AN ANALYSIS OF SEXUAL DIMORPHISM IN LENGTH AND WEIGHT RELATIONSHIPS OF IOWA DARTERS

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ABSTRACT

Iowa darters, *Etheostoma exile*, are commonly found throughout the Lake Superior watershed. However, given their abundance and non-game status, little is known about basic life history characteristics of these fish. Iowa darters were seined from Inch Lake (Bayfield County, WI) in May of 2010 and 2011 to assess sexual dimorphism in sizes. Collected fish were immediately frozen and later thawed and measured for total length (TL) and total weight (TW), and dissected to remove the gonads which were also weighed. Somatic weight (SW) was calculated for each fish. The mean TL of males and females did not differ. There was a weak difference in the relationships between log(TW) and log(TL) between male and female Iowa darters. There was a strong difference in the relationships between the log(GW) and log(TL) for males and females. However, a significant difference did not exist between log(somatic weight) and log(TL) between males and females. The weak difference in the TL-TW relationship between males and females appear to be due to the strong difference in the TL-GW relationship between the sexes. Additional research is planned to determine whether differences between males and females occur in age structure and diet.

INTRODUCTION

Iowa darters are small fish that are typically found in clear to slightly turbid, light brown water of small lakes, bogs, and small streams (Becker 1983). The range of Iowa darters extends east to New York, west to Montana, north to southern Canada, and south to portions of Illinois (Scott and Crossman 1973; Lee and Gilbert 1978). Most Iowa darters survive for two or three years, at which point they can reach a total length of 76 mm (Copes 1976). They are sexually mature by the age of one and reproduce from April to July, depending on location (Copes 1976). During the spawning period, males, but not females, often exhibit bright blue, green, red, and orange colors (Copes 1976).

Sexual dimorphism, the difference in size and morphology between males and females, is common throughout the animal kingdom and occurs frequently in various fish species, often involving differences in color (Hedrick and Temeles 1989; Moe 2002). Differences in coloration between the sexes of Iowa darters during the spawning period are well known. However, little else is known about other forms of sexual dimorphism in Iowa darters. The objective of this study was to determine if sexual dimorphism was evident regarding total length (TL), total weight (TW), gonad weight (GW), and somatic weight (SW) of Iowa darters.

METHODS

Site description

Iowa darters were collected from Inch Lake, located in the Inch Lake State Natural Area in Bayfield County, Wisconsin (Figure 1). Inch Lake is a 31-acre soft-water seepage lake that has a maximum depth of 12.5 meters ("Wisconsin State Natural Areas Program Inch Lake (No. 499)" 2011). The shoreline consists of both forested and wetland areas. The fish community of

Inch lake is dominated by largemouth bass (*Micropterus salmoides*), yellow perch (*Perca flavecsens*), bluegills (*Lepomis macrochirus*), black crappies (*Pomoxis nigromaculatus*), and bluntnose minnows (*Pimephales notatus*) (D.H. Ogle, Northland College, personal communications). It is a highly regulated lake in that no fish can be harvested, though fishing is allowed only with the use of live bait; motors are prohibited. The substrate in the lake is mainly organic matter with some sand and cobble. In many shallow-water areas, vegetation is abundant. Several trees have fallen into the water along the shoreline, providing sufficient habitat for small fish.

Field methods

Iowa darters were collected in May of 2010 and 2011 using a 12.2 meter beach seine with 6.35 millimeter bar mesh. The seine hauls were completed by walking about 12 meters parallel to the shore. The range of depths of water seined was approximately 0.2 to 1 meters. All fish captured in the seine were identified to species and all Iowa darters were stored in plastic freezer bags filled with ambient-temperature lake water until returned to the lab roughly two hours later, where they were immediately frozen at -12 degrees Celsius.

Lab methods

The Iowa darters were removed from the freezer prior to dissection and allowed to thaw in lukewarm water for 10-15 minutes. Each fish was removed, blotted dry and assigned a unique identification number. Calipers were used to measure the TL of each fish to the nearest 0.1 mm and each fish was weighed on an electronic scale to the nearest 0.001 g.

The tip of a pin was used to remove approximately ten scales from the left side of each fish in the area above the lateral line but below the anterior dorsal fin (Held and Peterka 1974). The scales were spread out on a glass microscope slide and a clear piece of tape was placed over the scales on the slide, which was then labeled with the unique identification number.

Fine dissection scissors were used to open the fish cavity from the vent to the pectoral fins. Stomachs were extracted under a microscope, viewed at 20x magnification, with a cut where the esophagus joins the stomach and another cut along the pyloric sphincter (Fisher 1990). Each extracted stomach was stored in 95% ethanol in microcentrofuge tubes labeled with the unique identification number.

The gonads were removed under a microscope at 20x magnification using fine dissection scissors. The sex was determined by visual examination of the gonads. If the gonads were not found or were too small to be classified, then the sex was recorded as "juvenile" (Khudamrongsawat *et. al* 2005). The gonads were blotted dry using paper towel and were weighed to the nearest 0.001 g. The SW of each Iowa darter was calculated by subtracting the GW from the TW. Each pair of gonads was stored in 95% ethanol in a small microcentrofuge tubes labeled with the unique identification number.

The saggital otoliths were removed from each Iowa darter with fine dissection scissors and forceps under a microscope at 20x magnification. The otoliths were allowed to dry on a labeled glass microscope slide, and a piece of clear tape was placed over the top of them for storage.

Data analysis

Total length frequency histograms were created for males and females and the distributions were compared using a two-sample Kolmogorov-Smirnov test. Mean TL was compared between males and females with a two-sample t-test. The relationships between TW-TL, GW-TL, and SW-TL were compared between males and females with indicator variable regressions on the log-log scale for each relationship. All analyses were performed using the R environment, version 2.14.2 (R Development Core Team 2012) and α=0.05.

RESULTS

The mean length (p=0.9627) and length frequency distributions (p=0.2827) did not differ between males and females (Figure 2). There was a weak difference between males and females in the positive relationship between log(TW) and log(TL) (p=0.09001; Figure 3). While both slopes for males and females were significant, the slope for males was greater than that of the females (slopes=2.6098 and 3.1948 g/mm, respectively). There was a strong difference between the male and female slopes in the positive relationship between log(GW) and log(TL) (p=0.0063; Figure 4). The slope of the female Iowa darters increased significantly with a slope of 4.5354 g/mm while the slope of the male Iowa darters had a slope of 1.0497 g/mm and did not increase significantly. Finally, there was no significant difference between the sexes in the positive relationship between log(SW) and log(TL) (p=0.1724; Figure 5). The significant slope of the male Iowa darters was 2.6957 g/mm and the significant slope of the females was 3.1748 g/mm (p=0). However, there was a strong difference between the y-intercepts of the males and females ($p=1.1245*10^{-11}$).

DISCUSSION

There was a weak difference in the relationship between log(TW) and log(TL) and a strong difference in the relationship between log(GW) and log(TL) for males and females. Two studies conducted using the vermilion darter (*Etheostoma chermocki*) and the warrior darter (*Etheostoma bellator*) also found that the standard length was significantly correlated with body weight and gonad weight (Khudamrongsawat *et. al* 2005; Khudamrongsawat and Kuhajka 2007). In contrast to Iowa darters, though, the warrior darter males were larger than the female darters (Khudamrongsawat and Kuhajka 2007). This discrepancy between males and females of different species shows that not all trends in sexual dimorphism may be the same among species and, therefore, cannot be applied to all darter species.

The observed relationships between log(TW)-log(TL) and log(GW)-log(TL) for male and female Iowa darters may be related. The female Iowa darters had a greater slope than that of the males which contributed to the statistically different relationship in log(GW)-log(TL) data between males and females. The greater female GW may have caused the weak difference in the relationships between log(TW) and log(TL), ultimately causing a slightly greater overall female TW. The lack of a significant difference in the relationships between log(SW) and log(TL) for the sexes further supports this idea. As theorized for the Arkansas darter (*Etheostoma cragini*), it is possible that the significantly different log(GW)-log(TL) relationships between the sexes could be related to the early development of mature gonads in males, which consumed any other potential growth energy available (Taber *et al.* 1986).

This study had some limitations. The Iowa darters collected were from May 2010 and 2011, which only provided data for fish from two different years. If data were collected during the next few years, relationships could be compared between the years to see if there was any

temporal variation in the log(TW)-log(TL), log(GW)-log(TL), and log(SW)-log(TL) relationships. Additionally, the Iowa darters were collected by several different people. In the future, it would be most effective to limit the number of people collecting and handling the darters in order to eliminate any discrepancies between the ways in which the darters are collected. Finally, additional data will be collected from Iowa darters in order to determine if any differences occur between males and females in diet and age structure.

It is important to note that these data were collected from Inch Lake, a very unique lake to the Lake Superior Watershed area. Prior to 2007, fishing was permitted in this lake. However, in 2007, the WDNR implemented no-harvest regulations. This significant change in angling regulation may have an effect on species composition and recruitment for certain species, but little research has been done on such a drastic change in regulation. The Iowa darter data collected from the darters in Inch Lake may play an important role in the determination of whether Iowa darters are indirectly affected by the no-harvest regulations.

REFERENCES

Becker, G. C. 1983. Fishes of Wisconsin. University of Wisconsin Press pp 940-941.

Copes, F. A. 1976. The Iowa darter *Etheostoma exile*. American Currents. Nov.-Dec.

Fisher W. L. 1990. Life history and ecology of the orangefin darter *Etheostoma bellum* (Pisces: Percidae). American Midland Naturalist 123: 268-281.

Hedrick, A. and E. Temeles. 1989. The evolution of sexual dimorphism in animals: hypotheses and tests. Trends in Ecology and Evolution 4:136-138.

Held, J. W. and J. J. Peterka. 1974. Age, growth, and food habits of the flathead minnow, *Pimephales promelas*, in North Dakota saline lakes. Transactions of the American Fisheries Society 103: 743-756.

Khudamrongsawat, J., D. A. Arrington, B. R. Kuhajda, A. L. Rypel. 2005. Life history of the endangered vermilion darter, *Etheostoma chermocki*, endemic to the Black Warrior River System, Alabama. Journal of Freshwater Ecology 20:469-477.

Khudamrongsawat, J. and B. R. Kuhajka. 2007. Life history of the warrior darter (*Etheostoma bellator*) and comparison with the endangered vermillion darter (*Etheostoma chermocki*). Journal of Freshwater Ecology 22: 241-248.

Lee, D. S. and C. R. Gilbert. 1978. *Etheostoma exile* (Girard), Iowa darter. Atlas of North American Freshwater Fishes. North Carolina State Museum of Natural History, Raleigh. pp 646.

Moe, M. 2002. The breeder's net: science, biology and terminology of fish reproduction. Advanced Aquarist 1(5). Accessed on 24 Apr. 2012.

R Development Core Team (2012). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. URL http://www.R-project.org/.

Scott, W. B. and E. J. Crossman. 1973. Freshwater Fishes of Canada. Fisheries Research Board of Canada Bulletin 184:1–966.

Taber, C. A., B. A. Taber, and M. S. Topping. 1986. Population structure, growth and reproduction of the Arkansas darter, *Etheostoma cargini* (Percidae). The Southwestern Naturalist 31: 207-214.

"Wisconsin State Natural Areas Program Inch Lake (No. 499)." *Inch Lake State Natural Area*. 18 Nov. 2011. Web. Accessed on 24 Apr. 2012. <http://dnr.wi.gov/org/land/er/sna/index.asp?SNA=499>.

APPENDIX

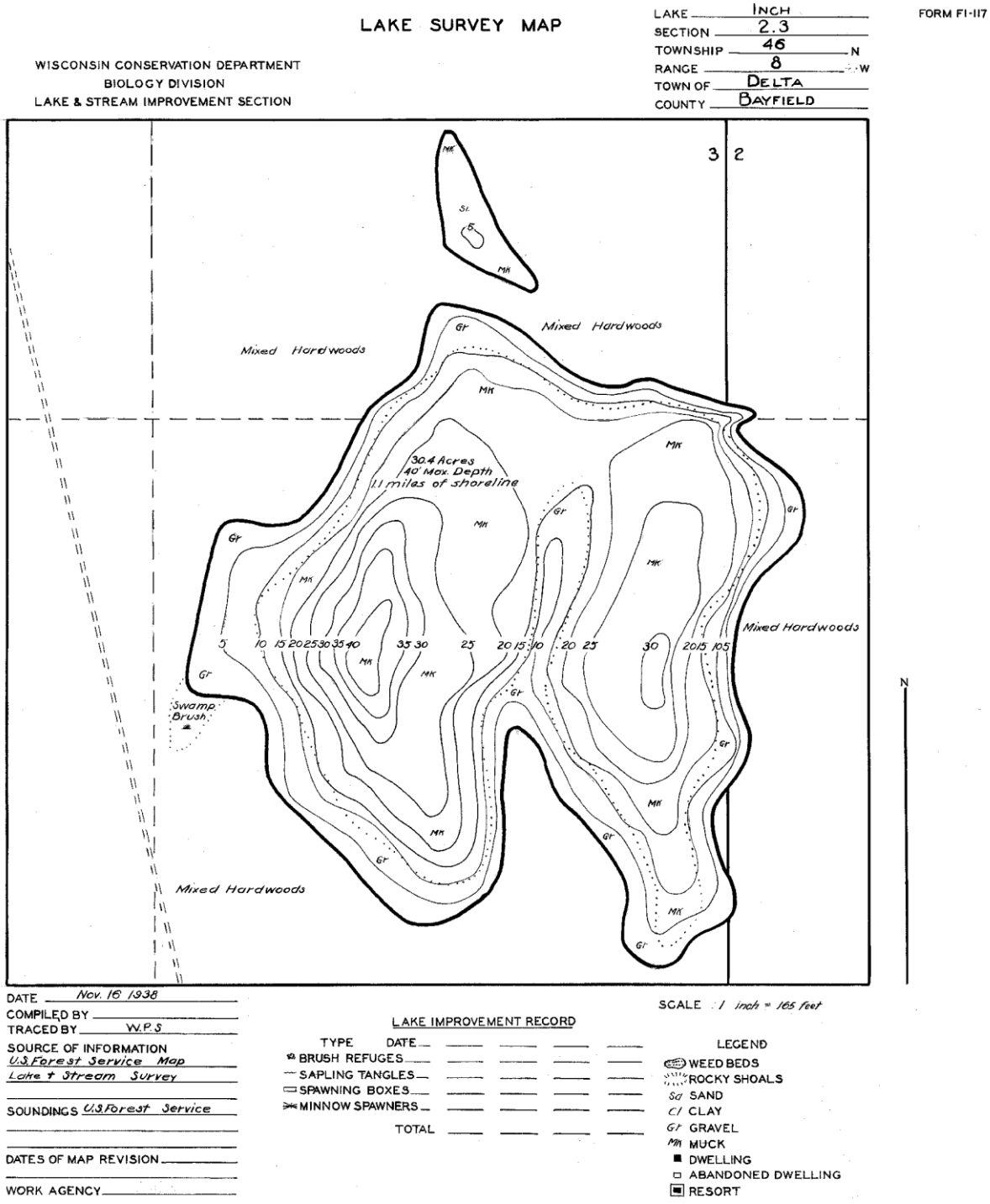

Figure 1. Department of Natural Resources map of Inch Lake providing information regarding sediments, vegetation, and depths in areas of the lake.

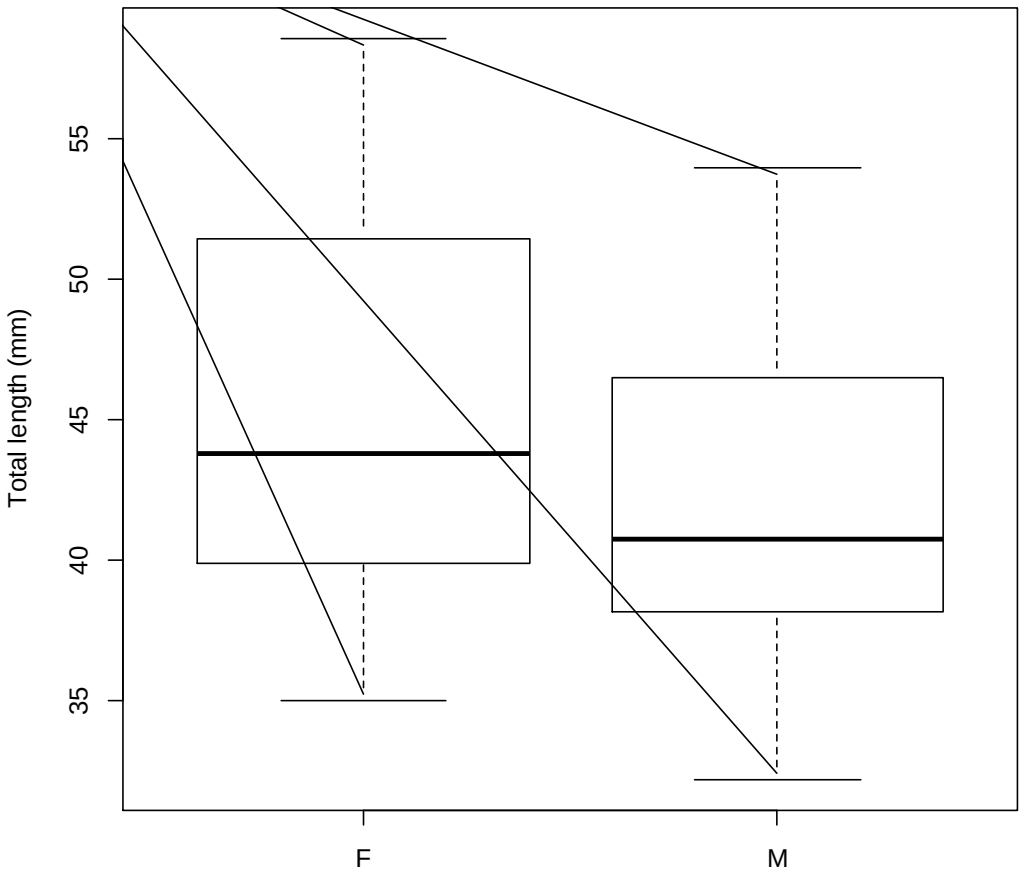

Figure 2. Boxplot of total length of female (F) and male (M) Iowa darters in Inch Lake, WI.

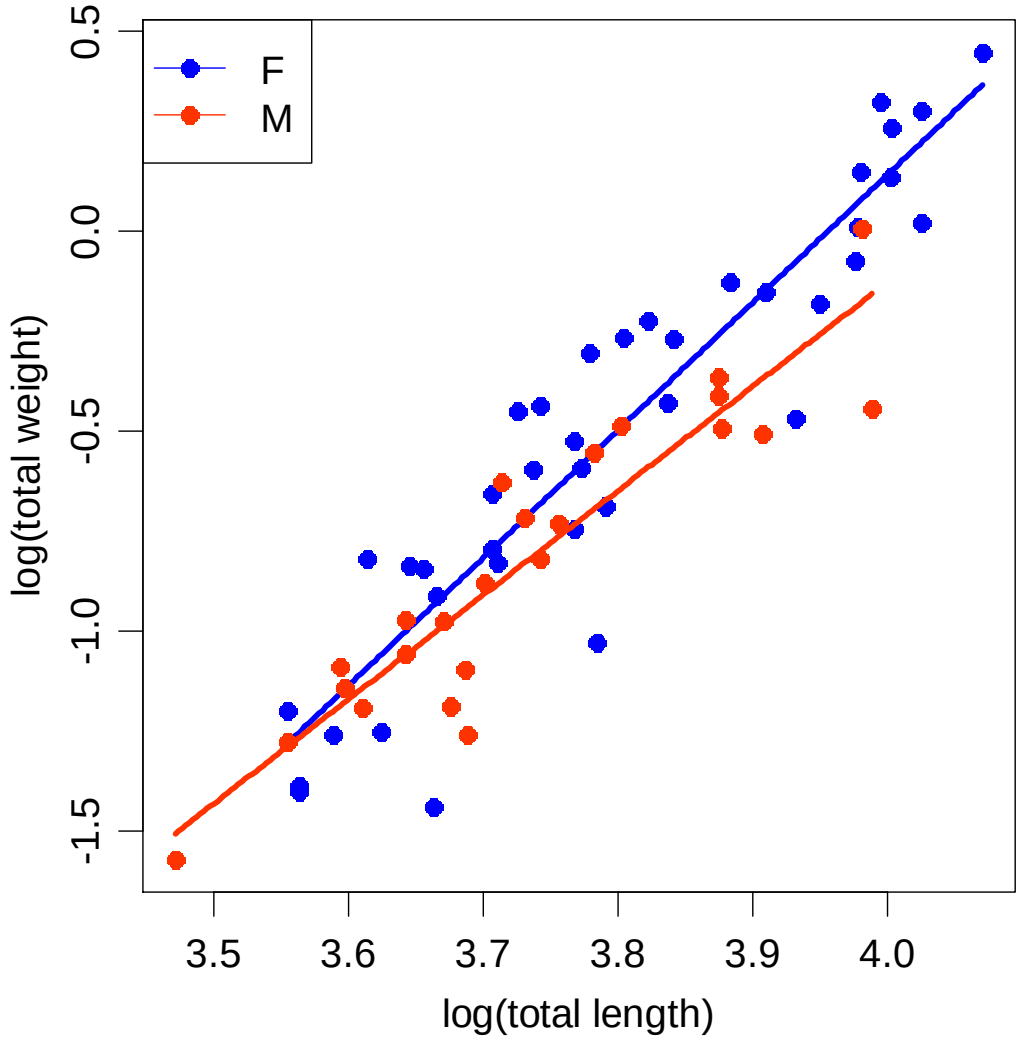

Figure 3. Total weight (g) versus total length (mm) for female (F) and male (M) Iowa darters in Inch Lake, WI. Note that both axes are on the log scale.

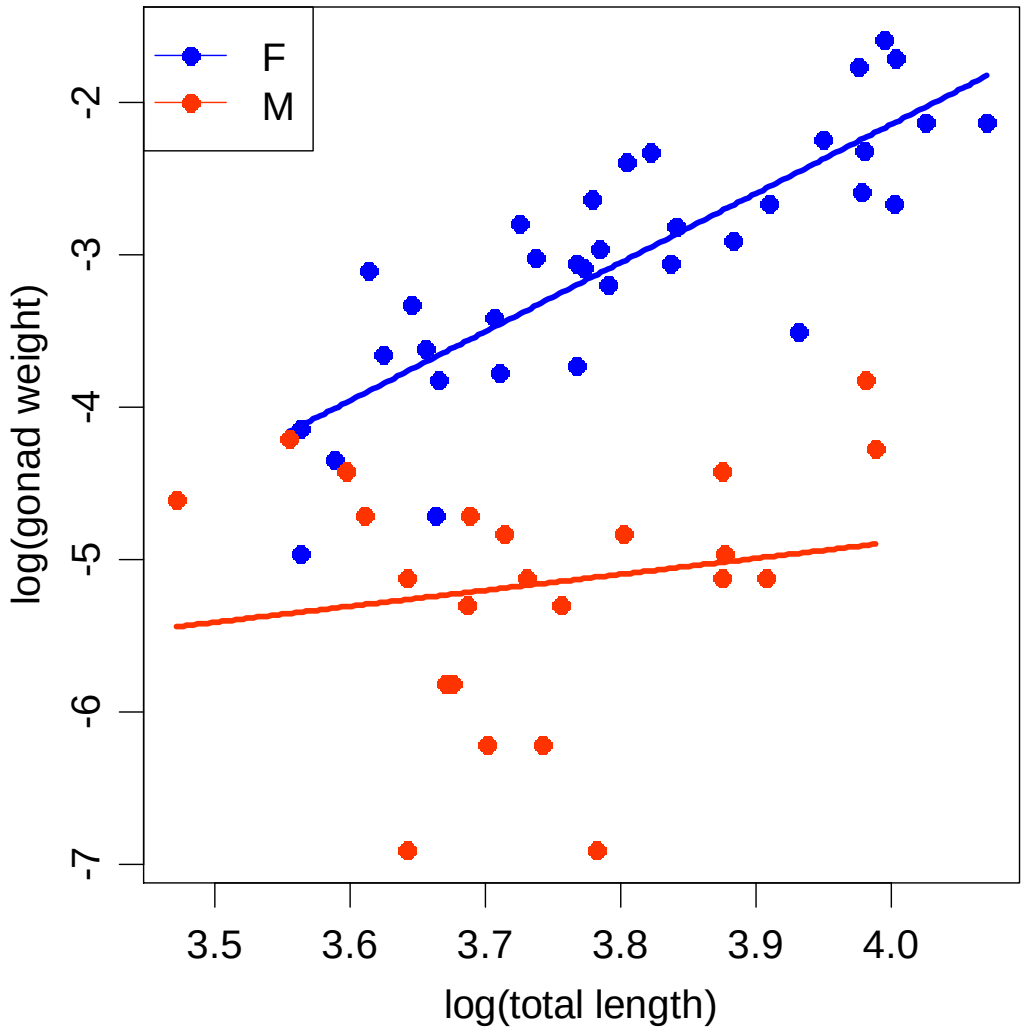

Figure 4. Gonad weight (g) versus total length (mm) for female (F) and male (M) Iowa darters in Inch Lake, WI. Note that both axes are on the log scale.

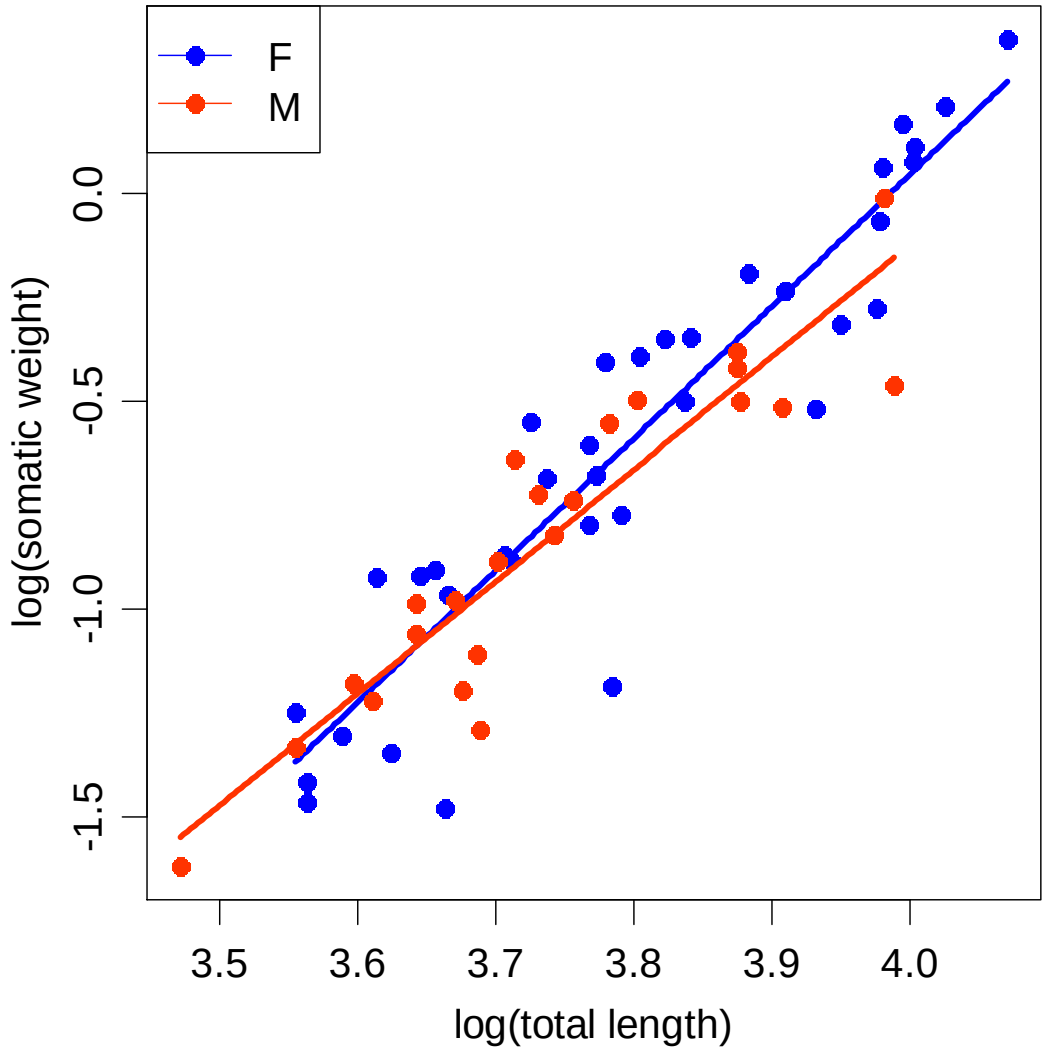

Figure 5. Somatic weight (g) versus total length (mm) for female (F) and male (M) Iowa darters in Inch Lake, WI. Note that both axes are on the log scale.