidum in milk. Part vomited. 4 oz. castor oil given 4 hours later
22	1-27-25	2-2-25	2-4-25	8 days	2 days	2-7-25	11 days	About 1/3 dose, same as #19. Animal escaped and died at home
89	11-21-25	11-29-25	11-29-25	8 days	none	12-7-25	16 days	1.5 grams neoarsphanamine intramuscularly

Table XI Continued

130	?	About 11-26-26	12-2-26	?	About 6 days	12-2-26	?	Developed abscess at point of injection. o.5 gram sulpharsphenamine intramuscularly
				Calomel				
58	4-15-25	4-24-25	4-25-25	10 days	1 day	recovered	-	2 grains calomel
			4-27-25					" " " 2 days later
66	4-24-25	5-4-25	5-5-25	11 days	1 day	5-8-25	14 days	2 grains calomel
			5-6-25					2 grains calomel 18 days later
67	4-28-25	5-9-25	5-9-25	11 days	none	5-15-25	17 days	2 grains calomel
			5-11-25					2 grains calomel 2 days later
59	4-24-25	5-4-25	5-4-25	10 days	none	5-12-25	18 days	2 grains calomel
			5-5-25					" " " 1 day later
				Carbon tetra chloride				
34	2-14-25	2-23-25	2-24-25	10 days	1 day	3-2-25	16 days	2.75 cc carbon tetrachloride in capsules 1 tbs. of epsom salts in water
41	2-19-25	2-26-25	2-26-25	7 days	None	3-2-25	11 days	3.5 cc carbon tetrachloride in capsules. 1 tbsp. Epsom salts in water 3 hrs.later

Table XI Continued

42	2-19-25	2-27-25	2-27-25	8 days	None	3-5-25	14 days	5.5 cc carbon tetrachloride in capsules. 1 tbsp. of Epsom salts in water 4 hours later
45	2-12-25	2-19-25	2-20-25	8 days	1 day	2-28-25	16 days	4 cc carbon tetrachloride 1 tbsp. Epsom salts in water 3 hrs.later
51	3-5-25	3-12-25	3-11-25	6 days	1 day before	3-19-25	14 days	3 cc carbon tetrachloride in capsule. 1 tbsp. of Epsom salts in water
60	4-5-25	4-12-25	4-6-25	1 day	6 days before	4-18-25	13 days	3 cc carbon tetrachloride and 1 tbsp. Epsom salts 5 hrs. later
127	12-2-26	12-11-26	12-2-26	1 day	8 days before	12-18-26	16 days	1 cc carbon tetrachloride in soft gelatin capsules
			12-2-26					"
			12-4-26					"
			12-5-26					"
			12-6-26					"
			12-7-26					"
			12-9-26					"

Table XI Continued

131	12-29-26	1-5-27	12-30-26	1 day	6 days before	Recovered		1 cc carbon tetrachloride in soft gelatin capsules, twice each day
			12-31-26					"
			1-1-27					"
			1-2-27					"
			1-3-27					"
			1-4-27					"
			1-5-27					"
133	1-14-27	1-23-27	1-15-27	1 day	8 days before	1-28-27	14 days	1 cc carbon tetrachloride in soft gelatin capsule, three times per day
			1-16-27					"
			1-17-27					"
			1-18-27					"
			1-19-27					"
			1-20-27					"
			1-21-27					"
			1-22-27					"
The following 3 dogs were treated by practicing veterinarians.								
76	?	5-29-26	6-3-26	?	5 days	6-14-26	?	3 doses of dog distemper serum, later salol and bismuth subintrate in paraffin oil. Enemas were given every 2 days. Forced feed for about a week before death.

Table XI Continued

78	5-31-25	6-8-25	6-15-25	15 days	7 days	6-18-25	18 days	Castor oil, paraffin oil, and ether every 4 hours
			6-16-25					Same treatment
80	?	6-3-25	6-3-25	?	None	6-12-25	?	One oz.castor oil.
			6-4-25					2 grains calomel & 5 cc botulinus antitoxin
			6-5-25					5 cc botulinus antitoxin and potassium permanganate stomach lavage, ate raw beef
			6-6-25					2 raw eggs and predigested beef extract night and morning
			6-7-25					One ounce milk of bismuth, 4 times per day
			6-8-25					"
			6-9-25					"
			6-10-25					"
			6-11-25					"
			6-12-25					Same treatment in morning. Died during night

Only two (2) dogs recovered out of twenty-two (22) that were treated. One (1) out of four (4) treated with calomel recovered and one (1) out of eight (8) treated with carbon tetrachloride recovered.

Dr. Thomas D. Wyatt M. D. (4) working in the department of Pharmacology of the University of Oregon Medical School, studied a disease of dogs which he called salmon poisoning. This work was done in 1924 and 1925. A report of his studies is contained in his thesis which is on file at the library of the University of Oregon, Medical School, Portland, Oregon. This thesis was reviewed. His description of the disease does not in any way coincide with the observations recorded in these studies. It would seem that he must have been studying an entirely separate disease from that reported here. He produced an extract of salmon which he claimed would immunize any and all dogs to salmon poisoning. His product was tried in these studies through the courtesy of Dr. J. N. Shaw, to whom it was supplied by Dr. Wyatt. The results of this experiment follow:

Experiment with Dr. Thomas D. Wyatt's Immunizing Material Against Salmon Poisoning in Dogs.

July 31, 1925 -	Immunizing material received from Dr. Wyatt and stored at room temperature until used.
Sept. 8, 1925 -	Dog No. 86 received one cc. of Dr. Whatt's material. Injection made under the skin of the abdomen using a sterile syringe and applying tincture of iodine as a skin antiseptic at the point of injection.
Sept. 22,1925 -	Dog No. 86 received 2 cc. of Dr. Wyatt's material, injected in the same manner, used in previous injection.
Nov. 11, 12 & 13	Feces from dog 86 examined for fluke eggs with negative results. Technique consisted of crushing feces in water, filtering thru coarse cheesecloth, centrifuging and examining sediment with microscope.
Nov.14, 1925 -	Dog No. 86 fed large amount of "sore-back" male dog salmon or chum. This fish was obtained from Wilson River, Tillamook County, Oregon. Numerous living cystic flukes were demonstrated in the kidneys, gills, and muscular tissue of this fish.
Nov. 19, 1925 -	5 P. M. Dog No. 86 Temp. 103.4° F. Appetite good. Dog playful and not noticeably abnormal. Microscopic examination of feces for fluke eggs negative.
Nov. 20, 1925 -	10 A. M. Dog No. 86 Temp. 105.1° F. Complete anorexia. Slightly drowsy. Fluke eggs fairly numerous in smear of feces that clung to thermometer. 4 P. M. Temp. 105.6 F.

Nov. 21, 1925 - 10 A. M. Temp. 105.6° F. Depression marked.

Nov. 22, 1925 - 10 A. M. Temp. 104.2° F. Depression more marked. Animal very drowsy.

Nov. 23, 1925 - 8:30 A. M. Temp. 103.6° F. Complete anorexia continues. Animal becoming weaker.

Nov. 24, 1925 - 10 A. M. Temp. 103° F. Slight purulent conjunctivitis.

Nov. 25, 1925 - 10 A. M. Temp. 101.6° F. Animal just able to stand.

Nov. 26, 1925 - 10 A. M. Temp. 100.4° F. Animal extremely weak. Vomiting. Complete anorexia since Nov. 20

Nov. 27, 1925 - 10 A. M. Temp. 99.8° F. Too weak to stand.

Nov. 28, 1925 - 8 A. M. Dog No. 86 found dead in kennel.

8:30 Autopsy Dog No. 86

Gross Pathology: Hemorrhagic inflammation of mucosa of entire intestinal tube, inflammation most severe in ileum, myriads of living mature flukes identical with those previously described as causing so-called salmon poisoning in dogs and foxes present throughout the lumen of the intestines, fluke eggs innumerable in intestinal contents, ileo-cecal lymph gland markedly enlarged and containing pus, cervical lymph glands slightly enlarged, no gross pathological lesions observed in the lungs, liver, kidneys, or other organs of the body.

Conclusions: - Injection of Dr. Wyatt's immunizing material according to his directions did not protect this dog against salmon poisoning.

Salmon Poisoning in Animals Other Than the Dog.

As stated before, this disease has been produced experimentally in coyotes (Canis lestes). The results of this experiment were published in the Journal of the American Veterinary Medical Association (5). A copy of this report follows:

COYOTE SUSCEPTIBLE TO SALMON POISONING

By C. R. Donham and B. T. Simms
Department of Veterinary Medicine
Oregon Agricultural Experiment Station
Corvallis, Oregon

In a previous report[1] it was suggested that coyotes might be susceptible to the so-called salmon poisoning. People living in the sections of western Oregon where this disease is most prevalent have believed this to be true. Cram[2] has reported finding the fluke (Nanophyes salmincola Chapin) which caused this trouble, in the intestines of an apparently healthy coyote trapped in western Washington. She suggests the possibility of the coyote being a natural host of this fluke. It seems probable that there is some other host than the dog, as it is difficult to believe that in few dogs living along the infested streams could contaminate them sufficiently to cause the large number of flukes which are present in practically every salmon or trout taken from these streams.

Studies with coyotes (Canis lestes) have been made as follows: Two coyotes (1 and 2) were received from R. R. Spalding, one of the predatory-animal hunters of the U. S. Biological Survey, on March 21, 1926. On March 27, a large amount of trout containing living cystic flukes were placed in the cage with these coyotes. It had been eaten by the following morning.

Ten days later coyote 1 was apparently sick. Temperatures were not taken. On April 10, fourteen days after the fish was eaten, this coyote was found dead in the cage.

Autopsy revealed typical lesions of salmon poisoning. Large numbers of both mature flukes and fluke eggs were present in the bowel content. Microscopic examination showed flukes buried in the mucosa of the duodenum. Coyote 2 was fed fish containing living cystic flukes five times, as follows: April 10, April 26, May 3, May 17 and May 18. This animal did not at any time show any definite symptoms. It was destroyed May 22, four days after it had eaten parasitized fish the last time.

On autopsy, a marked hemorrhagic inflammation of the entire intestinal mucosa was found. There was also present a diphtheritic membrane on the mucosa of the duodenum and jejunum, but there was no free blood in the intestinal content, as is usually present in dogs dying

from salmon poisoning. Flukes were very numerous throughout the entire intestine. These parasites were approximately the size of mature flukes, but contained only one or two eggs each. Their movements were more active than those of mature ova-producing flukes.

Two coyote pups (3 and 4), estimated at six to eight weeks of age, were received from Mr. Spalding April 21, 1926. The pups were about the same size, but one (No. 3) was the more agressive and habitually drove the other away when food was placed in the cage. Fish containing living cysts was placed in their cage, April 26 and May 3.

On May 8, twelve days after the first fish was fed, coyote 3 was dead. Autopsy showed severe inflammation of the intestine with free blood in the bowel. Numerous mature flukes containing ova, numerous immature, very active flukes, and large numbers of ova were present in the intestinal content.

On May 17, fourteen days after the second fish was fed, coyote 4 was dead. Typical lesions of salmon poisoning, i.e., severe hemorrhagic inflammation of the intestinal mucosa with free blood, numerous mature flukes and numerous fluke eggs in the bowel content, were found on autopsy.

Received for publication, December 29, 1926.

Discussion

The habits of the coyotes made it impossible to observe symptoms until the later stages of the disease. It is probable that coyote 2 suffered from salmon poisoning and recovered, as the lesions found were quite similar to those observed in dogs which have recovered from attacks of the disease. The active movements of, and the absence of eggs, in the flukes found in this coyote indicated that they were developing from the cysts which were eaten four or five days before the animal was destroyed.

Coyote 3 probably contained flukes from both feedings of parasitized fish, one eaten twelve days before death and one five days before death.

Coyote 4 died fourteen days after fish was placed in the cage the second time. It is probable that it did not have an opportunity to eat any of the first fish placed in the cage.

Conclusions

The coyote (Canis lestes), as well as the dog, the blue and the silver black fox, is susceptible to salmon poisoning.

It develops lesions typical of those found in dogs suffering from salmon poisoning.

References

Donham, C. R., Simms, B. T., & Miller, F. W.; So-Called salmon poisoning in dogs. Jour. A. V. M. A., lxciii (1926), n.s. 21 (6), pp. 701-715.

Cram, E. B.; Wild carnivores as hosts of the trematode previously found in dogs as the result of salmon poisoning. No. Amer. Vet., vii (1926), 7, pp. 42-43.

Foxes have developed symptoms, similar to those described above in dogs, after eating parasitized salmon. The course and the time of death were also similar to salmon poisoning in dogs. See Table XII.

Summary of Foxes

Table XII

Group	No. of foxes	History of eating fish recently	Number of Deaths	Autopsy diagnosis of salmon poisoning	Diagnosed by
1	2	+	2	2	Dr. T. B. Carter, D.V.M., Portland, Oregon
II	6	+	6	1	Home laboratory
III	1	+	1	1	" "

In Group 1 two (2) foxes succumbed. These were autopsied by Dr. Thos. B. Carter of Portland, Oregon, who reported that he found numerous flukes and fluke eggs which, in his opinion, were identical with those he had observed in the laboratory of the Department of Veterinary Medicine in dogs that died of salmon poisoning. A check with the company that sold the fish eaten by Group II indicated that this fish was taken from fresh water. One fox in Group II and those in Group III were autopsied and diagnosed as salmon poisoning in this laboratory.

Part III

DESCRIPTION AND LIFE CYCLE OF PARASITE

Mature Fluke

The mature fluke, which is found in the intestines of affected animals, is a distomum, approximately 500 microns in length, and oval in outline. It is hermaphorditic so each parasite produces eggs. Figure 1 is a microphotograph of the mature fluke. A quantity of these organisms were sent to the Zoological division of the Bureau of Animal Industry for identification and study. Dr. Edward A. Chapin (5) identified this fluke as a new genus of trematode and named it *Nanophyes salmincola*. He gives the generic diagnosis as heterophyidae. There may be other animals than dogs, foxes and coyotes which act as the natural hosts of the mature parasites. Attempts to find another host of the mature fluke included examinations of the following animals with negative results. It is not known that all of the animals mentioned here had eaten fish recently before examination of their intestinal tracts was made, but all the wild animals originated in districts in which parasitized fish were very numerous.

Number	Animal	Origin
1	Douglas Pine Squirrel (*Sciurus douglassii*)	Eddyville, Ore.
2	Western robins (*Planesticus migratorius propinquus*)	" "

3	Western crows (Corous-brachy-rhynchos-hesperis)	Eddyville, Ore.
1	California skunk (Mephitis occidentalis)	" "
1	Wild cat (Lynx fasciatus pallescens)	" "
1	Northwest Belted Kingfisher (Ceryle alcyou caurina)	" "
1	Northwest coast Heron (Ardea-herodias-fannini)	" "
2	Chickens (mature) (Fed para-sitized fish)	Corvallis, Ore.
1	Duck (domesticated) (Fed para-sitized fish)	" "
3	Water dogs (salamander) (Notophthalmus torosus)	Oak Ridge, Ore.
1	Mussel	" " "
1	Otter	Beaver, Ore.

Cysts began development in the following animals, but did not reach maturity.

Number	Animal	Origin
4	Cats (fed) parasitized fish	Corvallis, Ore.
1	Pacific Mink (Mustela vision energumenos)	Eddyville, Ore.
1	Western Raccoon (Proeyon-psora-pacifica)	" "
1	Northwest Belter Kingfisher (Ceryle alcyou caurina)	Oak Ridge, Ore.

Eggs which were apparently those of Nanophyes salmincola were present in the intestinal tract of one Pacific mink in which no flukes were found.

E. B. Cram (7) found specimens of Nanophyes salmincola Chapin in the small intestines of three wild animals, a coyote (Canis lestes), a raccoon (Procyon psora pacifica) and lynx, (Lynx fasciatus). All of these animals had been captured near Olympia, Washington.

Numerous experiments have been conducted in attempts to develop a satisfactory method of preserving and mounting these mature flukes. Various materials and preservatives were tried, all with very unsatisfactory results. Dr. Stanley B. Freeborn, Asso. Prof. of Entomology, University of California, succeeded in preserving them. His formula and instructions follow:

"Place the specimens directly in Carnoy-phenol which consists of:

Absolute alcohol	20 cc
Chloroform	15 cc
Glacial acetic acid	5 cc
Phenol crystals to raise volume by	10 cc

Watch them and when they get almost clear enough, take off most of the Carnoy-phenol and, tipping them into a lower edge of the watch glass, add pure glycerine drop by drop to the upper portion so that it will gradually run down and diffuse with the clearing agent. They can then be set aside and mounted at leisure in glycerine jelly

in ringed slides."

Eggs and Miracidia

The eggs of Nanophyes salmincola are a brownish yellow color when washed and are oval in shape, the greatest diameter being about 75 microns. See Figure III. All attempts to hatch these eggs failed. Consequently miracidia were not observed. Table XIII gives the results of these experiments.

Attempts to Hatch Fluke Eggs
Table XIII

Date	Medium	Container	Temperature	Date of examination	Results
1-30-25	Tap water	Corked glass bottle	About 70° F. Room	2-3-25	Negative
				2-7-25	"
				2-20-25	"
				2-23-25	"
				3-13-25	"
1-30-25	Tap water	Sealed glass tubes	37° C.	2-7-25	"
				2-23-25	"
				3-13-25	"
				11-20-25	"
1-30-25	0.85% salt solution	Corked glass bottle	About 70° F. Room	2-3-25	"
				2-7-25	"
				2-20-25	"
				2-23-25	"
				3-13-25	"
1-30-25	"	Sealed glass tubes	37° C.	2-7-25	"
				2-23-25	"
				3-13-25	"
				11-20-25	"
1-30-25	Tap water	Corked glass bottle	Atmospheric	2-20-25	"
				2-23-25	"
				3-13-25	"
				4-10-25	"

Table XIII Continued

1-30-25	0.85% salt solution	Corked glass bottle	Atmospheric	2-20-25	Negative
				2-23-25	"
				3-13-25	"
				4-10-25	"
6-18-26	Water from Oak Creek near Corvallis	"	18° C.	6-21-26	Clear round globules forming in the eggs.
				7-7-26	No further change.
				8-12-26	Some of these eggs were clear and had their opercula displaced as if an embryo had been liberated. No embryos were found. Some normal unaltered eggs were seen.
6-18-26	Water from Oak Creek	Berkfield filter	Submerged in Oak Creek near Corvallis	6-21-26	Negative
				7-1-26	"
				7-8-26	Negative. Eggs seemed to be less numerous
5-4-27	Washed tap water	Corked glass bottle	Room	5-13-27	Negative
				5-17-27	"
				5-23-27	Some change resembling segmentation

Table XIII Continued

	5-25-27	Eggs looked about ready to hatch
	5-31-27	Eggs looked clear on one side and dark on other
	6-9-27	No change
	6-10-27	" "
	6-13-27	" "
	6-20-27	" "

Goniobasis plicifera var silicula (Gould) the first intermediate host.

Since the majority of flukes whose life cycles are known pass a part of these cycles in snails, attempts were made to determine whether some snail acted as the intermediate host of the salmon poisoning fluke. Of the eighteen (18) species of fresh water snails of Oregon collected and identified* only one Goniobasis plicifera var silicula (Gould) was present in considerable numbers in almost every western Oregon stream. Therefore, this species was the first one considered.

The distribution of this species as determined by an incomplete survey seemed identical with the distribution of salmon poisoning. With the exception of one stream, specimens were numerous in all the creeks and streams examined on the Siuslaw, Alsea, Yaquina, and Tillamook water sheds on the western slope of the Coast Range Mountains of western Oregon. Streams of the Willamette water shed from both the Coast Range (west side) and Cascades (east side)

* Identifications were by Mr. A. W. Hanham, Duncan B. C. Canada, Mrs. I. S. Oldroyd, Stanford University, Palo Alto, California, Dr. J. R. C. B. Tomlin, British National Museum, London, Dr. H. A. Pilsbry, Philadelphia Academy of Natural Sciences, and Drs. Paul Bartsch and Marshall, U. S. National Museum, Washington, D. C.

contained large numbers of these snails. In the upper parts of some of the Cascade streams where the water was quite cold these snails were either absent or present in only small numbers. But farther down these streams the snails were numerous.

Surveys were not made in either southwestern Oregon or northwestern California. In western Washington these snails were found as far north as Olympia. They were not found in western Washington streams north of Olympia nor were they found in western British Columbia. They were not found east of the Cascade Mountains in either Oregon or Washington.

Three different cercaria were found in this species of snail. One, a furciferous or forked tailed type, was seen only twice and was not considered seriously as being a form of the salmon poisoning fluke. Any eyes cercaria was found in this species quite frequently but its distribution did not seem closely correlated with parasitism in fish. The third type, a cercaria without eye spots, was present in snails from nearly every stream examined in western Oregon.

The sporocyst form of this parasite was not identified. Mother redia, daughter redia, and cercaria were studied.

Mature mother redia, filled with daughter redia, were 530 by 160 microns. Movement of these mature forms was very sluggish. It was difficult to estimate the number of daughter redia because of the opacity of the mother form.

Daughter redia were distomatous, quite active in the immature stage, but very sluggish when filled with cercaria. Sizes varied from 160 by 80 microns in those not containing cercaria to 325 to 160 microns in those filled with cercaria. From three (3) to twelve (12) cercaria were found in ripe daughter redia.

Cercaria were of the following average dimensions:

Body - extended 192 by 16 microns.	Contracted-88 by 85 m.	
Tail - " 100 by 10 microns.	" 55 by 23 microns.	

Swarming of these cercaria was never observed. Specimens obtained by crushing parasitized snails lost their tails and encysted in from thirty (30) minutes to two hours. Such cysts were on either the bottom or the sides of the glass containers in which the cercaria were observed. Encysted cercaria were never found on grass or leaves placed in these containers.

There was apparently a seasonal variation in the occurrence of these parasites in snails. Specimens collected from Oak Creek about one mile west of Corvallis

during the early spring months were either not infested or only slightly infested. More than 50% of the specimens collected during June and July were parasitized. In August the percentage of infested snails was decreasing and parasites were not found in snails examined from this creek during the late fall months.

It was apparently true too that there was a seasonal variation in the number of parasites in fish. Chinook salmon which had only recently come into fresh water were taken from some of the coast streams during both fall and spring months. The fall run fish were usually the more heavily parasitized. Fall run steel head trout, which come later than the fall run of Chinook salmon, were not as heavily parasitized as were the salmon. February and March run of steel head trout were only slightly parasitized.

The distribution of parasitized fish in the open streams was apparently identical with both the distribution of the snail G. plicifera var silicula and the occurrence of salmon poisoning in dogs. (Table XIV)

Distribution of Parasitized Fish

Genera Salmo, Salvelinus and Onchorynchus

Table XIV

Group	Date Obtained	Species of fish	No. of fish	Origin of Fish	Goniobasis plicifera var silicula found on water shed	Snails parasitized.
1	1-10-25	Jack salmon	2	Yaquina River Trib. Eddyville, Ore.	Yes	Yes
2	1-10-25	Steel-head salmon	1	" "	"	"
3	1-10-25	Silverside salmon	21	" "	"	"
4	1-10-25	Chinook salmon	1	" "	"	"
5	2-3-25	Cutthroat trout	4	? ?	"	"
6	3-16-25	Trout	5	Yaquina River Trib. Eddyville, Ore.	"	"
7	3-17-25	Cutthroat trout	2	Tillamook Co., Ore.	"	"
8	3-17-25	Steel-head salmon	6	Nestucca River, Tillamook Co.	"	"
9	3-30-25	Cutthroat trout	1	Tillamook Co., Ore.	"	"
10	4-6-25	" "	2	Gold Creek, Ore.	"	"
11	4-6-25	" "	1	Tillamook Co., Ore.	"	"
12	4-6-25	Speckled Mt. Trout	2	Muddycreek, Bellefountain, Ore.	"	"
13	4-24-25	Trout	10	Alsea R. near mouth Walport, Ore.	"	"
14	4-27-25	Trout	14	?	"	"
15	4-27-25	Speckled Mt. Trout	1	Lake Creek (Siuslaw River), Ore.	"	"
16	4-27-25	Cutthroat trout	2	" " "	"	"
17	5-4-25	Trout	20	Triangle Lake-Lane Co. Oregon	"	"

Table XIV Continued

18	5-29-25	Cutthroat trout	1	Kilchis R. Tillamook Co.	"	"
19	6-23-25	Speckled Mt. Trout	6	Tributary of McKenzie River near McKenzie Bridge, Ore.	"	"
20	7-3-25	Chinook salmon	1	Siuslaw R. Tiernan,Ore.	"	"
21	7-9-25	Speckled Mt. trout	1	Willamette R. Corvallis	"	"
22	7-11-25	" " "	1	Alsea River, Alsea,Ore.	"	"
23	7-11-25	Chinook salmon	1	Nestucca R. Tillamook Co.	"	"
24	7-14-25	Salmon minnows	5	Yaquina R.Eddyville, Ore.	"	"
25	7-14-25	Speckled Mt. trout	10	" " " "	"	"
26	9-8-25	Salmon	1	Klamath R. near Eureka Cal.	Not Examined	Not Examined
27	9-12-25	Chinook Salmon	1	Tillamook Co., Ore.	Yes	Yes
28	11-7-25	Salmon	1	" " "	"	"
29	11-14-25	"	2	" " " Wilson River	"	"
30	11-14-25	"	1	Eddyville, Ore.	"	"
31	12-12-25	"	14	" "	"	"
32	12-14-25	"	1	Tillamook Co., Ore.	"	"
33	12-14-25	Jack salmon	1	" " "	"	"
34	3-26-26	Small trout & salmon fry	53	Yaquina R. Eddyville	"	"
35	4-10-26	Small trout	2	Tillamook Co. Ore.	"	"
36	4-15-26	Trout	12	" " "	"	"
37	5-2-26	Trout & salmon fry	20	Big Creek-Yachats, Ore.	"	Not Examined
38	5-17-26	Trout	12	" " " "	"	"
39	5-17-26	Steel-head salmon	1	Ten Mile " " " (20 yds. from ocean)	"	"
40	6-2-26	Trout	3	Willamette R. Corvallis	"	

Table XIV Continued

41	11-28-26	Salmon	2	Columbia R. Portland, Ore.	Yes	Yes
42	5-5-27	Trout	1	Trask River, Tillamook County, Oregon	"	"
43	5-16-27	Young salmon	1	Fall Creek-16 miles S.E. of Eugene, Oregon	"	"
44	5-29-27	Cutthroat trout	3	Oakcreek-Corvallis, Ore.	"	"
45	7-15-27	Cutthroat trout	1	Big Elk Creek, Elk City, Oregon	"	"
46	7-26-27	Chinook salmon	1	Santiam R. Detroit, Ore.	"	"

Salmon and trout originating in streams in which snails of this species were not found and in regions in which salmon poisoning had not been reported were not found to be parasitized. (Table XV.)

Fish Not Parasitized

Genera Salmo, Salvelinus and Onchorynchus.

Table XV.

Group	Species of Fish	Date Obtained	No. of fish	Origin	Goniobasis plicifera variety silicula found on water shed	Snails parasitized
1	Redside trout	7-3-25	14	Enterprise, Ore.	No exam.	
2	Eastern Brook T.	6-29-25	1	East Lake, South of Bend, Oregon	" "	
3	" " "	7-6-25	2	Linton Lake, McKenzie Pass, Ore.	" "	
4	Redside trout	6-23-25	2	Horse Creek, McKenzie River, Ore.	" "	
5	" "	6-23-25	1	McKenzie R. near McKenzie Bridge	" "	
6	Cutthroat trout	3-17-25	1	Cultus Creek, B.C. Canada	" "	
7	Salmon	2-26-25	1	Probably salt water Newport Ice & Fish Co.,Newport, Ore.	" "	
8	"	6-22-25	8	Astoria-probably salt water.	" "	
9	Chinook salmon	7-8-25	1	Skagit R. Wn.	No snails found	
10	Cutthroat trout	6-29-27	2	Upper Nicomickel Creek, B.C.Canada.	" " "	

Table XV Continued

11	Cutthroat trout	6-29-27	2	Campbell River B. C. Canada	No snails found	
12	" "	6-29-27	2	Salmon River-Fraser River,B.C. Canada	"	
13	" "	6-29-27	2	West Creek-Fraser River,B.C. Canada	"	
14	Salmon	5-3-27	12	Columbia R. The Dalles, Oregon	Snails found	Yes
15	Silverside salmon	11-30-26	2	Columbia R. Rainier, Oregon	"	"
16	Rainbow trout	7-19-26	2	Diamond Lake (land-locked) Ore.	No exam.	
17	Trout	6-14-26	75	Lake near Eddyville, Oregon	" "	
18	Salmon	7-18-25	3	Whiz Fish Co. Alaska	" "	
19	Steel-head trout	2-2-28	1	Pine Creek, Half-way, Oregon	" "	

All the native Pacific Coast trout and salmon are anadromous when not land-locked. This being true, it was impossible to determine where fish that were caught in the open streams had become parasitized. Fortunately, both the Fish Commission and the Game Commission of Oregon maintain hatcheries in which trout and salmon are kept confined in ponds from the time of hatching. Nine (9) hatcheries were visited, thirteen (13) trips being made, in studies of correlation between snails and parasitized fish.

The number of cystic flukes (metacercaria) in the fish of these hatcheries was always found to be in direct proportion to the number of snails found infested with the cercaria described above.

The Gold Creek Hatchery in Tillamook County (State Fish Commission) was visited three times. On the first visit May 29, 1925, the examination of sixty-four (64) salmon and trout varying in age from one day to one year failed to reveal the presence of any cystic flukes. At the time of the second visit May 5, 1927, several young salmon were examined with negative results. On the third visit August 17, 1927, about two hundred young Chinook salmon were brought to the laboratory and kept in a tank. More than twenty (20) of these fish were examined for cystic flukes with negative results. On the second

and third trips rather extensive examinations for snails in Gold Creek, the stream supplying the hatchery pounds, were made. No specimens of G. plicifera var silicula were found.

The Bonneville Hatchery (State Game Commission) in Multnomah County was visited August 29, 1927 and several fish were examined for cystic flukes with negative results. No snails of the Goniobasis genus were found in either the ponds or the stream supplying these ponds.

At the Crooked Creek Hatchery (State Game Commission) in Klamath County five (5) eastern brook trout were examined on August 19, 1927. Neither were cystic flukes found in any of the fish nor were Goniobasis plicifera var silicula found in the ponds or streams supplying these ponds with water.

At the Roaring River Hatchery (State Game Commission) in Linn County a small number of snails was present in the stream supplying the ponds at the time of the first visit July 18, 1926. Seven (7) out of twenty-four (24) young cutthroat and eastern brook trout examined were found to be slightly parasitized. A second trip to this hatchery July 9, 1927 resulted in finding only two (2) cystic flukes in the five (5) eastern brook trout examined. Very few snails were present in the stream supplying water to the ponds. Less than 20 percent of the snails examined were

found to be parasitized.

The Oak Park Trout Farm in Lincoln County (privately owned) was visited September 8, 1926. A single encysted fluke was found in the one (1) cutthroat trout examined. No snails of any kind could be found in the ponds but Goniobasis were found in small numbers in the stream supplying the ponds. These snails were not examined for redia and cercaria.

The Santiam Hatchery (State Fish Commission) in Marion County was visited June 5, 1927. Its water was obtained from two sources, viz. Santiam River and Stout Creek. No snails of the genus Goniobasis were found in either the Santiam River or the flume carrying water from this river to the ponds. Four (4) young Chinook salmon which were taken from a pond supplied with water from the Santiam River only were examined for parasites with negative results. Snails (G. plicifera var silicula) were fairly numerous in Stout Creek. Three (3) of the five (5) snails examined contained mother and daughter redia as described above. Four (4) young Chinook salmon taken from a pond supplied with both Stout Creek and Santiam River water were all found to be slightly parasitized.

At the Siuslaw Hatchery (State Fish Commission) which was visited May 29, 1927, snails were found in large numbers in Middle Creek, the stream supplying the ponds. More than 50% of the mature snails examined were infested with the redia and cercaria described above. So far as could be determined no other types of redia and cercaria were present in these snails.

More than a dozen young silverside and Chinook salmon (four (4) and five (5) months old respectively) were examined and parasites were found in every one. While complete examinations were not made of each fish it was estimated that the average number of encysted flukes in each fish was more than twenty-five (25). Since there were one and a half million (1,500,000) young fish in these ponds it was believed there were more than thirty-five million (35,000,000) parasites in this group of fish.

A few sick fish were observed at this hatchery. An examination of these did not reveal any larger number of parasites than were found in the healthy fish.

The Willamette Hatchery (State Game Commission) in Lane County was visited twice. At the time of the first visit July 25, 1926 large numbers of G. plicifera var silicula were observed both in the ponds in which the young fish were kept and in Salmon Creek, the stream

supplying the ponds. More than 80 percent of the mature snails examined harbored redia and cercaria. Both the eyed cercaria, mentioned above, and the cercaria described above as having no eye spots were present. The latter were the more numerous.

More than two dozen young eastern brook and rainbow trout were examined and every one was heavily parasitized. Cystic flukes were found in gills, kidney and muscle. Examinations of entire fish were not made but from the portions examined it was estimated there were more than one hundred (100) parasites in each fish.

The young fish at this hatchery were dying very rapidly. The sick and the dead ones studied were not more heavily parasitized than were those which were not sick. All the mature rainbow trout in the ponds here were apparently in good health. One of these was studied and it proved to be heavily parasitized.

The second visit to this hatchery was made June 19, 1927. Snails were not nearly so prevalent in the ponds as they had been the previous year but it was not difficult to find specimens. Only a few snails were examined. They were found to contain daughter redia and cercaria of the type above described.

Only one of the five young trout examined was found to be parasitized.

The superintendent stated that the ponds had been thoroughly cleaned and heavily limed after the 1926 hatched fish were liberated.

A very short visit was made to the Willamette Hatchery of the State Fish Commission on June 19, 1927. It is immediately adjacent to the State Game Commission Hatchery of the same name. Both hatcheries obtain their water from Salmon Creek. The ponds of this hatchery had not been cleaned and limed and snails were very numerous in them. Snails from these ponds were not examined. Young salmon from these ponds were parasitized.

Table XVI Hatchery Studies

Name and location of Hatchery	Time of Visit	Number and types of fish examined	Cystic flukes in fish	Goniobasis plicifera var silicula in streams or ponds	Snails parasitized
Gold Creek (Fish Commission) Tillamook County	5-29-25	64 salmon & trout	none found		
	5-5-27	Several Salmon	"	none found	
	8-17-27	20 Chinook salmon	"	" "	
Bonneville (Game Commission) Multnomah County	8-29-27	Several Eastern Brook T. " Cutthroat Trout " Chinook salmon	"	" "	
Crooked Creek (Game Commission) Klamath County	8-19-27	5 Eastern Brook Trout	"	" "	
Oak Park Trout Farm (Privately owned) Lincoln County	9-8-26	1 cutthroat	one cyst	None in pond. Few in stream.	None found
Roaring River (Game Commission) Linn County	7-18-26	24 cutthroat and eastern brook T.	cysts in 7	None in ponds. Few in stream	
	7-9-27	5 eastern brook trout	cysts in 2	None in ponds. Few in stream	Slightly
Santiam (Fish Commission) Marion County	6-5-27	4 Chinook salmon	none found	None in ponds. None in streams	
		" " "	All slightly parasitized	None in pond. Fairly numerous in stream	60 percent parasitized

Table XVI Continued.

Siuslaw (Fish Commission) Lane County	5-29-27	Several Silverside Salmon. Several Chinook Salmon	All parasitized (25 or more cysts per fish)	Numerous in both ponds and stream	50 percent parasitized
Willamette (Game	7-25-26	Many Eastern Brook Trout. Many Rainbow T.	All heavily parasitized	Very numerous in both ponds and stream	80 percent parasitized
	6-19-27	5 Rainbow T.	1 para-	Few snails in ponds. Numerous in stream	Parasitized
Willamette (Fish Commission) Lane County	6-19-27	Several Chinook Salmon	All parasitized	Many snails in ponds and stream	

Experimental Infestation of Fish with Metacercaria.

The following studies were made to determine whether fish under controlled conditions would become parasitized when exposed to parasitized snails.

Four months old eastern brook trout about three (3) inches in length were obtained from the Roaring River Hatchery of the State Game Commission on July 9, 1927. The kidneys of five (5) of these fish were examined and two (2) were found to be parasitized. They were divided into two (2) approximately equal groups, each of which was placed in a galvanized iron tank. These tanks received continuous supply of water from the Corvallis city mains. The temperature in these tanks was recorded twice daily. It varied from a minimum of 59° F the morning of July 12th to a maximum of 72° F the morning of August 15. The temperature did not exceed 67° F at any other time.

These fish were fed ground liver twice daily. Several fish died during the first day. By the third day losses had stopped and there were about one hundred (100) fish remaining in each tank.

On July 12, 1927 a large number of snails were obtained from Oak Creek about one mile west of Corvallis and placed in tank No. 1. Examinations of some of these snails were made and about 40 percent were found to be

parasitized. On July 25 snails from Alsea River about three miles east of Tidewater which showed about 60 percent infestation were placed in this tank. Again on August 1, snails which showed about 80 percent infestation and which were obtained from Mary's River were placed in the tank.

No snails were placed in tank No. 2 and the fish in it were held as a control group. The fish in both tanks grew well and never showed any appreciable difference in size, general appearance, or activity. They were kept for a six months' period or until January 9, 1928 when they were destroyed. With the exception of a very heavy loss on August 19 when the water was accidentally turned off, the death rate of both groups was very low.

Examinations of fish from both these tanks were begun July 25. The method of procedure was as follows: The fish to be studied were selected from the tanks, brought to the laboratory, and placed in numbered containers. Those making the examinations were not advised as to the tank from which the fish had been obtained until the examinations were finished and recorded. The entire kidneys, liver, gills, and digestive tube of each fish were examined with a No. 5 eye piece and a 16 m.m. objective. These organs were prepared for study by placing them between two (2) glass slides and compressing them

sufficiently to allow such studies. The muscle just ventral to the dorsal fin was examined in this manner in all fish studied preceding July 27. Examinations of the entire muscular systems of two (2) fish (one (1) from each tank) were made on July 27. All studies made subsequent to this date included the entire muscular systems as well as the entire kidneys, livers, digestive tubes and gills. Fourteen (14) fish were examined from tank No. 1 and thirteen (13) from tank No. 2 between July 25 and August 20, 1927.

The number of encysted flukes was, in every instance, greater in the fish from tank No. 1. The fish from this tank showed an average of one hundred and twelve and thirty-five hundredths (112.35) parasites each while the fish from the control tank averaged only thirteen and sixty-nine hundredths (13.69) parasites each. The largest number found in any fish from tank No. 1 was three hundred and seventy-two (372) while twenty-five (25) was the maximum number found in any fish from the control tank. (Tables XVII and XVIII).

Parasite Counts from Infested Tanks

Table XVII

Fish No.	Date	Exam. By	Kidney	Liver	Digestive Tube	Muscle	Gills	Total
1	7-25-27	S	0	6	6	11	5	28
2	7-25-27	S	3	3	6	17	0	28
3	7-26-27	S	3	1	0	25	3	32
4	7-26-27	S	1	3	0	19	4	27
5	7-26-27	S	2	1	6	18	5	32
6	7-27-27	M	7	3	6	19	1	36
7	7-27-27	S	5	1	4	91	10	111
8	7-28-27	M	4	1	4	47	3	59
9	8-1-27	S	1	2	6	84	5	98
10	8-1-27	M	3	1	3	77	12	96
11	8-3-27	S	5	3	8	297	3	316
12	8-5-27	S	7	13	8	208	10	246
13	8-11-27	S	17	13	21	310	11	372
14	8-20-27	M	13	10	10	54	4	91
Total			71	61	88	1277	76	1573
Average			5.07	4.36	6.28	91.21	5.43	112.35

Parasite Counts from Control Tanks

Table XVIII

Fish	Date	Exam. by	Kidney	Liver	Digestive tube	Muscle	Gills	Total
1	7-25-27	S	0	0	1	5	1	7
2	7-26-27	S	0	0	0	6	1	7
3	7-26-27	S	2	0	0	6	2	10
4	7-26-27	S	1	0	0	6	0	7
5	7-26-27	S	0	0	0	4	3	7
6	7-27-27	M	0	1	0	7	3	11
7	7-27-27	S	3	0	0	16	4	23
8	7-28-27	M	0	0	1	10	3	14
9	8-1-27	M	0	2	0	6	3	11
10	8-3-27	S	1	1	0	21	0	23
11	8-5-27	S	3	0	6	12	0	21
12	8-11-27	S	2	2	0	19	2	25
13	8-20-27	M	2	1	0	9	0	12
Total			14	7	8	127	22	178
Average			1.08	.54	.61	9.77	1.69	13.69

Metacercaria

The metacercaria of Nanophyes salmincola were found in the muscles, kidney, liver, wall of the digestive tube and gills of salmon and trout. See figures III and IV. They were most numerous in kidney tissue. In muscle they were especially numerous in two regions: first, in the muscles dorsal to the supraspinous processes of the vertebrae near the tail and second, just ventral to the large dorsal fin.

These cysts (metacercaria) averaged about one hundred and forty (140) microns in diameter and were round. A big variation in size was noticed in the same fish. No explanation of this was found. In some cases, especially when they were encysted in the muscle tissue, they were surrounded by a second or extra capsule. See figure IV. The nature of this capsule was not determined. In a few instances, two metacercaria were found included in one of these secondary capsules. The cysts (metacercaria) were easily detected in the tissues of fish with the naked eye. They frequently showed a rather vigorous movement when observed with the microscope. However, in many instances, it was impossible to demonstrate any evidence of life in cysts that were alive and that did develop to maturity and produce symptoms and death when eaten by dogs.

Effects of temperature on cysts.

The cysts (metacercaria) were destroyed by cooking or prolonged freezing of the fish. Two (2) susceptible dogs were fed parasitized salmon which had been thoroughly cooked. No ill effects followed. Some parasitized fish was exposed to six (6) days of freezing weather. The weather bureau records showed the temperatures as follows:

December	22,	1924	Maximum	32°F	Minimum	5°F
"	23	"	"	33	"	-3
"	24	"	"	31	"	2
"	25	"	"	25	"	-8
"	26	"	"	21	"	-5
"	27	"	"	34	"	8

This fish had produced salmon poisoning before it was exposed to these temperatures, and was harmless to susceptible dogs after it had been frozen.

Effects of drying on cysts.

A piece of parasitized fish was placed in the sunshine and allowed to decompose and dry for five (5) days. It was then fed to dogs and produced salmon poisoning in them. In another experiment, salmon kidney containing many living cysts (metacercaria) was spread in a thin layer on manilla paper and allowed to dry at room temperature for one week. This paper and the dried cysts were given per orum to a susceptible dog without producing symptoms.

Effects of iceing fish and decomposition of fish tissues.

Parasitized salmon were kept in a cool room about 35° F. and covered with cracked ice. After forty-six (46) days these fish were quite badly decomposed and no evidence of movement of the cysts was seen. These encysted flukes remained alive and produced symptoms and death in dogs after being stored sixty-three (63) days. Later, in the more completely decomposed tissues, no cysts could be identified with the microscope and salmon poisoning symptoms did not develop when this fish was fed to susceptible dogs.

Parasitized fish frequently produced salmon poisoning in dogs after it had been iced and refrigerated in the usual manner of transporting fish for human consumption.

Zoological distribution of metacercaria.

These metacercaria have been found in three genera of the family SALMONIDAE only; viz. Salmo, Salvelinus and Onchorynchus.

Pacific Coast salmon (genus Onchorynchus) are hatched in the fresh water of the mountain streams. When about one (1) year old they migrate to the ocean and remain in salt water three (3) or four (4) years and then return to the fresh water, usually going to the same stream from which they originated. The salmon return to fresh

water for spawning purposes, after which act they die. The spawned salmon develop a discoloration of the skin, which has resulted in the popular term of "sore-back" salmon. Metacercaria or cysts were found in young salmon fry before they left fresh water and in the mature salmon after they returned to it. They were not found in ocean-caught salmon. They were found in fish taken from brackish water. It is generally believed that salmon sometimes go up stream and then drift back to the salt water so that the point from which the fish is taken does not necessarily indicate the length of time the fish has been in fresh water. The cysts (metacercaria) were found in fish that were still in good physical condition, before the flesh became soft, and before they had spawned or developed the "sore-back" condition. In one instance parasites were found in a fish taken from a small stream not more than 20 yards from the breakers of the ocean. The cysts were more numerous in fish taken from points quite far from the salt water, that is, fish that had been in fresh water for a considerable length of time. They were most numerous in apawned salmon that were about ready to die. Counts of metacercaria were made in weighed amounts of fish tissue. In one (1) instance they were found at the rate of approximately one (1) million to the pound in muscle tissue of a Chinook salmon.

Native western trout (genus Salmo) may remain in fresh water but it is generally believed that those which are not land locked go to salt water. Encysted flukes were found in young trout only two (2) months of age and in large mature fish. In a fourteen (14) inch cutthroat trout, two thousand six hundred and seventy-six (2676) metacercaria were counted in sixty-five (65) milligrams of kidney tissue. This is at the rate of approximately one and one quarter ($1\frac{1}{4}$) million to the ounce.

Several other species of fish, most of which originated in streams from which either salmon or trout containing cystic flukes had been taken, were examined. All these examinations were negative. (Table XIX)

Fish Not Parasitized

Other Genera

Table XIX

Group	Species of Fish	No. of fish	Origin of Fish
1	Whitefish	2	Willamette River near Corvallis, Oregon.
2	Smelt	2	Sandy river (Columbia River, Oregon)
3	Chub	1	Muddy Creek, Bellefountain, Oregon.
4	"	1	South fork of Willamette River, Oregon.
5	Sea Bass	1	Netarts Bay, Tillamook Co. Oregon.
6	Small mouth bass	1	Willamette River, Corvallis, Oregon.
7	Silver perch	1	Netarts Bay Tillamook, Ore.
8	Suckers	5	Umatilla River, Umatilla, Oregon

Part IV.

D I S C U S S I O N

Etiology and Immunity

From the data recorded in this report it will be noted that salmon poisoning in dogs is very definitely associated with an intestinal fluke. The symptoms and course of the disease would be considered as indicative of an infectious trouble rather than a result of intestinal parasitism. Most of the affected dogs died but occasional cases recovered. Dogs that recovered had acquired a very definite, active, permanent immunity to subsequent attacks of this disease. This immunity would further suggest that the etiology of salmon poisoning may be of an infectious nature. Immunities against intestinal parasitism are extremely rare in medical literature.

It is considered quite probable that the etiology of this trouble may be an infectious agent and that this fluke (Nanophyes salmincola) merely provided the mode of entrance of this agent. The efforts to transmit the disease, transfer and produce the immunity, and isolate pathogenic bacteria have not been successful. These studies were not sufficient to justify any conclusions.

There is some evidence which indicates that the fluke may produce a toxin which is responsible for at

lease a part of the symptoms. If this is true, this may explain the origin of the immunity. On the other hand, considerable evidence has been accumulated which indicates that dogs may develop a degree of resistance to the parasites by having had previous smaller doses of them. When symptoms did develop there was no relationship between the numbers of fluke cysts ingested and the severity of symptoms or the percentage of recoveries. There was much more pathology of the intestine in cases of gross infestation. This might suggest that pathology of the intestinal tract was all due to the mechanical injury produced by the flukes burrowing into the mucosa. In contrast to this theory, the necrosis of the intestinal mucosa extended the entire length of the alimentary canal. Furthermore, intestinal pathology was present in average cases at points where no flukes were found, either free in the intestine or burrowed into the mucosa. The exciting cause of symptoms and the origin of the immunity have not been proven.

In these studies the percentage of recoveries was negligible. Some influence must increase the percentage of recoveries under natural conditions in the sections where practically all dogs are exposed to this trouble. There is no apparent lack of dog population in the coast

region. All of these dogs that are permitted to roam have plenty of opportunity to eat parasitized fish. This is because the dead spawned salmon can be found along the banks of any of the mountain streams at certain seasons of the year. Many of these dogs eat fish regularly and are not affected. The owners' reports divide these immune dogs into two classes. First, most of them are reported to have been affected with salmon poisoning and to have recovered. There is no uniformity in the methods of treatment or care given by the dog owners. These recoveries may be due to a hereditary increased resistance present in the families of dogs that have survived in the salmon poisoning area for generations. Second, reports claim that a few dogs have a natural immunity. If such an immunity does occur it may be an inherited condition. The natives believe this to be true. They believe that pups from an immune mother are less susceptible. Furthermore, they think that the milk of an immune bitch offers some protection to pups. This was not apparent in the two litters studied in this work. There is a third class of dogs inhabiting the coast section. Frequently the pet house dog is carefully guarded to prevent it from eating fish. Many of these dogs have been imported from sections where salmon poisoning does not occur. It is apparently true that practically all dogs that are taken

into the coast region die if they are allowed to eat salmon or trout. Owners have reported that certain medicinal treatments were quite satisfactory when used on native dogs but were worthless when used on dogs purchased from other parts of the country. This might be interpreted to mean that the native dogs naturally recover more frequently.

Many dog owners claim that they can immunize some pups by giving them a small amount of fish. They say that such puppies will develop symptoms of salmon poisoning and that a good percent will recover. They do not report that dogs have been given small amounts of fish without producing symptoms. In these studies, dogs have been killed with fewer flukes than it would usually be possible to give by feeding fish without the aid of a microscope. Perhaps it is true that puppies of coast section families of dogs do recover in greater numbers than dogs of different ancestry. This might be due to an inherited resistance to this fluke.

Encysted Flukes - Metacercaria

The cysts varied greatly in size in the same fish and in different fish. There was no relationship between the size of the cysts and the size, age, or species of fish. Both large and small ones were found in salmon that had recently returned to fresh water which would indicate that

they were recently infested.

The length of life of the cyst in the fish could not be determined by the use of the microscope. The dark material in the cyst may be fecal material.

Just why the cysts do not remain in the salmon while they are living in salt water is not understood. No studies were made to determine how soon the cysts disappear in fish confined in either fresh or salt water. Cysts are present in salmon taken from brackish water. Possibly the salt of ocean water is not the factor which causes ocean caught salmon to be free from these parasites. It may be that the cysts leave the body of the fish in time.

As a result of investigations of losses of young trout at the Willamette Hatchery (State Game Commission) in 1925, Dr. Henry B. Ward[8] reported that an encysted fluke was responsible. His description of the parasite was not complete. Therefore it is impossible to determine whether the fluke he described was Nanophyes salmincola. Since this parasite was found to be very numerous in trout at this hatchery at the time of the visit in 1926 as described above, and since no other cystic flukes have been found in either trout or salmon in Oregon, it is logical to conclude that Dr. Ward very probably ob-

served this parasite. He did not report any examinations of apparently normal fish.

Dr. Ward's conclusions are contrary to the results recorded in this report.

In the muscle tissue, the cysts frequently were surrounded by an extra capsule. The exact nature of it was not determined. It may be an inflammatory exudate which acts as a protective membrane, walling off the fluke cyst from the muscle tissue. In a few instances two cysts were seen included in one of the extra capsules. This might suggest that these capsules originated from the tissues of the fish rather than from the structures of the cyst.

Period of Incubation of Salmon Poisoning.

The period of incubation in general seemed to be a little longer in the summer months. This might be due to the length of time that the cysts had been in the fish, or to some change in the fish itself during different seasons of the year. It may be the result of some phenomenon in the dog. Perhaps the climatic condition was the principal factor.

Symptoms and Diagnosis

There are no constant diagnostic symptoms. This condition could be easily confused with some forms of

canine distemper. Finding evidence of Nanophyes salmincola is the only method of arriving at a positive diagnosis. Because of the period of incubation, dogs may be transported to almost any part of the country before developing visible symptoms. In this respect salmon poisoning in dogs is not strictly a local condition.

Control.

The prompt use of an efficient emetic soon after the dog has eaten parasitized fish is said to prevent the disease.

Since these flukes become deeply imbedded in the intestinal mucosa, it would seem that ordinary intestinal vermifuge treatments could not be very satisfactory. A medicinal agent carried by the circulating blood might prove satisfactory. Apparently symptoms do not appear until after the flukes have matured and burrowed into the mucosa. Consequently, successful destruction of the flukes in cases showing visible symptoms might not be of any value, particularly if the symptoms are a result of either a toxin from the fluke or an infectious agent introduced by it. Successful control will probably involve a method of immunization rather than a curative treatment.

Life Cycle of Parasite

Host of Mature Parasite

It would seem that there are not enough dogs inhabiting the coast section to contaminate the water of the mountain streams so grossly that the snails, salmon and trout taken from them would be so severely parasitized. There probably are other animals which act as the natural hosts of the mature parasite. The flukes may not be pathogenic in such a natural host. According to this theory the dog would be classed as an accidental host. If there is no such natural host, perhaps the parasites multiply someplace in their life cycle between the egg and the snail. Perhaps the parasites pass directly from one snail to another. This would not be in accord with the present accepted ideas pertaining to the life cycle of parasites of this type.

A warm blooded animal would be suspected as the natural host. Only members of the order CARNIVORA are known as hosts of the mature parasite. The natural host would have similar feeding habits and would either catch fish to eat or eat dead fish found along the banks of the streams. It would seem that strictly herbivorous animals could be excluded in the search for a natural host.

Snail Hosts

Only the one snail Goniobasis plicifera var silicula (Gould) was studied as a possible molluscan host of the salmon poisoning fluke. It is well known that some flukes can develop in two different genera of snails. It is quite possible that another snail, in addition to the one already studied, may sometimes act as the molluscan host of the fluke under consideration. Goniobasis plicifera (Lea) occurs in some of the western Oregon streams and would naturally be suspected as a possible host.

Observations of snails have indicated that severe infestation does not necessarily influence the health of the host.

Possibility of Human Infestation

These flukes might develop in the human intestine and might be pathogenic. The human usually does not eat raw fish. They do eat very much the same diet as the dog.

The early settlers of the coast region relate two incidents of supposed salmon poisoning in humans which resulted in death. Neither of these incidents could be verified. One story is of two men who were on a hunting trip in the Alsea mountains and ate some salmon after slight cooking over a hot rock. Dr. M. M. Davis of Eugene, Oregon, was reported to have attended these men. His re-

ply to a letter of inquiry stated that he though he remembered the incident but could not recall any details. The other case was a pioneer family in Lincoln County, Oregon. The entire family is said to have died after eating partially cooked fresh water salmon. The report that the Indians commonly eat raw fish has not been verified.

There are many unsolved problems connected with these studies. Some of the more important ones are as follows:

1. Definite proof of the exciting cause of symptoms and death in affected animals.

2. The cause of the pathology of the intestinal tract.

3. The origin of the acquired immunity, possibility of it being result of intestinal parasitism, infectious agent, or parasite toxin.

4. Method of transmitting and producing the immunity.

5. The possibility of hereditary resistance and immunity.

6. The possibility of successful medicinal treatment of affected animals.

7. The hatching of the fluke eggs and other studies to determine the complete life cycle of the parasite.

8. The possibility of a natural host of the parasite in addition to the animals which are known to act as hosts.

9. The possibility of control of the disease by interrupting the life cycle of the parasite.

10. The possibility of injury to the life processes of infested fish.

11. The length of time the encysted flukes may remain in salmon and trout.

12. The exact minimum and maximum temperatures which will destroy the encysted parasites.

13. The possibility of human infestation with the production of a diseased condition.

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Part V.

S U M M A R Y

1. Salmon poisoning affects dogs, foxes and coyotes.
2. It is definitely associated with the fluke *Nanophyes salmincola* (Chapin)
3. The mature parasite occurs in the intestines of affected animals.
4. The mature fluke burrows into the mucosa of the intestine.
5. A part of the life cycle of this parasite is passed in the snail *Goniobasis plicifera var silicula* (Gould).
6. A cystic form of this parasite occurs in the muscles, kidneys, livers, gills and walls of the digestive tubes of trout and fresh-water salmon.
7. Cooking or prolonged freezing of fish destroys the parasite.
8. Occasional dogs recover and are then immune and can eat parasitized fish with impunity.
9. This immunity has not been explained or transmitted.
10. No satisfactory method of treatment or control is known.
11. The complete life cycle of the parasite is not known.

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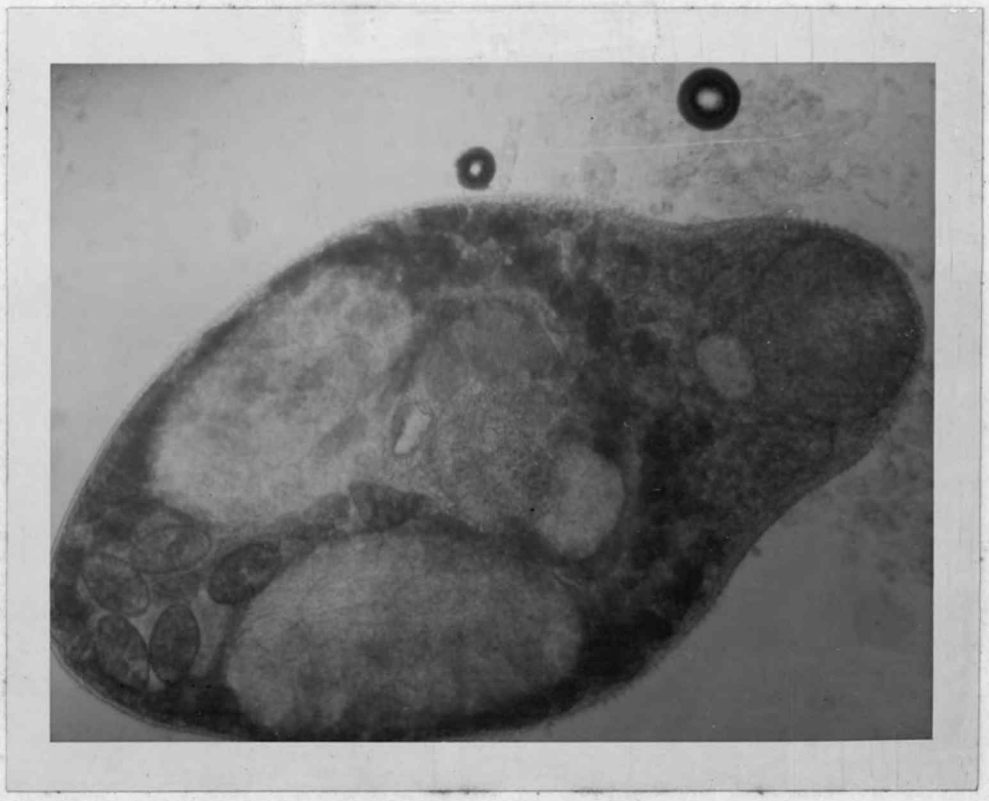

Figure I. (Magnified about 250 diameters)
The mature fluke, Nanophyes Salmincola Chapin, found in the intestines of animals affected with salmon poisoning. Five eggs are present in the body of this parasite. Oral and ventral suckers may be noted.

Figure II. (Magnified about 100 diameters) Mature fluke Nanophyes Salmincola Chapin imbedded in the mucosa of the intestine.

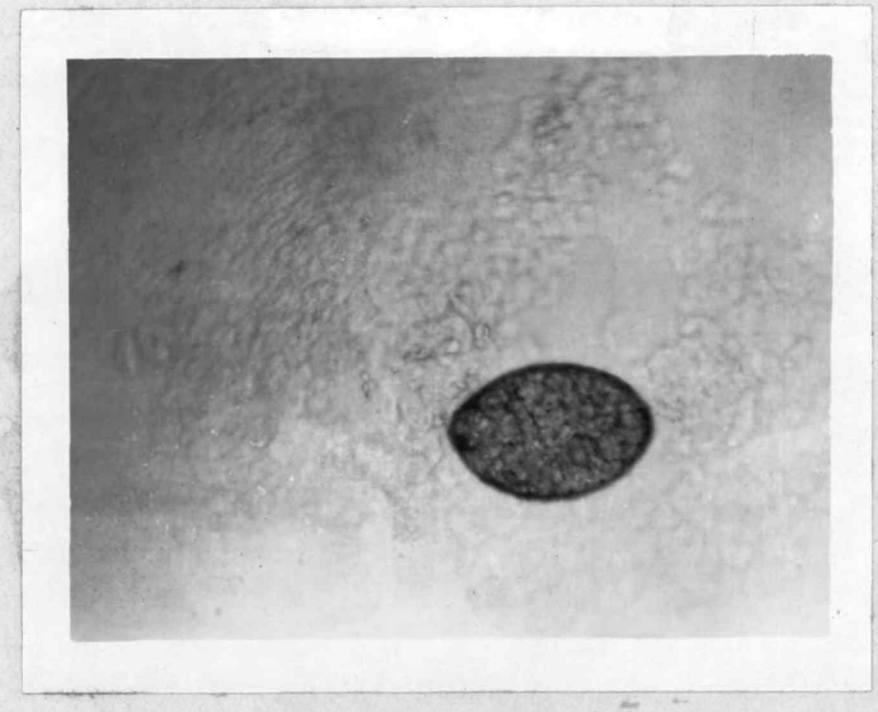

Figure III. (Magnified about 500 diameters)

The egg of Nanophyes Salmincola Chapin.

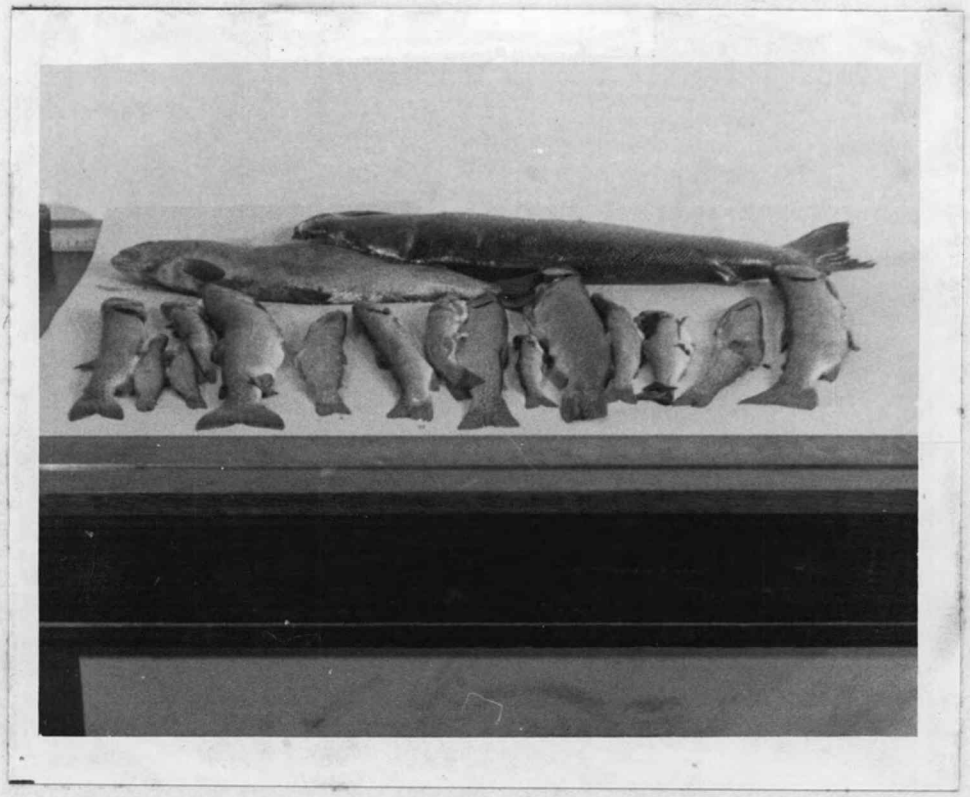

Figure IV.

A group of parasitized trout taken from a mountain stream in western Oregon.

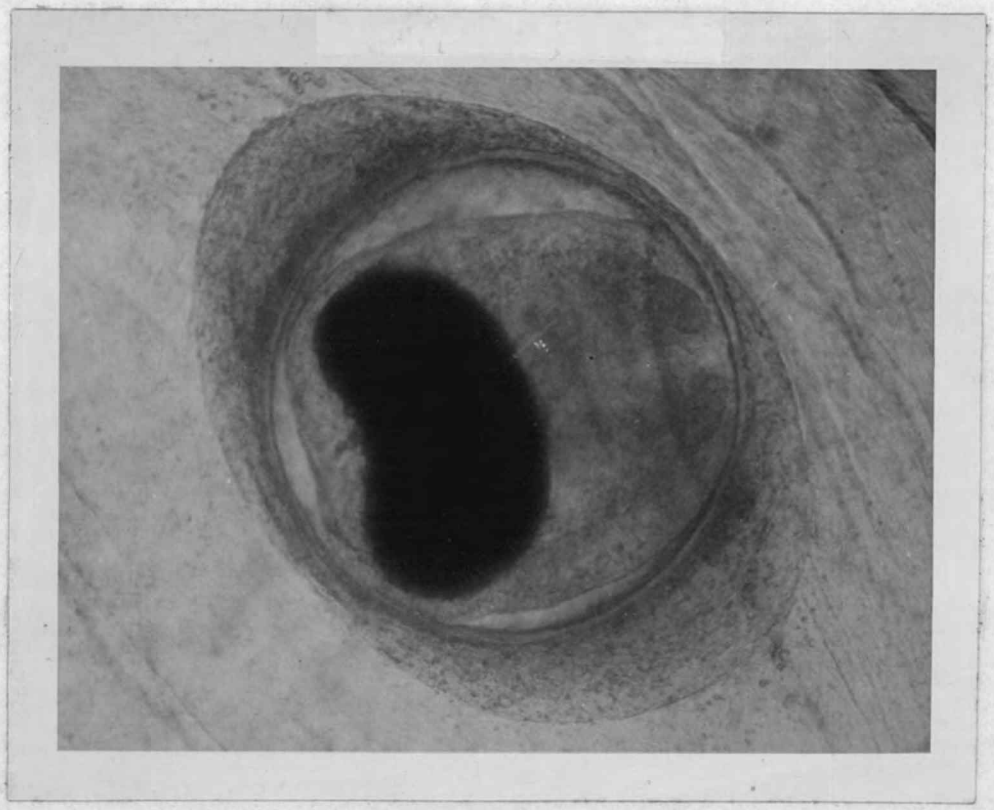

Figure V. (Magnified about 400 diameters) Cyst, metacercaria, Nanophyes Salmincola Chapin. Found in the muscle tissue of trout and fresh water salmon.

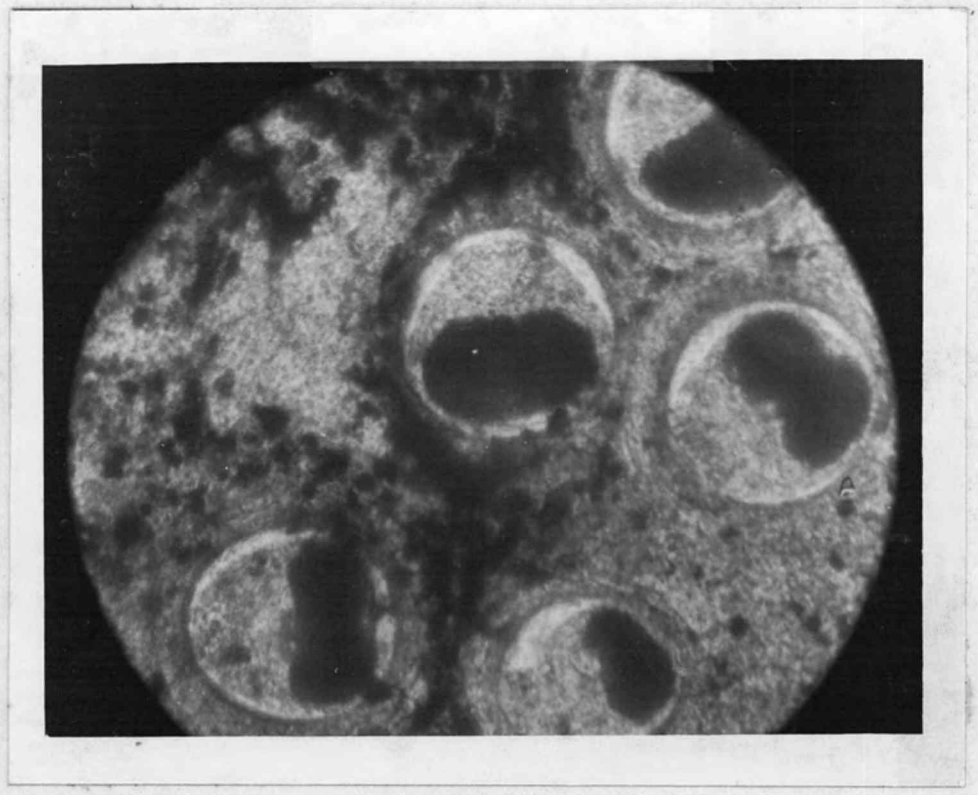

Figure VI. (Magnified about 175 diameters) Cyst, metacercaria, Nanophyes Salmincola Chapin, found in the kidney tissue of trout and fresh water salmon.

Figure VII.

A dog showing typical symptoms of salmon poisoning.

Figure VIII.

A sick dog showing pus discharge from the eyes.

Figure IX.

Two sick dogs, affected with salmon poisoning.

Figure X.

Two sick and two immune dogs. All fed parasitized fish the same day.

Figure XI.

An immune dog. Repeatedly fed parasitized fish.

Figure XII.

Goniobasis plicifera var silicula (Gould)

Figure XIII.

Collecting snails Goniobasis plicifera var silicula (Gould) from a mountain stream. Note snails on bottom of the stream.

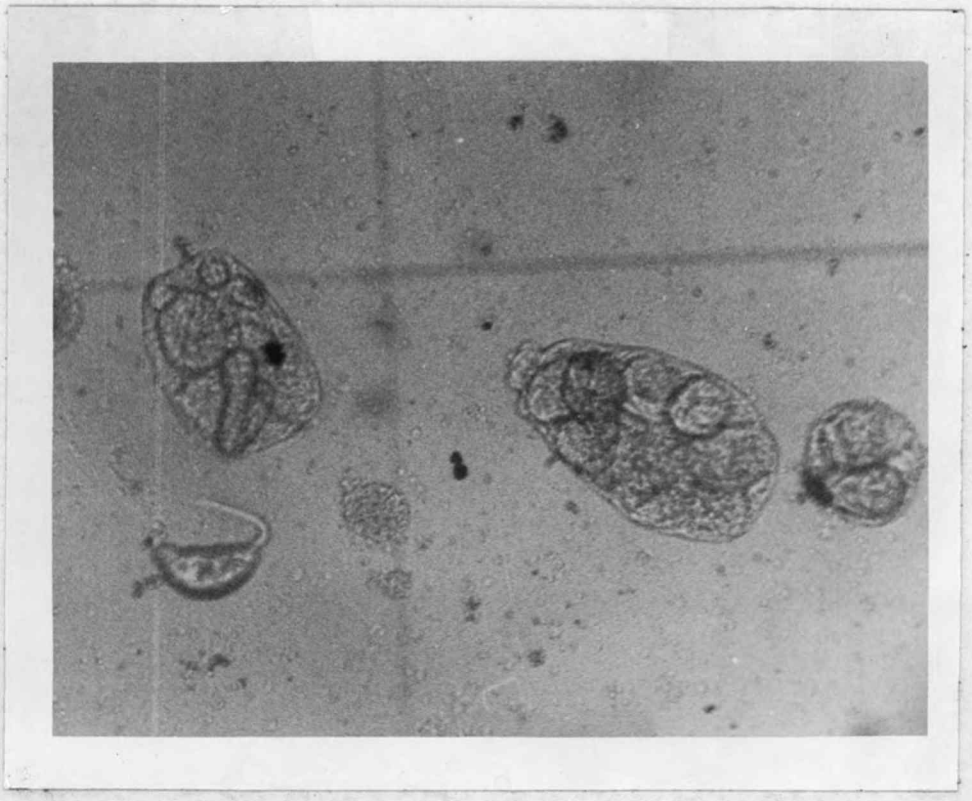

Figure XIV.

(Magnified about 70 diameters) Three Daughter redia containing cercaria and one free cercaria. (Obtained by crushing a snail.)

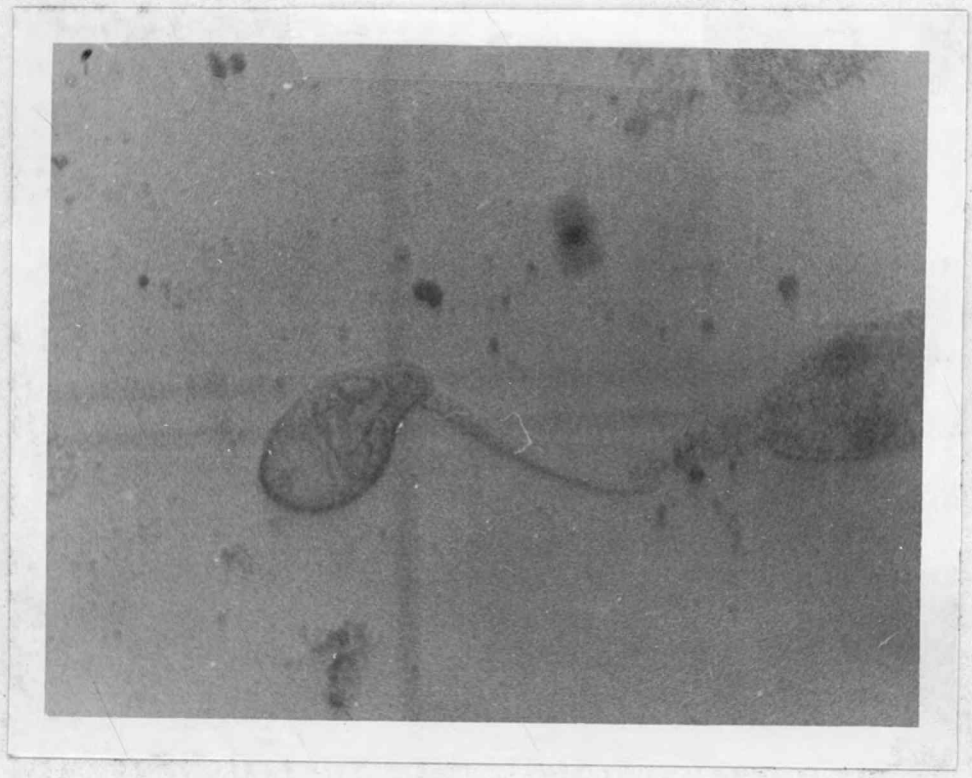

Figure XV.

(Magnified about 140 diameters). Free swimming cercaria (obtained by crushing a snail.)