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Running title: Yellow Grub in Black Bass from Ozark and Ouachita Reservoir Lakes

Yellow grub (*Clinostomum margintum*) is a commonly found parasite in fish. Numerous species of fish have been found to harbor the metacercarial stage of this parasite and it presumably can infect any North American freshwater fish (Hoffman 1999). Fish are infected by larval forms released from the first intermediate host, a planorbid snail, which in turn have been infected by larvae hatched from eggs deposited in the water from the definitive host, the fish-eating great blue heron (*Ardea herodias*). The metacercariae can invade most tissues of the host's body with the exception of bone and perhaps internal organs.

Most of the reports of this parasite in Arkansas (and Missouri) have been concerned with black bass (*Micropterus* spp.) with one other major host reported, the channel catfish (*Ictalurus punctatus*), which was found to be heavily infected in a commercial pond in Northwest Arkansas (Daly and Singleton 1994). The first report on yellow grub in Ozark bass was made in 1972 on 72 bass collected from 6 Southwest Missouri streams (Taber 1972). Since then there have been a number of reports from Arkansas but most have concerned infected black bass in rivers and creeks (Daly et al 2002, Daly Jr. et al 1999). One lake study was by Cloutman (1975) who found no yellow grub in 88 largemouth bass from Lake Fort Smith, and very light and uncommon infections in smaller centarchid hosts. Another was by Becker et al (1978) who found no yellow grub in Beaver Lake bass. The purpose of this study was to obtain more data on lake bass hosts and to compare the distribution and abundance of yellow grub in lake bass with bass infections in streams.

In 1990, 17 smallmouth (*M. dolomieu*), 88 spotted (*M. punctulatus*), and 73 largemouth bass (*M. salmoides*) were collected from boat marinas and other bass tournaments and examined for the presence of yellow grub. Necropsy was done on all soft tissues and recorded. The population parameters, as defined by Bush et al 1997, are mean abundance (average/fish), maximum abundance (heaviest infection in a single host), mean intensity (average of infected fish only) and prevalence (percent of infected hosts), Standard length, ranging from 30 to 50 cm, as well as circumference, of bass hosts were measured but no significant correlation was found between size and any of the population parameters; results similar to stream studies by Daly and coworkers.

The new distribution and abundance data of yellow grub in Arkansas upland reservoirs can be found in Table 1. When compared to data on Arkansas streams and older lake reports infection with yellow grub in reservoir lakes is very light compared to those in Ozark and Ouachita streams (Fig. 1). Stream locales were much higher in yellow grub mean abundance with two exceptions: The White River in Northwest Arkansas and in Missouri streams with *M. salmoides*. The first may have been due to an increase of human activity disturbing the herons during at the building of Beaver Dam and the second due to the different susceptibilities of bass species in a stream relative to a lake setting.

Although in Arkansas and Missouri yellow grub in bass are found more abundantly in streams than in lakes that is not necessarily true elsewhere in lake fish. Heavy infections have been found in yellow perch (*Perca flavescens*) from lakes in Northern Minnesota (Elliot and Russert 1949, Fischthal 1949). The size, age, and general conditions of the lake (natural versus man-made) may indicate physical factors that may have something to do with the less infected bass in Arkansas reservoir lakes. Insofar as size of the lakes is concerned, Lake Erie, which is much larger than the Minnesota lakes, has a substantial perch fishery but there have been no reported problems with the grub. Anecdotally, much smaller Lake Simcoe, just north of Lake Erie in Canada has reported infections (*pers. comm.*, Ohio State University Biological Station, Sandusky, Ohio). The lack of ability for the parasite to survive in a reservoir lake environment in Arkansas was best shown by the decreasing prevalence and abundance of *C. marginatum* in largemouth bass (*M. Salmoides*) from pre-impoundment to post-

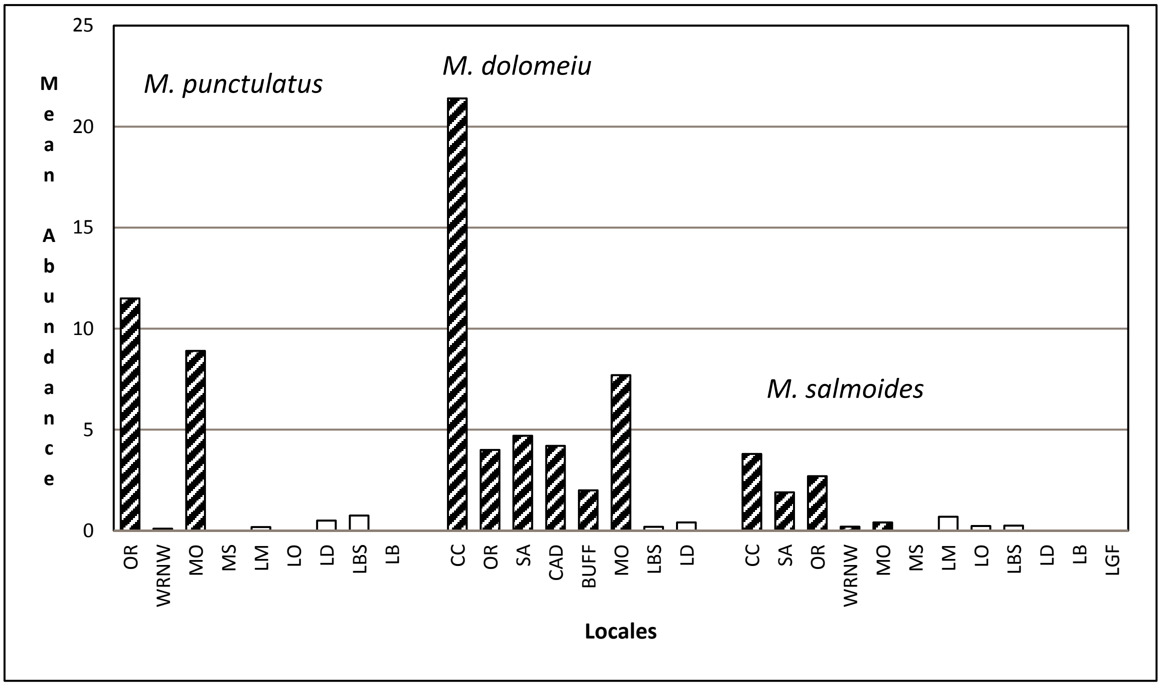

Figure 1. Abundance and distribution of *Clinostomum marginatum* (yellow grub) in Arkansas black bass. The locales are designated with respect to lakes, which are preceded by an L and streams that are not preceded by an L, with the exception of the Maumelle Spillway (MS). Locale abbreviations are as follows: Ouachita river (OR), Pre-impounded river forming Beaver Lake (WRNW), 6 Missouri streams in Southwest Missouri (Mo), Crooked Creek (CC) Saline River (SA), Caddo River (CAD), Buffalo River (BUFF), Lake Maumelle (LM), Lake De Gray (LD), Lake Bull Shoals (LBS), Lake Ouachita (LO), and Beaver Lake (LB). The data on Lakes Ouachita, De Gray, Maumelle, Bull shoals and the Maumelle spillway are newly reported here (Table I.). Data from Crooked Creek and Caddo River are from Daly et al 1992, Daly JJ Jr. et al 1999 and Daly et al 2002. Saline River and Ouachita River data are from Daly et al 2007. Data from other locales are as follows: Buffalo River, Kilambi and Becker 1977; Beaver Lake, Becker et al 1978; Missouri streams, Taber 1972. Data from Arkansas streams are an average for all locales on a given stream. Variances for published data and from lake bass can be found in Literature Cited and Table 1.

impoundment conditions as reported by Becker et al 1978. Populations dwindled to zero. In the same study, another digenetic trematode, *Posthodiplostomum minimum* (white grub), which also uses a planorbid snail and the great blue heron and other fish eating birds as hosts, showed an initial decrease in abundance and prevalence after impoundment but rebounded in the lake after 6 years. Reservoirs are relatively recent in Arkansas when compared to natural bodies of water. One physical factor is that reservoirs are deep and offer less feeding opportunities for the herons than streams. Ponds and shallower lakes such as those in Minnesota and Lake Simcoe may provide more shallow feeding areas for the birds. Given that conditions may not be right for the parasites to develop substantial populations in reservoir lakes may mean that unless adaptive changes are made (unlikely) then they will continue to be mainly river (and pond) parasites in Arkansas. The success of white grubs in Beaver Lake indicates that the three hosts are present, but something in the yellow grub life cycle is missing. Survival of yellow grub depends upon the presence of all three hosts, but the proper dispersion of these hosts is also necessary to affect transmission and keep the reproductive potential at a level needed for maintaining the parasite population. That snail and fish hosts are present in the reservoirs is indicated by some level, albeit low, of yellow grub infections in the bass. Bonett et al 2012, found that salamanders in a small creek with few fish had *C. marginatum* metacerariae that were a genomic match for the same forms in largemouth bass from an adjacent pond indicating infection was spread by herons defecating in the stream which may not have been their preferred feeding area based on paucity of fish in the stream. It would seem likely that the low prevalence of yellow grub in Arkansas reservoir lakes may also be due to infection of snails by transitory herons that were infected by feeding on contaminated fish in streams (or catfish ponds). The maintenance of yellow grub by themselves in the reservoir lake environment is questionable due to very low intensities.

Table 1. Population parameters of *Clinostomum marginatum* in black bass (*Micropterus* spp.) from locales in Ozark and Ouachita Mountain reservoir lakes in Arkansas. Locale abbreviations are identified in Fig. 1: N = Host number, Abundance = mean abundance, Maximum abundance = maximum infection in one host, Intensity = mean of infected hosts only, ± = standard deviation. All bass were donated by boat dock operators, from bass tournaments, and individual fishermen with the exception of Maumelle Spillway bass which were seined.

Locale	N	Prevalence (%)	Maximum	Abundance	Intensity
M. dolomeiu					
Lake Bull Shoals (LBS)	17	12	2	0.19 ± 0.41	1.25 ± 0.43
M. punctulatus					
Maumelle Spillway (MS)	19	0	0	0	0
Lake Maumelle (LM)	55	1.8	10	0.18 ± 0	10
Lake Ouachita (LO)	6	0	0	0	0
Lake DeGray (LD)	4	25	2	0.50 ± 1	2.0
Lake Bull Shoals (LBS)	4	25	3	0.75 ± 1.5	3.0
M. salmoides					
Maumelle Spillway (MS)	29	0	0	0	0
Lake Maumelle (LM)	8	25	3	0.63 ± 1.2	2.5 ± 0.7
Lake Ouachita (LO)	13	23	1	0.23 ± 0.44	1.0 ± 0
Lake DeGray (LD)	4	0	0	0	0
Lake Bull Shoals (LBS)	11	11	2	0.27 ± 0.65	1.5 ± 0.71
Lake Greers Ferry (LGF)	8	0	0	0	0

A caveat, however, is that there may be "hotspots" in the lakes as yet undetected since yellow grub are not uniformly distributed in streams and have low to high intensity locales (Daly et al 2002, Daly Jr. et al 1999, Daly et al 1992). However the lowest abundance found in one locale on an Arkansas stream was 1.5±1.7 (SD) which was greater than any sampling of lake bass hosts seen in Table 1 (Daly et al 1999). Black bass in streams are more restricted territorially than lake bass perhaps providing more opportunities for infection from emerging cercariae. It would seem that the varying intensities of yellow grub infections, whether on lakes or streams, would be evidence for the presence of feeding and/or mating herons and could thus act as "sentinels" for the presence of great blue herons and their numbers. Numbers of yellow grub metacercairae in bass are dependent on the best confluence of heron, snail, and fish hosts and in Arkansas that would seem to be in the upland streams.

Acknowledgements

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