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Life cycle and incidence of *Diplostomum spathaceum* Rudolphi (1819) (Trematoda: Diplostomatidae) in Utah

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LIFE CYCLE AND INCIDENCE OF *DIPLOSTOMUM SPATHACEUM* RUDOLPHI (1819) (TREMATODA: DIPLOSTOMATIDAE) IN UTAH

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ABSTRACT.— *Diplostomum spathaceum* (Trematoda: Diplostomatidae) causes a disease known as diplostomatosis (eye fluke disease) and has been found to be widespread throughout the fish of Utah. Totals of 756 snails (5 species), 893 fish (21 species) and 6 species of birds were examined for the presence of larval and adult *D. spathaceum* from 17 collecting sites throughout Utah. Pathologic effects such as blindness, subacute inflammatory reactions, cornea perforation, and ruptured globe due to diplostomatosis upon the fish host are listed. Fish host and parasite infection data of *D. spathaceum* for the major lakes of Utah are given.

Diplostomum spathaceum is a strigeoid trematode (Trematoda: Diplostomatidae) causing a disease of fish known as diplostomatosis or eye fluke disease.

Diplostomatosis was reported in 1974 in Strawberry Reservoir, Utah, a body of water considered to be Utah's number one trout lake. Within the past year (November 1974 to November 1975) a detailed survey of 19 major lakes (Table 4 and Fig. 1) revealed a widespread infection of *D. spathaceum* in fish throughout Utah.

Extensive studies concerned with its life cycle, development, taxonomy, pathology, and control have been carried out on two geographic fronts: the Soviet Union where the fluke is known as *Diplostomum spathaceum* Rudolphi, 1819 (Bauer 1959) and the United States where it was once classified as *Diplostomum flexacaudum* (Cort and Brooks 1928) (Van Haitsma 1930). Recent investigations concerning this fluke have taken place in England, Western Europe, Mexico, Africa, Italy, and the United States. In the western half of the United States numerous local outbreaks have been reported in Colorado, North Dakota, Washington, Idaho, and Utah.

The developmental cycle of *D. spathaceum* is typical of strigeoid life cycles as described by LaRue (Palmer 1939). The egg passes out with the feces of the definitive host, a piscivorous bird, and develops in 21 days into a free-swimming miracidium. The miracidium penetrates and undergoes several asexual multiplications within the hepatopancreas of a variety of snail hosts. Within six weeks daughter sporocysts develop into free-swimming furcocercous cercariae which penetrate the gills, skin, and eyes of a variety of second intermediate fish hosts. Cercariae enter small blood vessels of the gills and fins (Ratanarat-Brockelman 1974) of fish and are conveyed by the blood stream to the eyes (within 30 minutes) where they become infective metacercariae in 45-120 days. Some cercariae may penetrate directly through the lens of the eye. Becker and Brunson

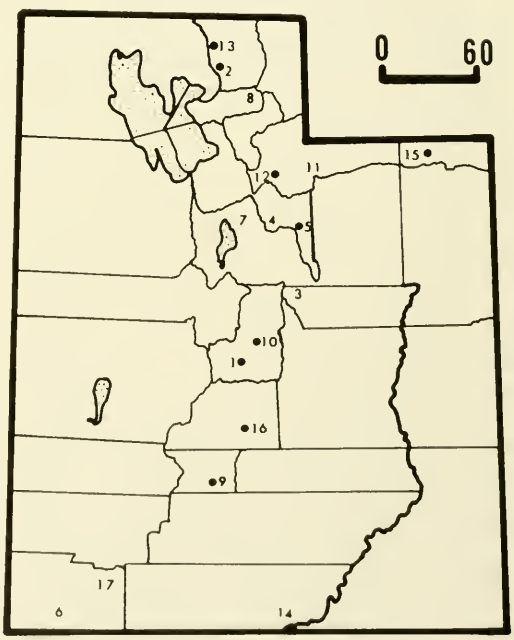

Fig. 1. Collecting sites for intermediate and definitive hosts of *Diplostomum spathaceum* in Utah. Numbers of collecting sites are coded for Table 4. Those sites marked by solid dot symbols were positive for *D. spathaceum*.

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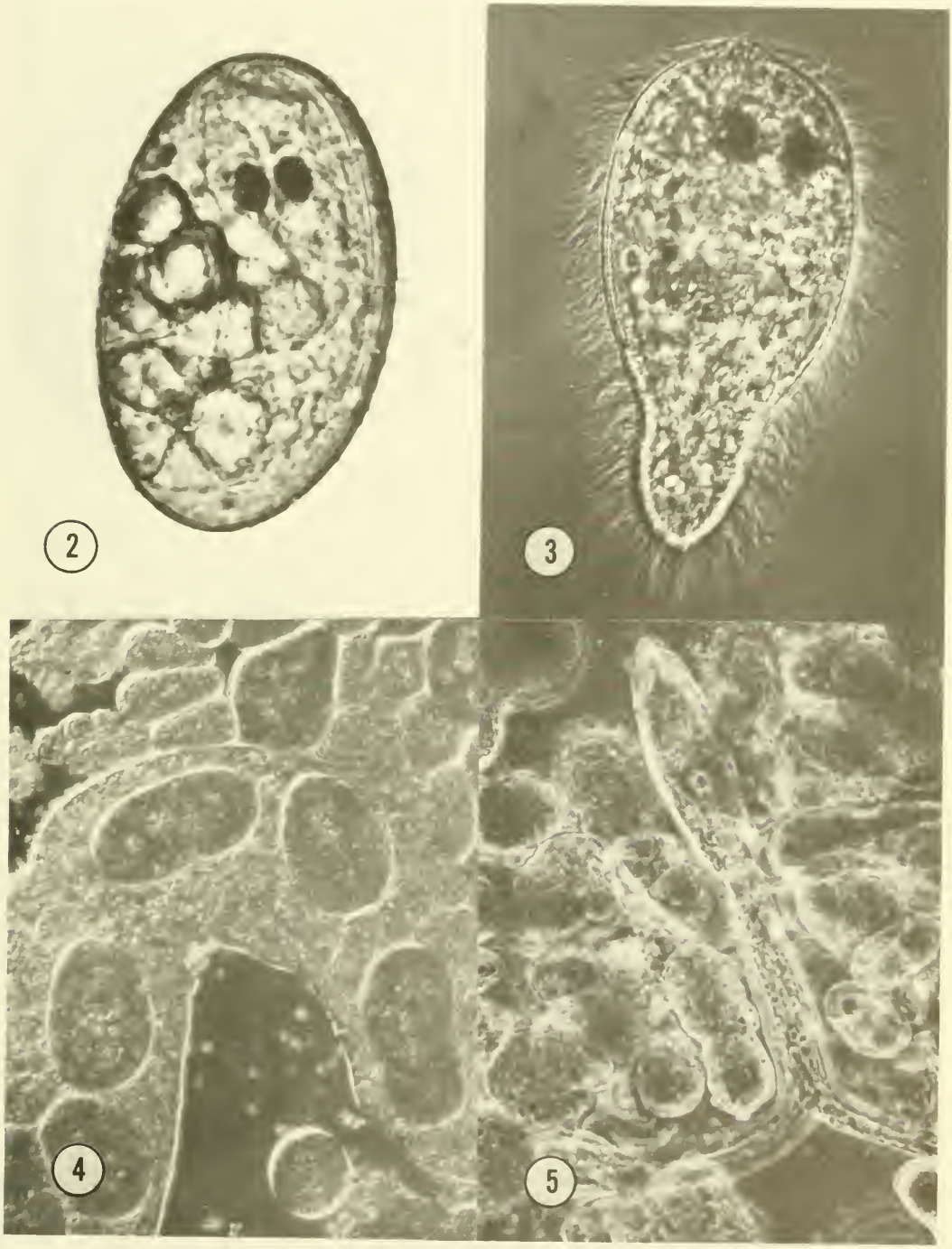
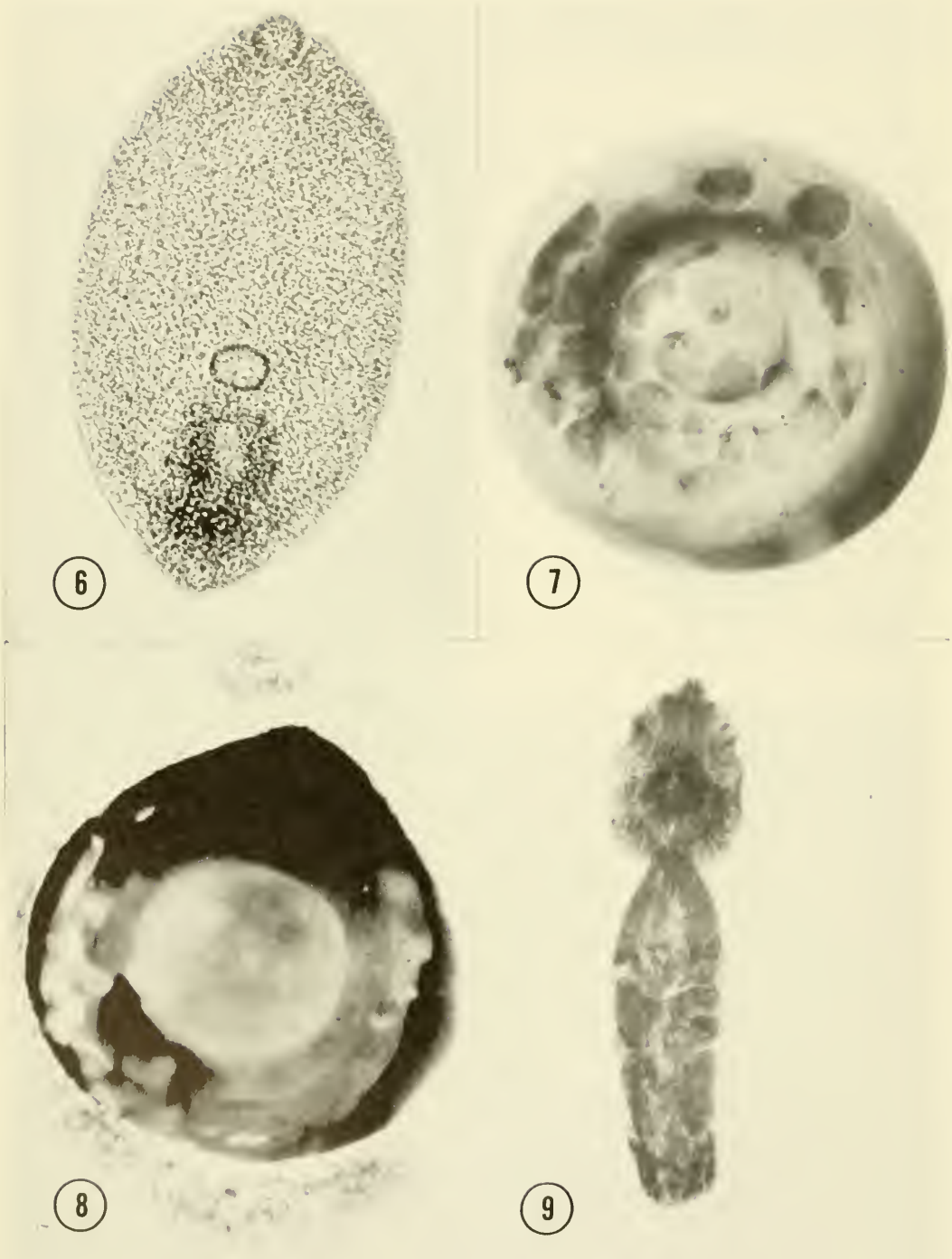
(1960) found that Rainbow Trout (*Salmo gairdneri*) may have acquired *D. spathaceum* by feeding on molluscus containing precocious metacercariae. Once infected fish are ingested by a gull or other piscivorous bird, adult worms develop within the intestine in 3-5 days. Figures 2-9 illustrate the larval and adult stages



Figs. 2-5. Life stages of *Diplostomum spathaceum*: 2, Egg containing unhatched micracidium; 3, Miracidium; 4, Mother sporocyst; 5, Cercaria among daughter sporocysts.



Figs. 6-9. Life stages of *Diplostomum spathaceum*: 6, Metacercaria removed from the eye of an infected fish; 7, Lens of an infected fish containing metacercariae (this lens was fixed and stained); 8, Lens of fish showing effects of metacercariae on the lens; note individual metacercaria and cataract of the inner lens; 9, Adult recovered from a ring-billed gull.

of *D. spathaceum* recovered from snail, fish, and bird hosts throughout Utah. The life cycle of *D. spathaceum* is depicted in Figure 10.

D. spathaceum causes much damage to the eyes of a variety of fish. Mass infection may lead to permanent damage in the form of cataract and herniation and even death of the infected freshwater fish.

Compared with research involving a closely related strigeoid trematode (Palmieri 1975), *D. spathaceum* seems to lack host specificity as a larvae and adult. Recently the danger of infection by the metacercariae of *D. spathaceum* in the eye of humans has received great concern. Ferguson (1943) found that the metacercariae could develop equally well in a variety of vertebrate hosts including fish, amphibians, reptiles, birds, and mammals. Two reports exist in the literature concerning human infections. The first case involved the recovery of four worms within the cataractous lens of a five-month-old child. The second report showed recovery of worms from the eyes of a fifty-five-year-old fisherman (Ashton et al. 1969). In the latter case it was determined that the cataract-causing fluke was similar in size and shape to those flukes reported from the lens of fish.

Because diplostomatosis exists as a potential public health problem in Utah, a one-year study concerned with the natural life history of *D. spathaceum* was initiated. The purpose of this paper is to report the known natural intermediate and definitive hosts, host habitats, and host specificities of *D. spathaceum*.

Materials and Methods

Molluscan hosts.— At each individual collection site (Fig. 1) sampling of all species of potential snail hosts was carried out. Once collected, snails were cooled to

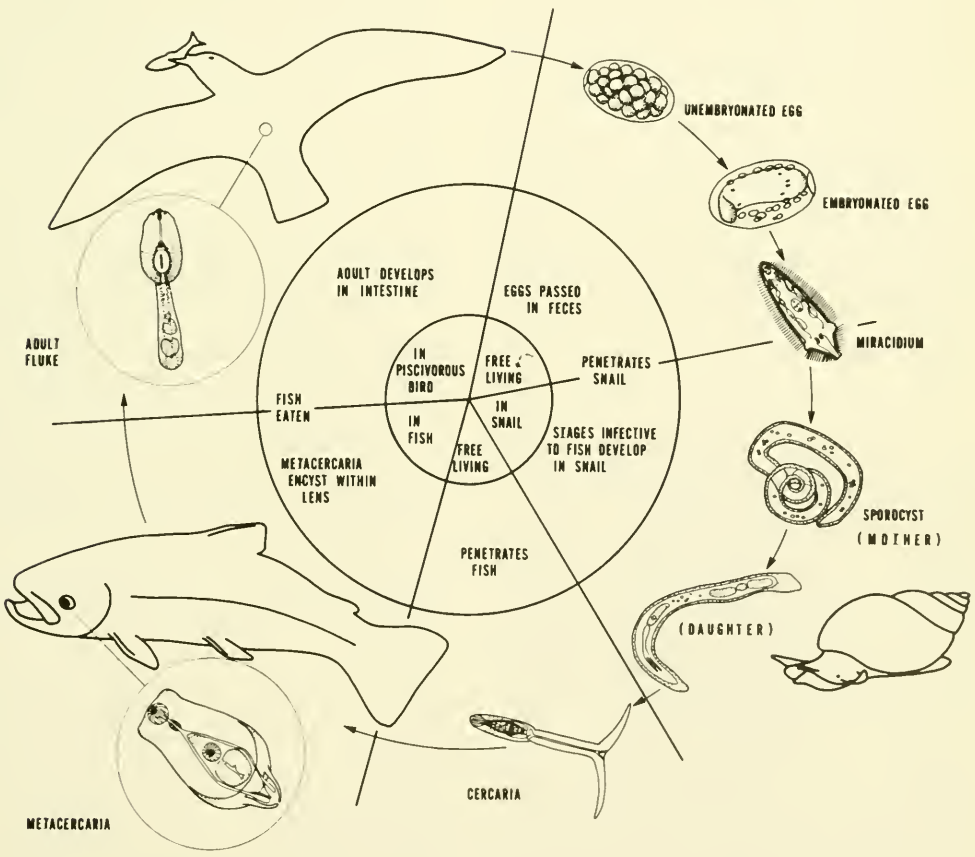


Fig. 10. Life cycle of *Diplostomum spathaceum*.

5 C until examined in the laboratory. Routine laboratory methods were utilized in identification and examination of snail hosts. Identification of sporocysts and shed cercariae of *D. spathaceum* was done at time of examination. Nonshedding snails were measured, crushed, and examined for developing larval forms of *D. spathaceum*. Shedding snails were isolated, cercariae identified and then handled, as were the nonshedding snails.

Fish hosts.— A survey of piscine hosts was accomplished with the cooperation of the Utah Wildlife Resources and local fishermen (creel content examination) at each collection site. Fish were collected by electrofishing, gill net, hook and line, and seine, cooled to approximately 1 C with crushed ice, and returned to the laboratory for examination. In the laboratory fish were weighed, sexed, measured, and examined for metaceracriae of *D. spathaceum*. Each individual eye was extracted and carefully examined, records of fish and lens condition determined, and individual numbers of worms found infecting the right and left eye recorded.

Avian hosts.— Collection of possible avian definitive hosts was accomplished by the use of firearms at each collection site (Fig. 1). Birds were placed in plastic bags and covered with ice until returned to the laboratory. Birds were examined utilizing routine laboratory techniques All birds were examined within 12 hours of collection for adult worms of *D. spathaceum*.

Specimen preparation.— Cercariae of *D. spathaceum*, isolated from infected snails, were fixed in hot buffered (pH 7.2) formalin, dehydrated in ethanol, stained in Mayers paracarmine, counterstained in fast green, cleared in methyl salicylate, and mounted in permount. Both metacercariae and adults of *D. spathaceum* were washed in avian physiological saline, fixed in AFA (alcohol, formalin, and acetic acid), dehydrated in ethanol, and stained, as were the cercariae.

Habitat analysis.— Four ecological variables were recorded: water type (stream, river, pond, lake); water quality (temperature and depth); shoreline characteristics (rocky, light vegetation, heavy vegetation, and sand/silt); and miscellaneous information on host habitat conditions unique to each collection site.

Results

Molluscan hosts.— A total of 756 snails including five species (*Lymnaea palustris*, *L. stagnalis*, *L. auricularia*, *Physa gyrina* and *Gyraulus circumstriatus*) was collected. The only snails shown to be positive for sporocysts and cercariae of *D. spathaceum* were *L. palustris* and *L. stagnalis*, although *L. auricularia* was experimentally infected with *D. spathaceum* in the laboratory. Of 306 *L. palustris* collected, 5.7 percent demonstrated a positive infection for *D. spathaceum*. The range of lengths of *L. palustris* collected was 11-27 mm with the range of infected snails varying from 18 to 22 mm. Although not as common, 6.5 percent of 31 *L. stagnalis* were shown to be infected with *D. spathaceum*. *L. stagnalis* ranged from 13 to 21 mm in length with infected snails showing a narrow length variation of 18 to 19 mm. Of the three other species of snails collected, no sporocyst or cercarial infection of *D. spathaceum* was noted. A complete record of snail collections and percent infections can be found in Table 1.

Fish hosts.— A total of 893 fish including 21 species was recovered at collection sites throughout Utah (Fig. 1). Ten species were found to be natural hosts for metacercariae of *D. spathaceum* (Table 2). Of these ten hosts, all are new state records and *Catostomus discobulus*, *C. platyrhynchus*, *C. ardens*, *Salmo clarki*, *Richardsonius balteatus*, and *Gila atraria* are new host records for *Diplostomum spathaceum* (Table 3). Of the eleven other piscine hosts examined (Table 4), no metacercariae of *Diplostomum* were found.

The rate of infection of *D. spathaceum* varied from 5.8 percent for *Catostomus*

Table 1. Summary of snail hosts examined for *Diplostomum spathaceum* in Utah.

Snails	Number	Percent infected
Lymnaea palustris	306	5.7
Lymnaea stagnalis	31	6.5
Lymnaea auricularia	19	0.0
Physa gyrina	395	0.0
Gyraulus circumstriatus	5	0.0

TABLE 2. Summary of fish hosts positive for metacercariae of *Diplostomum spathaceum* in Utah.

Fish host	Number	Range of infection with Metacercariae (%)
Salvelinus fontinalis	12	0-100
Salmo trutta	13	12.5-100
Catostomus discobolus	26	0-5.8
Salmo clarki	104	0-88
Micropterus salmoides	61	0-49
Catostomus platyrhynchus	72	60.5-100
Salmo gairdneri	346	0-100
Richardsonius balteatus	27	0-100
Gila atraria	89	0-67
Catostomus ardens	14	100

discobulus (Chiselmouth sucker) collected from Flaming Gorge to 100 percent found in seven species of fish from five separate localities (Table 4).

Although the number of metacercariae in the right and left lenses of individual hosts seldom was identical, no significant lens preference was noted. Examination of data related to host-sex susceptibility to infection by metacercariae of *D. spathaceum* revealed no significant correlation.

A complete listing of individual collecting sites, dates of collection, percent of infection of each species of fish by metacercariae of *D. spathaceum*, average number of metacercariae per fish, number of metacercariae in both right and left eyes, average and range of length of fish examined, total number of each species of fish examined at each collecting site, average and range of weight of fish examined as well as fish host sex, can be found in Tables 5 and 6.

BIRD HOSTS.— At each study site avian species seen feeding upon fish were collected and examined for adults of *D. spathaceum*. The six major species of avian hosts recovered were the California gull (*Larus californicus*), ring-billed gull (*L. delawarensis*), western grebe (*Aechmophorous occidentalis*), mallard duck (*Anas platyrhynchus*), American coot (*Fulica americana*), and the eared grebe (*Podiceps casdicus*). The two gulls (*L. californicus* and *L. delawarensis*) represent the only natural infections. Although mallard ducks have been reported as definitive hosts, attempts to experimentally infect them on the laboratory proved unsuccessful.

TABLE 3. Summary of fish negative for metacercariae of *Diplostomum spathaceum* in Utah.

Fish	Number
Lepomis macrochirus	11
Cyprinus carpio	31
Ictalurus punctatus	3
Catostomus latipinnis	17
Thymallus arcticus	15
Ictalurus melas	10
Stizostedion vitreum	2
Morone chrysops	15
Perca flavescens	6
Gilia copei	10
Rhinichthyes cataractae	10

DISCUSSION

Collection sites throughout Utah were of three ecological types: desert lakes, mountain valley lakes, and high alpine lakes. Examination of molluscan, fish and avian hosts at these sites revealed a widespread infection of *D. spathaceum*.

This study indicates *Lymnaea palustris* and *L. stagnalis* as the first intermediate hosts. From the range of size of infected snails, it appears that only older snails harbor this infection in Utah (Table 1).

Infection of the eye capsules of fish intermediate hosts by metacercariae of *D. spathaceum* seems to occur within several families of fish as indicated in Table 2. The ability of cercariae to penetrate and develop within young and old fish, male or female hosts, and fish having exper-

TABLE 4. Collecting sites for intermediate and definitive hosts of *Diplostomum spathaceum* in Utah.

Identification no. *	Collection site	County
1	Nine-Mile Reservoir	Sanpete
2	Mantua	Box Elder
3	Scofield Reservoir	Carbon
4	Deer Creek Reservoir	Wasatch
5	Strawberry Reservoir	Wasatch
6	Ash & Laverkan Creeks	Washington
7	Utah Lake	Utah
8	Pineview Reservoir	Weber
9	Otter Creek Reservoir	Piute
10	Palisades Lake	Sanpete
11	Mirror and Lost Lakes	Summit
12	Rockport Reservoir	Summit
13	Hyrum Reservoir	Cache
14	Lake Powell	Kane and San Juan
15	Flaming Gorge Reservoir	Daggett
16	Fish Lake	Sevier
17	Kolob Reservoir	Washington

*Refers to numbers on Figure 1

TABLE 5. Fish host and parasite infection data of *Diplostomum spathaceum* for the major lakes of Utah.

Date of collection (day/month/year)	Collection locality	Hosts collected	Average and range of length (cm)	Average and range of weight (gm)	Total no. of fish	Total males	Total females
31-V-1975	Deer Creek	*Salmo gairdneri*	31(24-37)	—	17	5	12
		Perca flavescens	22(20-25)	—	5	2	3
		Salmo trutta	50(50)	—	1	1	0
16-V-1975	Nine-Mile	*Salmo gairdneri*	20(14-51)	130(36-750)	20	5	15
3-VII-1975	Reservoir	*Salmo gairdneri*	16(12-16)	—	12	4	8
11-VII-1975		*Salmo gairdneri*	41(34-49)	850(660-1980)	10	2	8
16-V-1975	Sanpete River	*Salmo trutta*	26(19-30)	—	8	3	5
2-V-1975	Mantua Reservoir	*Micropterus salmoides*	20(18-23)	119(87-227)	57	35	22
29-V-1975	Scofield	*Salmo gairdneri*	—	—	61	11	50
	Reservoir	*Gila atraria*	19(10-28)	130(45-355)	34	16	18
		Richardsonius balteatus	11(10-12)	22(15-30)	3	2	1
		Salmo clarki	—	—	6	0	6
12-VI-1975	Ash and Laverkan Creek	*Catostomus discobulus*	16(12-18)	173(50-445)	9	2	8
		Catostomus latipinnis	21(13-32)	72(28-275)	16	8	8
5-VI-1975	Strawberry	*Salmo clarki*	35(21-52)	511(100-1370)	75	41	34
	Reservoir	*Salmo gairdneri*	30(14-49)	382(55-1178)	35	23	12
		Salvelinus fontinalis	36(32-39)	604(415-720)	4	2	2
		Catostomus platyrhynchus	18(16-20)	66(45-110)	21	4	17
		Catostomus ardens	43(42-46)	1078(885-1445)	11	8	3
		Richardsonius balteatus	11(10-12)	13(9-15)	5	1	4
8-VII-1975	Strawberry	*Salmo gairdneri*	—	—	2	0	2
10-VII-1975	Reservoir	*Salmo gairdneri*	—	—	2	1	1
30-X-1975	Strawberry	*Salmo clarki*	—	—	10	—	—
	Reservoir	*Salmo gairdneri*	—	—	53	—	—
		Salvelinus fontinalis	—	—	3	—	—
		Catostomus platyrhynchus	—	—	9	—	—
		Richardsonius balteatus	—	—	22	—	—
27-VI-1975	Pineview	*Salmo gairdneri*	26(22-29)	480(450-625)	9	2	7
		Salmo clarki	25(15-35)	557(440-605)	2	0	7
		Cyprinus carpio	28(21-40)	532(180-1165)	3	1	2

26-VI-1975	Utah Lake	*Morone chrysops*	24(21-25)	155(120-180)	15	6	9
		Cyprinus carpio	40(32-51)	935(615-1495)	10	2	8
		Ictalurus melas	28(26-31)	324(265-460)	10	2	8
8-VII-1975	Otter Creek	*Salmo gairdneri*	—	—	43	11	32
18-VII-1975	Palisades	*Salmo gairdneri*	30(23-37)	317(128-546)	42	13	29
22-VII-1975	High Uinta Mountain Lakes	*Salmo gairdneri*	24(10-37)	236(155-507)	16	4	12
		Salvelinus fontinalis	22(19-37)	139(90-178)	3	1	2
		Salmo clarki	26(26)	170(170)	1	0	1
		Thymallus arcticus	25(24-26)	—	15	13	2
5-VIII-1975	Rockport Reservoir	*Catostomus ardens*	53(52-54)	1475(1275-1675)	2	2	0
		Salmo gairdneri	23(19-29)	110(21-249)	3	2	1
		Gila atraria	18(16-22)	46(10-109)	3	1	2
7-VIII-1975	Hyrum Reservoir	*Catostomus platyrhynchus*	36(21-46)	648(209-1349)	32	17	15
		Salmo gairdneri	35(33-38)	458(400-596)	8	3	5
14-VIII-1975	Lake Powell	*Cyprinus carpio*	34(31-40)	596(428-730)	18	12	6
		Lepomis macrochirus	13(10-23)	68(19-250)	11	10	1
		Micropterus salmoides	37(30-44)	700(477-1044)	4	4	0
		Ictalurus punctatus	31(25-36)	281(137-403)	3	2	1
		Stizostedion vitreum	41(37-45)	959(492-1026)	2	2	0
20-IX-1975	Flaming Gorge	*Catostomus ardens*	40(40)	787(787)	1	0	1
		Gila atraria	25(20-33)	236(95-305)	52	31	21
		Catostomus discobulus	33(25-42)	481(249-1035)	17	11	6
		Salmo gairdneri	32(30-35)	365(305-423)	4	2	2
25-X-1975	Fish Lake	*Gila atraria*	16(12-20)	52(70-110)	9	4	5
		Richardsonius balteatus	11.5(11-12)	10(10)	2	0	2
		Catostomus ardens	39(39)	670(670)	1	0	1
		Salmo gairdneri	32.5(30-35)	408(320-495)	2	1	1
		Salmo trutta	140(81-196)	3539(650-5680)	5	4	1
7-XI-1975	Kolob Reservoir	*Salmo clarki*	26(30-34)	217(120-400)	16	10	6
		Catostomus platyrhynchus	21(19-24)	146(115-205)	10	7	3
		Salvelinus fontinalis	22.5(21-24)	148(120-195)	6	3	3
		Salmo gairdneri	24(20-29)	185(110-295)	3	2	1

TABLE 6. Fish host and parasite infection data of *Diplostomum spathaceum* for the major lakes of Utah.

Date of collection (day/month/year)	Collection locality	Hosts collected	Percent infection of fish	Avg. no. metacercariae in right eye	Avg. no. metacercariae in left eye	Avg number metacercariae/host
31-V-1975	Deer Creek Reservoir	*Salmo gairdneri*	0.0	0.0	0.0	0.0
		Perca flavescens	0.0	0.0	0.0	0.0
		Salmo trutta	0.0	0.0	0.0	0.0
16-V-1975	Nine-Mile Reservoir	*Salmo gairdneri*	55.0	24.5	31.0	55.5
3-VII-1975		*Salmo gairdneri*	100.0	78.0	76.0	154.0
11-VII-1975		*Salmo gairdneri*	100.0	23.9	25.6	49.5
16-V-1975	Sanpete River	*Salmo trutta*	12.5	1.3	10.0	11.3
2-V-1975	Mantua Reservoir	*Micropterus salmoides*	49.0	1.9	2.1	4.0
29-V-1975	Scofield Reservoir	*Salmo gairdneri*	0.0	0.0	0.0	0.0
		Gila atraria	0.0	0.0	0.0	0.0
		Richardsonius balteatus	0.0	0.0	0.0	0.0
		Salmo clarki	0.0	0.0	0.0	0.0
12-VI-1975	Ash and Laverkan Creek	*Catostomus discobulus*	0.0	0.0	0.0	0.0
		Catostomus latipinnis	0.0	0.0	0.0	0.0
5-VI-1975	Strawberry Reservoir	*Salmo clarki*	88.0	4.2	3.1	7.3
		Salmo gairdneri	97.0	18.8	21.2	40.0
		Salvelinus fontinalis	100.0	64.3	76.6	140.9
		Catostomus platyrhynchus	100.0	55.2	56.8	112.0
		Catostomus ardens	100.0	4.9	3.9	8.8
		Richardsonius balteatus	80.0	14.0	16.6	30.6
8-VII-1975	Strawberry Reservoir	*Salmo gairdneri*	100.0	11.5	22.0	33.5
10-VII-1975		*Salmo gairdneri*	100.0	0.5	1.5	2.0
30-X-1975	Strawberry Reservoir	*Salmo clarki*	90.0	1.8	1.3	3.1
		Salmo gairdneri	90.0	7.2	6.1	13.3
		Salvelinus fontinalis	100.0	16.3	14.3	30.6
		Catostomus platyrhynchus	100.0	79.8	77.3	157.1
		Richardsonius balteatus	5.0	3.4	3.8	7.2
27-VI-1975	Pineview	*Salmo gairdneri*	0.0	0.0	0.0	0.0
		Salmo clarki	0.0	0.0	0.0	0.0
		Cyprinus carpio	0.0	0.0	0.0	0.0
26-VI-1975	Utah Lake	*Morone chrysops*	0.0	0.0	0.0	0.0
		Cyprinus carpio	0.0	0.0	0.0	0.0
		Ictalurus melas	0.0	0.0	0.0	0.0
8-VII-1975	Otter Creek	*Salmo gairdneri*	25.6	1.2	2.0	3.2
18-VII-1975	Palisades	*Salmo gairdneri*	95.0	8.8	9.2	18.0
22-VII-1975	High Uinta Mountain Lakes	*Salmo gairdneri*	0.0	0.0	0.0	0.0
		Salvelinus fontinalis	0.0	0.0	0.0	0.0
		Salmo clarki	0.0	0.0	0.0	0.0
		Thymallus arcticus	0.0	0.0	0.0	0.0
5-VIII-1975	Rockport Reservoir	*Catostomus ardens*	100.0	1.5	3.0	4.5
		Salmo gairdneri	0.0	0.0	0.0	0.0
		Gila atraria	67.0	1.0	1.0	2.0
7-VIII-1975	Hyrum Reservoir	*Catostomus platyrhynchus*	60.5	65.1	80.7	145.8
		Salmo gairdneri	0.0	0.0	0.0	0.0
14-VIII-1975	Lake Powell	*Cyprinus carpio*	0.0	0.0	0.0	0.0
		Lepomis macrochirus	0.0	0.0	0.0	0.0
		Micropterus salmoides	0.0	0.0	0.0	0.0
		Ictalurus punctatus	0.0	0.0	0.0	0.0
		Stizostedion vitreum	0.0	0.0	0.0	0.0
20-IX-1975	Flaming Gorge	*Catostomus ardens*	100.0	1.0	1.0	2.0
		Gila atraria	0.0	0.0	0.0	0.0
		Catostomus discobulus	5.8	3.0	0.0	3.0
		Salmo gairdneri	0.0	0.0	0.0	0.0

(Table 6 continued)

25-X-1975	Fish Lake	*Gila atraria*	100.0	14.8	11.6	26.4
		Richardsonius balteatus	100.0	6.0	2.0	8.0
		Catostomus ardens	100.0	29.0	35.0	64.0
		Salmo gairdneri	0.0	0.0	0.0	0.0
		Salmo trutta	80.0	2.5	1.0	3.5
7-XI-1975	Kolob	*Salmo clarki*	0.0	0.0	0.0	0.0
		Catostomus platyrhynchus	0.0	0.0	0.0	0.0
		Salvelinus fontinalis	0.0	0.0	0.0	0.0
		Salmo gairdneri	0.0	0.0	0.0	0.0

ienced a previous infection by metacercariae of *D. spathaceum*, seems to be equal.

The major definitive hosts in Utah are the ring-billed and California gulls. Beginning early in the spring and through late summer, the California gull is most prevalent. Once September arrives the ring-billed gull predominates. This accounts for the change in major definitive hosts throughout the seasons. Although over 38 avian hosts in seven families have been identified as definitive hosts of *D. spathaceum* throughout the world (McDonald 1969), in Utah no other piscivorous avian host was found positive for adult worms of D. *spathaceum*.

The ecological habitats examined in Utah varied greatly. Both desert and mountain valley lakes had the highest rate of infection of *Diplostomum*. The reason for this is indicated by the prevalence of the needed shoreline and bottom vegetation, so important for the development, growth, and reproduction of *Lymnaea stagnalis* and *L. palustris*. The lack of vegetation, snail and gull hosts, as well as the presence of low water temperatures, probably accounts for the low infection rate in high alpine lakes. In several man-made lakes throughout the state, a low rate or absence of infections of diplostomatosis was noted. This is likely due to the lack of shoreline vegetation.

The pathologic effects of *Diplostomum spathaceum* upon the fish host are many. Examination of those fish blinded with cataract (Fig. 9) and containing a heavy burden of larval metacercariae (Fig. 8) revealed stunted growth (length, girth, and weight), abnormal feeding behavior (lack of response to visual stimuli) and decreased visual acuity. Ashton et al. (1969) reported that larvae migrate to the eye via vascularvenous channels and showed that the lens, vitreous, or cortex of the eye may be proliferated with metacercariae. In older fish chronic infections, pronounced subacute inflammatory reactions in the vitreous involving heterophils, eosinophils, and macrophages with ingested lens material occurred. We found other effects of diplostomatosis upon the lens such as keratoconus, bulbothalmos, cornea perforation, ulcer, ruptured globe with lens expulsion and panothalmitis to be common in fish living in lakes which harbor heavy infections.

In summary, the rate of infection of *D. spathaceum* across Utah is high and is increasing in magnitude with time. Many fish species serve as intermediate hosts, but limited numbers of snail and bird hosts are present throughout Utah. The potential for exposure of mammalian hosts exists. Further investigations concerned with the control of diplostomatosis as well as potentials for health hazards to wildlife and man are warranted.

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