 0030-0950/78/0006-0318$1.50/0

INCIDENCE OF BLACK SPOT DISEASE IN FISHES IN CEDAR FORK CREEK, OHIO[1]

TIM M. BERRA and RAY-JEAN AU, Department of Zoology, The Ohio State University, Mansfield Campus, Mansfield, OH 44906

Abstract. A total of 4175 fishes belonging to 29 taxa in 6 families was examined for black spot disease. Of that total, 89% were infected with one or more metacercariae of the strigeid fluke, *Uvulifer ambloplitis*. *Rhinichthys atratulus*, *Semotilus atromaculatus* and *Campostoma anomalum* had the highest incidence of infection and the greatest number of individual parasites. Other pool-dwelling minnows such as *Notropis cornutus* and *Pimephales notatus* were also heavily infected, whereas *Notropis photogenus*, which prefers deep, swift riffles, had very few cysts. The only non-minnows to approach the high totals of the pool-dwelling cyprinids were *Catostomus commersoni* and *Etheostoma nigrum*. *Hypentelium nigricanz*, which prefers faster water than *Catostomus* and three species of *Etheostoma*, which, unlike *E. nigrum*, are riffle dwelling forms, also had lower incidences of infection and fewer cysts. *Cottus bairdi*, another rapid water species, did not develop black spot disease. Only 1 specimen of 225 *Ericymba buccata*, which occur over shifting, sandy bottoms, had a single cyst. Our data suggest that the species which inhabit the slower flowing waters of a stream are likely to be more heavily infected than their relatives which prefer faster water because snail hosts are absent and any cercariae present are more likely to be swept away in rapid water and thus have less of a chance to penetrate a host.

OHIO J. SCI. 78(6): 318, 1978

Black spot disease has been reported from many species of freshwater fishes from a variety of taxonomic groups and ecological niches (Hoffman 1967). At least 6 species of strigeid flukes have been reported to produce black spots in fishes (Olsen 1974), however the life cycles of only two closely related species (*Uvulifer ambloplitis* and *Crassiphiala bulboglossa*) are well known. Hoffman (1955) provided a key to the species.

A common causative agent of black spot disease is the diplostomid trematode *Uvulifer ambloplitis* (Hughes 1927). The life cycle of this metacercarial parasite, which in the older literature is called *Neascus ambloplitis* (=*Crassiphiala amploplitis*) and perhaps even *Cercaria bessiae*, has been studied by Hunter and Sanborn (1930), Hunter (1933), Hunter and Hunter (1934), and Hoffman and Putz (1965). It has been detailed and illustrated by Hugghins (1972) and Olsen (1974). Hoffman and Putz (1965) provided keys to four nominal species of *Uvulifer* which may be synonymous with *U. ambloplitis*.

The life cycle can be summarized as follows. An infected fish is eaten by the final host, a belted kingfisher, *Megaceryle alcyon*. The parasites attach to the intestinal mucosa of the bird where they mature and produce eggs within about 27 days. The eggs are excreted with the host's droppings and hatch into miracidia in approximately 21 days. The miracidia must enter a ram's horn snail (*Helisoma*) where they produce sporocysts which give rise to cercariae that emerge after 42 days. The cercariae penetrate underneath the scales and into the musculature of the fish. Black spots result in about 22 days. *C. bulboglossa* has a similar life cycle. The parasites are not black themselves, but the fish deposit pigment around the encysted metacercariae as a reaction to the presence of the larval parasite (Davis 1967). The avian host is necessary for the completion of the

[1]Manuscript received 18 October 1977 and in revised form 2 May 1978 (#77-82).

life cycle, and should an animal other than a bird eat a diseased fish, there would be no danger of infection (Meyer and Hoffman 1976). There is no known treatment for this disease once a fish has become infected. Control of the disease in artificial situations such as farm pounds might result from vegetation removal which could reduce snail habitat, application of a molluscide, control of kingfishers nesting in the area, and the introduction of snail eaters such as redear sunfish, *Lepomis microlophus* (Spall and Summerfelt 1970).

The purpose of this paper is to report the natural incidence of infection of black spot disease among the fish species in a small North Central Ohio stream, Cedar Fork Creek.

MATERIALS AND METHODS

The study area is a 137 meter section of Cedar Fork Creek, a tributary of the Mohican River, Ohio River drainage, in Richland County, Ohio. Under normal conditions the width is 6–15m and the depth is 0.15–2m. This clear, unpolluted, rapid flowing, gravel-bottomed stream has a resident population of over 30 fish species and a series of alternating pools and riffles. Vegetation consists of filamentous algae with little emergent or floating plant cover. Belted kingfishers frequent the area and ram's horn snails are present. Collections were made, usually from 1030–1200 hours, with a 3m seine of 1.6mm mesh. The fish were preserved in 10% formalin and later transferred to 40% isopropyl alcohol for storage. Black spots were counted on the left side of each fish. This made it possible to sample more specimens, and we assumed that cysts were equally likely on either side. A dissecting microscope was used to differentiate melanophores from cyst pigment. The number of cysts and the total length for each fish were recorded. *U. ambloplitis* was identified by dissecting the cysts from several freshly caught fish species and examining the living metacercariae under the microscope. Since every individual cyst could not be checked on each host, our study may include more than one etiological agent of black spot disease.

RESULTS

A total of 4175 specimens belonging to 29 taxa in 6 families was examined. Of

TABLE 1

Species and total number of fishes examined for black spot disease.

Species	Total No.	No. Infected	% Infected	Avg. TL*	Range TL	Avg. NBS**	Range NBS	NBS** 10mmTL
Campostoma anomalum	419	418	99.7	60	31–148	33	0–475	5.8
Ericymba buccata	225	1	0.4	56	31–87	0	0–1	0.0007
Hybopsis amblops	4	3	75.0	57	47–66	3	0–8	0.5
Notropis cornutus	1793	1766	98.4	57	25–162	27	0–552	4.8
Notropis photogenus	21	20	95.2	91	75–99	11	0–41	1.2
Notropis rubellus	8	3	37.5	67	56–75	1	0–2	0.1
Notropis volucellus	2	0	0.0	57	52–60	0	0	0.0
Phoxinus erythrogaster	1	0	0.0	46	46	0	0	0.0
Pimephales notatus	787	778	98.8	46	20–90	14	0–139	3.0
Pimphales promelas	2	2	100.0	56	50–62	6	3–8	0.9
Rhinichthys atratulus	14	14	100.0	48	30–74	55	29–157	11.5
Semotilus atromaculatus	154	150	97.4	55	30–193	55	0–474	10.7
Carpiodes cyprinus	3	1	33.3	48	34–56	1	0–2	0.1
Catostomus commersoni	209	182	87.0	79	37–230	19	0–145	5.1
Hypentelium nigricans	29	18	62.0	126	39–235	2	0–9	0.2
Moxostoma sp.	25	11	44.0	74	31–350	3	0–32	0.6
Culaea inconstans	3	0	0.0	35	30–43	0	0	0.0
Cottus bairdi	74	0	0.0	46	31–77	0	0	0.0
Ambloplites rupestris	10	5	50.0	53	29–167	1	0–4	0.2
Lepomis sp.	21	5	23.8	61	25–117	1	0–15	0.2
Micropterus dolomieui	11	1	9.1	42	28–67	1	0–8	0.1
Micropterus salmoides	7	0	0.0	49	40–63	0	0	0.0
Etheostoma blennioides	24	21	87.5	55	31–78	9	0–42	1.6
Etheostoma caeruleum	127	110	86.6	43	27–55	6	0–39	1.5
Etheostoma flabellare	13	11	84.6	43	30–50	6	0–18	1.3
Etheostoma nigrum	180	169	93.8	45	27–58	14	0–81	3.2
Etheostoma zonale	6	6	100.0	41	36–45	8	6–11	1.8
Percina caprodes	1	1	100.0	96	96	2	2	0.2
Percina maculata	2	2	100.0	64	63–64	8	1–15	1.3

*Total length of the fishes (TL) are given in mm.

**NBS = number of black spots on left side of each specimen.

this total, 3698 (89%) were infected with one or more metacercariae on the left side (table 1). All *Rhinichthys atratulus* examined were infected, and they had an average of 11.5 black spots per 10mm of total length (TL). Other cyprinids, *Semotilus atromaculatus*, *Campostoma anomalum*, *Notropis cornutus* and *Pimephales notatus* were highly infected with many individual cysts (table 1). However, *Notropis photogenus*, which prefers deep, swift riffles, had only 1.2 cysts per 10mm TL. The only non-minnows to approach the high totals of the pool-dwelling cyprinids were *Catostomous commersoni* and *Etheostoma nigrum*.

Table 2 shows that the average number of black spots per 10mm TL varied from 2.8–5.3, but this did not appear to be a seasonal fluxuation. Nor did there appear to be an obvious relationship between the average TL of the fish and the average number of black spots.

TABLE 2

Seasonal data on incidence of black spot disease and number and size of fishes.

Date	July 1975	Sept 1975	Dec 1975	Apr 1976	July 1976	Dec 1976
Air °C	25.5	16.5	17.5	16.5	25.5	10.0
H_2O °C	22.0	13.5	6.5	11.0	22.5	4.0
No. fish	399	983	756	312	848	877
Avg. NBS*	22.3	21.0	15.3	36.1	16.6	26.7
Avg. TL**	61.0	45.0	40.0	68.0	59.0	70.0
Avg. NBS / 10mm TL	3.7	4.7	3.8	5.3	2.8	3.8

*NBS = Number of black spots on left side of each specimen.
**Total lengths of the fishes (TL) are given in mm.

centrarchids. Representatives from six other families were refractory.

Vinikour (1977), in describing *Neascus rhinichthysi*, indicated that there was a greater incidence of infection in a stream with a higher nutrient load than in a less productive stream. He also reported that dace smaller than 40mm were not infected and the incidence of infection in larger fish was 100% in the more productive stream.

None of the fishes we collected appeared to be in obviously poor condition from a heavy parasite burden. However, reports of the harmful effects of the parasite on fishes are mixed. Hubbs (1927) found that the parasite load of morphologically abnormal *Hybopsis gracilis* was much higher than the load of normal specimens. He attributed this to the tapeworm *Proteocephalus* and indicated that trematodes may have been a contributing factor. Hunter and Hunter (1938) listed several references which showed the harmful effects of parasites and reported that smallmouth bass fingerlings, *Micropterus dolomieui*, experimentally infected with *U. ambloplitis* showed a slight but statistically significant weight loss compared with control fish. Krull (1934) reported that pumpkinseed sunfish, *Lepomis gibbosus*, less than 30mm standard length died 2–4 days following exposure to *Cercaria bessiae* (= *U. ambloplitis*). Larger fish rarely succumed. Krull also described that penetration of the cercariae stimulated the fish to activity and caused the

DISCUSSION

Our figures, although higher in each instance, are similar to those reported by Evans and Mackiewicz (1958) for New York stream fishes. Their data were primarily winter counts, however. Hunter (1933) wrote that 47% of 2 species of *Rhinichthys* from New York and Connecticut were infected with *Neascus rhinichthysi*. In an experimental setting, Hunter and Hunter (1938) counted an average of 392 cysts per smallmouth bass fingerlings. Hoffman and Putz (1965) reported *U. ambloplitis* from 25 species of fishes in four families, however, they were only able to experimentally infect host to "go through the water by spurts in all directions."

Hoffman (1956) found that large numbers of *Crassiphiala bulboglossa* killed *Pimephales promelas* and *Fundulus diaphanus* 10–15 days after experimental infection. He also found no evidence of immunity as previously infected fish could be successfully reinfected. Vaughan and Coble (1975) found that *C. bulboglossa* did not effect the weight-length relationship of yellow perch, *Perca flavescens*, nor did the parasite increase vulnerability of the host to predation by piscivorous fish. Vinikour (1977) showed there was no significant difference in length-weight relationships between *Rhinichthys cataractae* infected and not infected with *Neascus rhinichthysi*.

The stimulus for this study was the casual observation that *Ericymba buccata*, which occurs over shifting sandy bottoms, did not have black spots. Table 1 certainly shows this to be the case. Only 1 specimen of 225 had a single black spot. Wallace (1976 and papers cited therein), who has published extensively on the life history of *Ericymba*, informed us that he has not encountered any specimen in the field or museum which had black spot. Hoyt (1969) noticed only 1 specimen of 1394 *Ericymba* examined that had 1 cyst. Hinson *et al* (1976) noted that *Ericymba* was free of *Crassiphiala bulboglossa* cysts. We feel that this lack of black spot is related to *Ericymba's* preference for more rapidly moving water over an unstable bottom which is not good snail habitat and which promotes rapid dilution of the cercariae.

Cottus bairdi likewise appears free from the disease. No cysts were found on 74 specimens. The reasons why some species are free of the infection are not clear. In the case of the sculpin, perhaps the swift flowing habitat and bottom dwelling niche lowered the chances of infection. The several species of darters present occupied the same portion of the stream, however, were infected, although less so than the pool-dwelling cyprinids and less that *E. nigrum*. This latter species is unusual for a darter in that it seems to prefer pools to riffles. The prickly scaleless skin of sculpins might also have an adverse effect on cercariae penetration. It is interesting to note that *Hypentelium nigricans* had only 0.2 cysts per 10mm TL, while *Catostomus commersoni* had 5.1, probably because *Hypentelium* is found in faster waters than *Catostomus*.

Other species listed in table 1 with a low incidence of infection were not present in sufficient numbers to draw any conclusions. Centrarchids are well known to be infected with black spot, however, the individuals found during this study were mostly juveniles and had probably not been at large long enough to be heavily infected, or the really massively infected individuals may die and not be sampled.

Our data suggest that the species which inhabited the slower flowing waters of a stream were likely to be more heavily infected than their relatives which preferred faster water. A similar conclusion was reached by Cloutman (1974), Hinson *et al* (1976) and Davis and Huffman (1977). This is due to the fact that the intermediate snail host, *Helisoma*, is a quiet-water snail and was not found in the rapid flowing waters of our study area after repeated searches. Furthermore any cercariae that might be present are more likely to be swept away in rapid water and thus have less of a chance to penetrate a host. Other factors such as host specificity, immunity, skin thickness, etc. may be involved as well.

Acknowledgments. Dr. John Crites, Department of Zoology, Ohio State University, verified the identification of *Uvulifer ambloplitis* and critically read and improved a draft of the manuscript. D. G. Cloutman pointed out some references and Ken Deaver helped us in the field. Richard Roberts allowed us access through his property which was subsequently purchased by the senior author. Support for this work was provided by a grant from The Ohio State University Mansfield Campus Faculty Professional Development Committee. Thanks are due Linda Linn who typed the manuscript and Babette Mullet who typed Table 1.

LITERATURE CITED

Cloutman, D. G. 1974 Monogenean and copepod parasites of fishes from the Smoky Hill River, Ellis County, Kansas. Trans. Kansas Acad. Sci. 77: 225–229.

Davis, H. S. 1967. Culture and diseases of game fishes. Univ. of California Press, Berkeley, 332 pp.

Davis, J. R. and D. G. Huffman 1977 A comparison of the helminth parasites of *Gambusia affinis* and *Gambusia geiseri* (Osteichthyes: Poeciliidae) from the upper San Marcos River. Southwest. Natural. 22: 359–366.

Evans, H. E. and J. S. Mackiewicz 1958 The incidence and location of metacercarial cysts (Trematoda: Strigeida) on 35 species of central New York fishes. J. Parasitol. 44: 231–235.

Hinson, G., D. Buth, D. Hendricks and T. Gazda 1976 Prevalence of metacercariae of *Crassiphiala bulboglossa* (Trematoda, Strigeoigea) in fishes of the headwaters of the Embarras River, Illinois. Trans. Illinois State Acad. Sci. 69: 176–187.

Hoffman, G. L. 1955 *Neascus Nolfi* N. Sp. (Trematoda: Strigeida) from cyprinid minnows with notes on the artificial digest recovery of helminths. Amer. Midl. Natural. 53: 198–204.

——— 1956 The life cycle of *Crassiphiala bulboglossa* (Trematoda: Strigeida). Development of the metacercaria and cyst, and effect on the fish hosts. J. Parasitol. 42: 435–444.

——— 1967 Parasites of North American freshwater fishes. Univ. California Press, Berkeley, 486 pp.

——— and R. E. Putz 1965 The blackspot (*Uvulifer ambloplitis* Trematoda: Strigeoidea) of centrarchid fishes. Trans. Amer. Fish. Soc. 94: 143–151.

Hoyt, R. D. 1969 The life history of the Silverjaw minnow, *Ericymba buccata* Cope, in Kentucky, and the anatomy and histology of its cephalic lateral line system. Unpub. Ph.D. dissertation. Univ. of Louisville, Louisville, 237 pp.

Hubbs, C. L. 1927 The related effects of a parasite on a fish. J. Parasitol. 14: 75–84.

Hugghins, E. J. 1972 Parasites of fishes in South Dakota. Bull. No. 484. Agri. Exp. Station, South Dakota State Univ. and South Dakota Dept. of Game, Fish and Parks, Brookings, SD, 73 pp.

Hughes, R. C. 1927 Studies on the trematode family Strigeidae (Holostomidae). No. 8. A new metacercaria, *Neascus amblophtis*, sp. nov., representing a new larval group. Trans. Amer. Microbiol. Soc. 46: 248–267.

Hunter, G. W., III 1933 The Strigeid trematode, *Crassiphiala ambloplitis* (Hughes 1927). Parasitology 25: 510–517.

——— and W. S. Hunter 1934 Further studies on fish and bird parasites. Suppl. 24th Ann. Rept. N. Y. State Conserv. Dept. No. IX, Rept. Biol. Surv. Mohawk-Hudson Watershed: 267–283

——— and W. S. Hunter 1938 Studies on host reactions to larval parasites. I. The effect on weight. J. Parasitol. 24: 477–481.

——— and W. S. Sanborn 1930. Contributions to the life history of *Neascus ambloplitis*, Hughes 1927. J. Parasitol. 17: 108.

Hunter, W. S. 1933 A new Strigeid metacercaria *Neascus rhinichthysi* N. Sp. Trans. Amer. Microbiol. Soc. 52: 255–258.

Krull, W. H. 1934 *Cercaria bessiae*, Cort and Brooks 1928. An injurious parasite of fish. Copeia 1934: 69–73.

Meyer, F. P. and G. L. Hoffman 1976 Parasites and diseases of warmwater fishes. Resource Publ. No. 127, U. S. Dept. Interior, Fish and Wildlife Service. Fish Farming Exp. Station, Stuttgart, AR, 20 pp.

Olsen, O. W. 1974 Animal parasites. University Park Press, Baltimore, 562 pp.

Spall, D. R. and R. C. Summerfelt 1970 Life cycle of the white grub *Posthodiplostomum minimum* (Maccallum 1921: Trematoda, Diplostomatidae), and observations on host-parasite relationsips of the metacercaria in fish. *In:* S. F. Snieszko (ed.) A symposium on diseases of fishes and shellfishes. Amer. Fish Soc. Spec. Publ. No. 5, Washington, DC.

Vaughan, G. E. and D. W. Coble 1975 Sublethal effects of three ectoparasites on fish. J. Fish Biol. 7: 283–294.

Vinikour, W. S. 1977 Incidence of *Neascus rhinichthysi* (Trematoda: Diplostomatidae) on longnose dace, *Rhinichthys cataractae* (Pisces: Cyprinidae), related to fish size and capture location. Trans. Amer. Fish Soc. 106: 83–88.

Wallace, D. C. 1976 Feeding behavior and developemental, seasonal and diet changes in the food of the silverjaw minnow, *Ericymba buccata* Cope. Amer. Midl. Natural. 95: 361–376.