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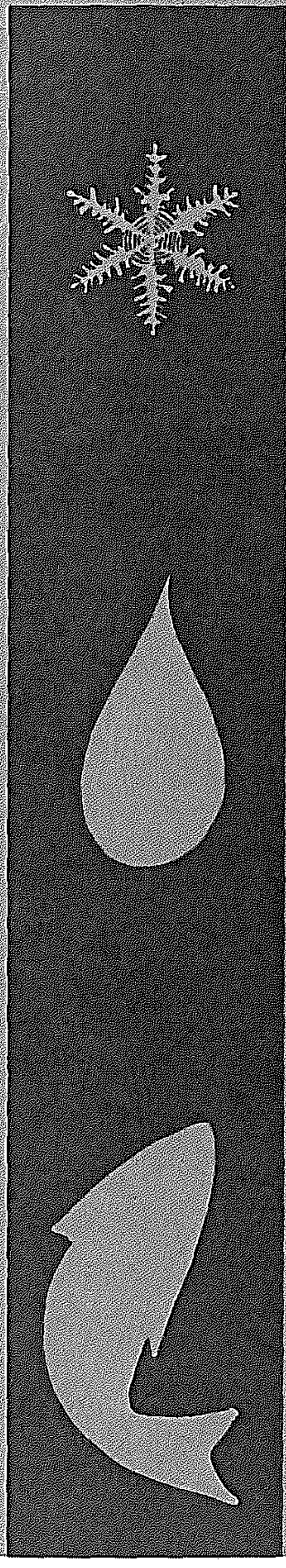

Reconnaissance Of The Distribution And Abundance Of Schistosomatium Douthitti, A Possible Human Disease Agent In Surface Waters In Alaska

By

L. G. Swartz

Project Number: A-020-ALAS
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Project Completion Report

RECONNAISSANCE OF THE DISTRIBUTION AND ABUNDANCE OF SCHISTOSOMATIUM DOUTHITTI, A POSSIBLE HUMAN DISEASE AGENT IN SURFACE WATERS IN ALASKA

by

L. G. Swartz

Project Duration: June, 1967 to August 31, 1967

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ABSTRACT

Studies during the summer and early fall of 1967 show that *Schistosomatium douthitti*, a blood fluke which may pose a health hazard to man, is well established in the surface waters and surrounding terrestrial environments in the Fairbanks area. It is almost certain that this situation exists throughout Interior Alaska. Ecologically and geologically, the lakes and ponds in which it has been found are the most abundant types in the Interior and both the specific lakes and the types which they represent are abundantly used by man.

The life cycle of the worm in this area is probably sustained mostly in small mammals, especially in *Microtus pennsylvanicus* but also in *Clethrionomys rutilus*. The infection certainly over-winters in the mammal host but probably also survives in the snail host under the ice. Although the fluke was only found in two of the nine mammalian species examined, it is probable that it occurs in other than *Microtus pennsylvanicus* and *Clethrionomys rutilus*.

Final Report

Reconnaissance of the Distribution and Abundance of

Schistosomatium douthitti, a Possible Human Disease Agent in Surface Waters in Alaska

by

L. G. Swartz
Department of Biological Sciences

Introduction

While undesirable chemical constituents and bacterial contamination are often considered in judging the water resources of an area, the possibility that worm parasites might be important is usually ignored. In the north temperate zone and at higher latitudes this omission has historically seemed justified. Recently, however, (Swartz, 1966a) a worm has been discovered in the Fairbanks area which may pose a very real threat to the health of man and certainly, since it is acquired from water, should be considered as a significant property of surface waters in this area.

This worm is a blood fluke (*Schistosomatium douthitti*) occurring as an adult in the mesenteric veins of various mammals. It is one member of a large group of worms called schistosomes, commonly parasitic in the blood vessels of mammals and birds. The life cycle of the worm is as follows: Eggs pass from the mammal via the feces and when the feces are dropped in water (a very common event among mammals, human or not) the eggs hatch liberating a free-swimming larva called a miracidium. The miracidium seeks out a snail belonging to the family lymnaeidae, and penetrates the body. In the "liver" of the snail the sporocyst stage develops and this gives rise in turn to another free-swimming larva called cercaria which leaves the snail.

During the free-living life of this larva it swims about seeking a mammal host. When the presence of a mammal swimming or walking in the water is sensed the cercaria penetrate the skin and migrate to the liver and spleen. Ultimately they reach the mesenteric veins, copulate and the females begin to lay eggs. These work their way through the tissues to the lumen of the intestine from whence they can pass out.

Schistosomes can be quite damaging to the host, in fact the human schistosomes of the genus <u>Schistosoma</u> are regarded by many scientists to have surpassed malaria in importance as the chief human disease killer. It is well known that a severe dermatitis can result from contact with natural waters containing the cercaria of members of the schistosome group (newspaper articles warning of "swimmer's itch" appear every summer in Interior Alaska). It has been assumed that this problem has derived from schistosomes naturally occurring in birds but the possibility that some of these more or less minor, though painful, infections can become systemic and much more serious has only recently become clear. Kagan (1953) and Penner (1941) showed that <u>Schistosomatium</u> could infect Rhesus monkeys and if this species can support the worm it seems quite possible that man could as well. Farley (1962) and Swartz (1966a) have commented on the implications of this state of affairs as a threat to humans bathing, drinking, or otherwise coming in contact with natural waters.

While the possible importance of this worm in human health is of considerable interest, various more purely scientific aspects deserve investigation. I have summarized the history of knowledge of the distribution of <u>S. douthitti</u> elsewhere (Swartz, 1966) and emphasized the implications of the publications by Penner (1942) and myself (Swartz, 1966a) which serve to indicate that the worm is probably present in the whole northern two-thirds of the continent. Its presence in interior Alaska (the closest previous record was in southern Manitoba published by Farley, 1962), particularly when the sole Old-World record is from South Africa (Porter, 1938), suggests that the genus at least, may be world-wide; possibly a classic in the failure to observe and appreciate a distributional pattern. While research centered in Alaska can hardly answer questions of world-wide distribution, determining the "solidity" of the infection in an area central in concepts of pleistocene zoogeography can hardly fail to be intellectually fruitful.

The gradual growth of the list of known natural definitive hosts to five, plus the list of experimentally infected animals, has begun to point to the possibility that the host specificity of the worm may be unexpectedly low (Swartz, 1966a). The taxonomic spectrum of suitable hosts is wide, including mostly rodents but including also, at a taxonomic extreme, the Rhesus monkey. Such a picture suggests that the worm may actually be capable of infecting almost any mammal which may come into contact with water containing the cercaria and that the "confines" of the list of known hosts is only apparent due to the likelihood that experimental infections would be tried on rodents and to the fact that scientists rarely look inside the mesenteric veins. An interesting point in all this is the possibility that the factors isolating parasite and host are less physiological factors than they are ecological.

The discovery of the worm (Swartz, 1966a) in a red-backed vole in interior Alaska was necessarily of qualified significance because it represented only a single observation. The present research was begun in order to test the hypothesis that numerous foci of infection might well exist and to lay a foundation for future more ambitious research programs.

Answers to the following specific questions were sought as well as information to form a basis for firmer reasoning on some of the more speculative points raised above:

1. How widespread geographically is the parasite in Interior Alaska?
2. What animal species naturally harbor the parasite?

3. What animal species can be infected experimentally?
4. What ecological factors influence the distribution of the parasite?

Procedure

1. A schistosome survey of small mammals living in or on the margins of bodies of fresh water was conducted. Animals were secured by trapping and shooting. Animals were examined microscopically according to standard parasitological techniques. In the Fairbanks area lakes and ponds included Smith Lake, Killarney Lake, Ballaine Lake, Ace Lake, Little Lake (near Harding Lake), "Airport Gravelpit", the airport float pond, "North Pole Lake", a gravel pit at 7.5 mile Richardson Highway, Rat, Reindeer, and Middle Lakes on Farmer's Loop Road and a small lake, "Steven's lake", in the Goldstream Valley on Steven's property (see map). In the Anchorage area collecting attempts were made at many places but were successful only in a slough at the second railroad bridge east of Girdwood. Similar fruitless efforts were made in the Alaska Range near the Denali Highway.
2. Snails, as the intermediate hosts for the parasite were collected, identified, and examined for larvae. Bodies of water sampled were Smith Lake, Ace Lake, Ballaine Lake, Rat Lake, Reindeer Lake and the gravel pit 7.5 miles down the Richardson Highway.
3. Snails from lakes known to support few or no schistosomes were experimentally infected with miracidia hatched from eggs obtained from infected mammals.
4. Ecological data were taken adequate to characterize roughly the habitat of snails, vertebrate hosts, and parasite. No detailed work on the biota or water chemistry was done.

Results

Mammal Hosts

Trapping success as well as muskrat shooting was so poor in the early portion of the summer that the endeavor to secure the vertebrate hosts was virtually abandoned in favor of collecting snails. Later it became possible to collect mammals with reasonable efficiency and the trapping program was resumed beginning in early August. Collection data are summarized in Table 1.

Nine mammal species were examined including muskrats (*Ondatra zibethica*), the red-backed vole (*Clethrionomys rutilus*), the meadow vole (*Microtus pennsylvanicus*, the tundra vole (*M. oeconomus*), the jumping mouse (*Zapus hudsonicus*), the cinereous shrew (*Sorex cinereus*), the dusky shrew (*S. obscurus*), the arctic shrew (*S. arcticus*). One northern bog lemming (*Synaptomys borealis*) was examined and found to be negative but was acquired from other sources from a poorly defined location. All mammals except the last were secured from the water itself or from within 10 meters of the water's edge.

The current status of the microtine population cycle in the Fairbanks area is ambiguous but an unusually large number of trap nights was necessary to catch prospective hosts. Shrews occupied a relatively high proportion of the catch but in terms of trapping effort expended per shrew seemed about normal. Seven *Zapus* were caught, six in a relatively restricted area around Rat and Reindeer lakes. I am used to regarding *Zapus* as an uncommon mouse. The discovery of what appears to have been relatively abundant population in this area suggests, as is normally the case, that the rare or uncommon animal is not really so when the appropriate habitat is found.

Necropsy data are presented in Table II. The first infection was found on August 22 in a very large *M. pennsylvanicus* (40.4g) and thereafter infections were found in the same host with reasonable frequency, mostly in animals of greater size (infected animals 31.5 g, range 21.9 - 41.0 g, uninfected animals

24.1 g, range 11.0 - 48.0 g). The only other infected host species was _C. rutilus_. A single large host (32.4 g, average 19.1 g, range 1.1 - 45.8 g) harbored three worms.

Most worms (13) were found in the veins draining the caecum, normally close to the point at which the veins emerged from the body of the caecum. One worm was found in a vein draining the large intestine, and one in a vein draining the small intestine, two young worms were found in the liver on August 3 and another on September 20.

Snail hosts

After early zealous but largely unsuccessful attempts to secure vertebrate hosts by trapping, shooting and any other possible means, attention was shifted to the snail hosts of _Schistosomatium_ with the hope that it would be possible to discover enough infected snails to reach the objectives of the research in this way.

Necropsy data are presented in Table III. The process of examination was conducted so that each snail had a chance to liberate free, fully developed cercaria to be examined before the snail itself was dissected. Although not members of the family lymnaeidae, and therefore unlikely hosts, a limited number of _Helisoma tribolvis_ were examined.

Considerable difficulty was experienced in attempting to identify the local schistosomes by their larval stages. In many cases the larvae were too young and the issue was further complicated by the fact that the larval trematode fauna of Alaska is virtually unknown. Although 629 possible snail hosts were dissected, none were found with schistosomes which definitely could be called _Schistosomatium_.

Conclusions

Although the return of data for effort expended is somewhat slim, some conclusions seem clearly warranted. Some of the data, while they do not justify firm conclusions, hint at possible phenomena and in that they stimulate further thought and research on possibly significant issues, may be even more valuable in the long run and do serve the objectives of the research.

1. It is clear that the infection is indeed solidly established in the Fairbanks area and probably in interior Alaska as a whole. The failure to show high infection rates does not militate against this conclusion since there are clear intimations that when the "proper" age class of the mammalian host is obtained, it is likely to be infected. A very large proportion of the hosts examined were young of the summer which are much less likely to have encountered the cercaria and lived the necessary period after infection for mature worms to have developed. This issue will be discussed later.

It is also evident that as far as spatial availability is concerned Schistosomatium is amply distributed to pose a problem to humans if future research should show that systemic infections in humans can in fact occur. The discovery of the worm in mammals living on the shores of Smith Lake, Ace Lake, Rat Lake and Reindeer Lake (see map) shows that it is to be found in the most typical and abundant types of lacustrine water in Interior Alaska, both in "average" sized lakes and in "pond" sized lakes. The research personnel came to feel that we could find Schistosomatium at any body of water if we could just manage somehow to catch large hosts. By and large, those lakes which remained negative were those at which few or no large hosts were caught. At least consistent with this hypothesis is the apparently random scatter of "positive lakes" (see map).

2. No new natural host species were discovered (see Swartz, 1966) but the summer's data do not diminish the probability that mammals other than Clethrionomys rutilus and Microtus pennsylvanicus may normally partake in the life cycle of the worm in Alaska. It is likely that infection rates are usually low, except perhaps in older animals, and the spectrum of hosts obtained, in numbers, variety of

age classes, and species was not great. These factors could easily account for failure to find the worm in other species.

It is interesting that infection rates in M. pennsylvanicus were 33.3 per cent and those in C. rutilus were only 0.8 per cent. At first blush these data would suggest that M. pennsylvanicus is far the more important in sustaining the life cycle of the worm in this area and in fact this may be so. On the other hand, very few of the C. rutilus that were examined seemed to be old animals and it is probable that this species was undergoing a more rapid increase in population than M. pennsylvanicus during this past summer (see below). If true, the conclusion that C. rutilus is a less "normal" host may not be correct. On two occasions, voles were seen swimming in Smith Lake (known to harbor Schistosomatium) and although it was not possible to capture either and thereby definitely identify them, they appeared to be C. rutilus. These observations would tend to reinforce the almost obvious conclusion that the habits of this species do permit frequent chances for infection.

3. No new data could be gathered on hosts which might experimentally be infected in the laboratory because the discovery of the worms from which to work was made so late in the summer.

4. The summer's work has produced a category of results which might be called "stimuli to fruitful thinking" about the general ecology of the life cycle complex involving host, parasite, and all the rest of the physical and biotic environment. Perhaps the most interesting field of future research on this worm lies in this area. Any possible future efforts at control either by direct means or those depending on avoidance of contact with the worm depends on knowledge of the basic ecological relationships embodied in how the parasite population interacts with its total environment. If one understands how a population or species survives, one can then attempt to manage it, if it seems desirable, in a reasonable and coherent way.

Huff, et. al., 1958, have described successful parasitism as a continuous series of events; entrance of the parasite into the host, establishment, emergence from the host, and transmission to another host. This representation may focus undue attention on the parasite, for some kinds of research, since it tends to remove the parasite from its position as one of an almost innumerable number of interacting components in an ecosystem. It is obvious that at any given moment in the evolution of an ecosystem, the component parts are adjusted to one another in some manner and disturbing the balance is likely to be an excellent way to alter the abundance of a given organism.

One of the most conspicuous adjustments lies in the timing of developmental events. Although the data are not thoroughly satisfying, the fact that infected voles tended to be older, possibly more than one year, suggests that infections found in this study were acquired in the previous summer and that the infected vole has lived through the winter. Young worms were found in the liver on August 30 and September 20 which roughly marks the period of possible infection from about August 20 to September 10. These voles could serve as a supply of infective miracidia for snails at least until the snails became inactive and possibly until freezing of the lake or pond in early October. If they survive the winter, they would then be available as a source of miracidia in the following open-water season. Probably little development of the sporocyst in the snail would take place in the winter until warming of the water in the spring (although data by Swartz, 1966b, present the possibility that flukes may acclimate metabolically to low temperatures and permit a greater degree of development than might be expected). In the spring and early summer, it is likely that no fully developed cercaria are normally produced. Schistosome sporocysts and cercaria were found in abundance in several lakes but typically were avian species or were too young to identify. Price (1930) states that 44 to 54 days are required for production of cercaria after infection of the snail. She does not state the temperature but she worked in the temperate zone and it seems probable that under natural conditions in interior Alaska development to the free cercaria is not normally complete until late summer. Seasonal patterns of lake temperatures are plotted in Swartz, 1966b and tend to support this conclusion. Mortality of snails heavily infected with trematode larvae is well known to be higher than that of "clean" or lightly infected snails and it is likely that survival of both snails and schistosomes (as larvae) over the winter is not good unless infections are light or new (and hence less damaging), acquired in the fall or late summer. It is possible that the prosperity of the parasite population depends fairly heavily on over-wintering in the mammal host. In this event snails would become infected in the spring and it would be difficult to distinguish these from those which had been penetrated by miracidia in the preceding year. Very possibly both mechanisms exist and serve to buffer the parasite populations from the sometimes extreme oscillations of mammal populations (especially voles).

Admittedly, much of the foregoing is speculative, but it may serve to indicate that a number of doors have been at least partially opened to further work.

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Table I

Summary of Mammal Collections

Locality	Dates	Trap Nights	Species	No. Caught	No. Caught 100 Trap Nights
Smith Lake	June 2 - Sept 18	2 + 2 shot	Ondatra zibethica	4	
		677	Clethrionomys rutilus	23	3.25
			Sorex cinereus	33	4.88
			S. arcticus	1	0.15
			Microtus pennsylvanicus	1	0.15
			Microtus sp.	1	0.15
			Zapus hudsonicus	1	0.15
Ballaine Lake	Aug. 17 - 19	275	C. rutilus	6	2.18
			M. pennsylvanicus	3	1.09
			M. oeconomus	2	0.73
			S. cinereus	6	2.18
Rat Lake	Aug. 21 - 25	424	C. rutilus	22	5.19
			M. pennsylvanicus	3	0.70
			M. sp.	1	0.24
			S. cinereus	9	2.12
			S. arcticus	1	0.24
			S. obscurus	3	0.71
			Z. hudsonicus	4	0.94
Reindeer Lake	Aug. 28 - Sept. 1	368	C. rutilus	10	2.72
			M. pennsylvanicus	1	0.27
			M. oeconomus	1	0.27
			S. cinereus	3	0.82
			Z. hudsonicus	2	0.54
Middle Lake	Sept. 5 - 7	252	C. rutilus	20	7.94
			S. cinereus	6	2.38
			S. arcticus	1	0.40
Ace Lake	Sept. 20 - 22	300	C. rutilus	4	1.33
			M. pennsylvanicus	2	0.67
			M. sp.	1	0.33
			S. cinereus	9	3.00
			S. arcticus	1	0.33
			S. obscurus	1	0.33
Airport Float Pond	Sept. 26 - 28	120	C. rutilus	3	2.50
			M. oeconomus	2	1.67
			S. cinereus	2	1.67
			S. obscurus	1	0.83
Airport Gravel Pit	Sept. 28 - 29	200	C. rutilus	1	0.50
			M. oeconomus	1	0.50

Locality	Dates	Trap Nights	Species	No. Caught	No. Caught 100 Trap Nights
Little Lake	Oct. 3 - 5	231	*C. rutilus*	12	5.20
"North Pole Lake"	Oct. 6 - 8	150		0	
Gravel pit, 7.5 mile Richardson Hwy.	Oct. 9 - 11	135	*C. rutilus*	2	1.50
			M. oeconomus	3	2.22
"Stevens Lake"	Oct. 18 - 24	260	*C. rutilus*	22	8.46
			M. oeconomus	2	0.77
Killarney Lake	Oct. 18 - 23	220	*C. rutilus*	1	0.45
			M. pennsylvanicus	2	0.91
			S. cinereus	4	1.82
Slough; 2nd railroad bridge east of Girdwood	(shot)		*O. zibethica*	2	
Steese Hwy.	?		*Synaptomy borealis*	1	

Totals collected & examined

Species	No. Caught	No. Caught 100 Trap Nights
O. zibethica	6	0.17
C. rutilus	125	3.46
S. borealis	1	--
M. pennsylvanicus	12	0.33
M. oeconomus	11	0.30
M. sp.	3	0.08
Z. hudsonicus	7	0.19
S. cinereus	77	2.13
S. arcticus	6	0.17
S. obscurus	5	
Total mammals	253	6.98

Table II

Summary of Mammal Necropsies

Locality	Species	No. Examined	No. Infected	Percent Infected	No. Worms per Infected Host
Smith Lake	*O. zibethica*	4	0	0	0
	C. rutilus	23	0	0	0
	S. cinereus	33	0	0	0
	S. arcticus	1	0	0	0
	M. pennsylvanicus	1	1	100	2
	M. sp.	1	0	0	0
	Z. hudsonicus	1	0	0	0
Ballaine Lake	*C. rutilus*	6	0	0	0
	M. pennsylvanicus	3	0	0	0
	M. oeconomus	2	0	0	0
	S. cinereus	6	0	0	0
Rat Lake	*C. rutilus*	22	0	0	0
	M. pennsylvanicus	3	1	33.3	1
	M. sp.	1	0	0	0
	S. cinereus	9	0	0	0
	S. arcticus	1	0	0	0
	S. obscurus	3	0	0	0
	Z. hudsonicus	4	0	0	0
Reindeer Lake	*C. rutilus*	10	0	0	0
	M. pennsylvanicus	1	1	100	9
	M. oeconomus	1	0	0	0
	S. cinereus	3	0	0	0
	Z. hudsonicus	2	0	0	0
Middle Lake	*C. rutilus*	20	1	95	3
	S. cinereus	6	0	0	0
	S. arcticus	1	0	0	0
Ace Lake	*C. rutilus*	4	0	0	0
	M. pennsylvanicus	2	1	50	5
	M. sp	1	0	0	0
	S. cinereus	9	0	0	0
	S. arcticus	1	0	0	0
	S. obscurus	1	0	0	0
Airport Float Pond	*C. rutilus*	3	0	0	0
	M. oeconomus	2	0	0	0
	S. cinereus	2	0	0	0
	S. obscurus	1	0	0	0

Locality	Species	No. Examined	No. Infected	Percent Infected	No. Worms per Infected Host
Airport Gravel Pit	_C. rutilus_	1	0	0	0
	M. oeconomus	1	0	0	0
Little Lake	_C. rutilus_	12	0	0	0
"North Pole Lake"	—	—	—	—	—
Gravel Pit, 7.5 miles Richardson Hwy.	_C. rutilus_	2	0	0	0
	M. oeconomus	3	0	0	0
"Stevens Lake"	_C. rutilus_	22	0	0	0
	M. oeconomus	2	0	0	0
Killarney Lake	_C. rutilus_	1	0	0	0
	M. pennsylvanicus	2	0	0	0
	S. cenereus	4	0	0	0
Slough; and railroad bridge east of Girdwood	_O. zibethica_	2	0	0	0
Steese Hwy.	_S. borealis_	1	0	0	0
Totals	_O. zibethic_	6	0	0	0
	C. rutilus	125	1	0.8	3
	S. borealis	1	0	0	0
	M. pennsylvanicus	12	4	33.3	4.2
	M. oeconomus	11	0	0	0
	_M. sp._	3	0	0	0
	Z. hudsonicus	7	0	0	0
	S. cinereus	77	0	0	0
	S. arcticus	6	0	0	0
	S. obscurus	5	0	0	0

Table III

Summary of Snail Collections and Necropsies

Locality	Species	No. Examined	Infected
Smith Lake	*H. trivolvis*	3	0
	L. palustris	41	0
	L. stagnalis	37	0
Ace Lake	*H. trivolvis*	1	0
	L. palustris	46	0
	L. stagnalis	14	0
Ballaine Lake	*H. trivolvis*	35	0
	L. palustris	75	0
	L. stagnalis	19	0
	L. auricularia	22	0
Gravel Pit, 7.5 miles Richardson Hwy.	*L. palustris*	94	0
	L. stagnalis	25	0
Rat Lake	*H. trivolvis*	6	0
	L. palustris	123	0
	L. stagnalis	18	0
Reindeer Lake	*H. trivolvis*	7	0
	L. palustris	24	0
	L. stagnalis	39	0
TOTAL	*H. trivolvis*	52	0
	L. stagnalis	152	0
	L. palustris	403	0
	L. auricularia	22	0
	Total, all snails	629	

(A-020-ALAS) Final Fiscal Report

Reconnaissance Of The Distribution And Abundance Of Schistosomatium Douthitti, A Possible Human Disease Agent In Surface Waters In Alaska

OWRR Funding	Budgeted	Actual Expenditure
Salaries & Wages:		
L. G. Swartz, Principal Investigator, 3 mo. @ $1,466.66/mo.	$4,500.00	$4,400.00
Graduate Assistants, 3 mo. @ $737.75/mo.	1,800.00	2,213.27
Expendable Supplies & Equipment:	125.00	376.69
Other:		
Contractual Services	550.00	118.36
Total	$6,975.00	$7,108.32