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GAPE:BODY SIZE RELATIONSHIP FOR SMALL-MOUTH BASS

The types and sizes of prey fishes consumed by predatory fish often are limited by gape dimensions of the predator (Slaughter and Jacobson 2008). In general, the size of prey consumed is positively related to predator size when prey are available across a wide range of sizes (Werner and Hall 1974). Opportunistic predators with large gape dimensions, such as smallmouth bass (*Micropterus dolomieu*), may consume a wide range of prey types and sizes, thereby exerting top-down influences on prey population dynamics and potentially restructuring aquatic communities (e.g., Werner and Hall 1974, Jackson 2002). Although feeding ecology of smallmouth bass varies with location and prey availability, they typically undergo several ontogenetic diet shifts throughout their development. After yolk sac depletion and as smallmouth bass increase in size from larvae to juveniles (~50 mm total length; TL), targeted prey typically proceeds from microcrustaceans (e.g., copepods) to larger zooplankters (e.g., cladocerans) to macroinvertebrates (e.g., ephemeropterans; Brown et al. 2009). Opportunistic feeding behaviors become more apparent during the juvenile stage (TL > 50 mm) when smallmouth bass begin to consume readily available aquatic macroinvertebrates and prey fishes (Clady 1974, Easton and Orth 1992). Studies evaluating adult feeding ecology highlight the importance of crayfish (Gangl et al. 1997, Liao et al. 2002, Bacula 2009) but also reveal the piscivorous nature of smallmouth bass in some locations (e.g., Jackson 2002, Liao et al. 2002, Bacula 2009, Wuellner et al. 2010).

Predation by smallmouth bass has the potential to influence population dynamics of prey fishes and to restructure aquatic communities. For example, high consumption rates by introduced populations of smallmouth bass lead to extirpation of several native cyprinids in Ontario waters (Jackson 2002). Additionally, there is concern in South Dakota that smallmouth bass predation may be adversely influencing recruitment of yellow perch (*Perca flavescens*; e.g., Bacula 2009). To understand the potential top-down influences on prey fish populations by predatory fishes such as smallmouth bass, it is important to understand the limitations of that predator's gape.

Although smallmouth bass diets and predatory impacts have been previously evaluated, relationships between horizontal gape width (GW) and total length (TL) have not been defined; previous studies have used the published relationship for ecomorphologically similar butterfly peacock bass (*Cichla ocellaris*; $GW = 0.12[TL] - 2.69$; Norton and Brainerd 1993, Hill et al. 2004, Wuellner et al. 2010). Use of ecomorphological surrogates in estimating predation potential may lead to erroneous conclusions regarding the extent of predation and magnitude of predatory impacts, especially if the surrogate relationship substantially over- or underestimates horizontal GW. The primary objective of this study was to quantify the relationship between GW and TL for

smallmouth bass. A secondary objective was to compare the GW:TL relationship developed for smallmouth bass to the GW:TL relationship previously developed for butterfly peacock bass.

We collected smallmouth bass from Clear Lake, Marshall County, South Dakota during August and September 2013 primarily using nighttime shoreline electrofishing for adults (i.e., >180 mm TL) and beach seines for juveniles (i.e., <180 mm TL), although some juvenile bass were collected via electrofishing. Additionally, catches of adult smallmouth bass were supplemented with fish captured via hook and line by a regional recreational angling association. For all smallmouth bass collected, we measured TL and maximum horizontal GW to the nearest mm; maximum horizontal GW was measured by stretching the mouth open and measuring the distance between the outside edges of the maxillary bone (Lawrence 1958, Hill et al. 2004, Slaughter and Jacobson 2008). We used simple linear regression to quantify the relationship between GW and TL, and to estimate the percent of variability in GW explained by TL. Once the GW:TL relationship was defined, we estimated horizontal GW for a population of smallmouth bass in Lake Sharpe, South Dakota, using the empirical equation for smallmouth bass defined herein and the previously-defined equation for butterfly peacock bass. We collected smallmouth bass from the lower reaches of Lake Sharpe from May to October 2006–2007 using short-term and overnight experimental gill net sets; we measured TL of all bass (Wuellner et al. 2010). We compared predicted mean horizontal GW as estimated with each equation using a two-sample t-test. We evaluated differences in the relationships between GW and TL defined by each equation using an analysis of covariance (ANCOVA). For all tests, differences were deemed statistically significant at $\alpha = 0.05$. All statistical analyses were performed using the Statistical Analysis System software package (SAS Institute 2010).

We measured horizontal GW (range = 4 mm to 65 mm) for 214 smallmouth bass ranging from 48 mm to 486 mm TL. As expected, GW increased linearly with increasing TL (Fig. 1), and approximately 97% ($P < 0.001$) of the variation in GW was explained by TL. The relationship between GW and TL for smallmouth bass is expressed as $GW = 0.13(TL) - 1.05$. Across the range of TL, GW estimated with the equation defined herein was significantly greater than GW estimated with the equation for butterfly peacock bass ($t_{1248} = -9.48$, $P < 0.001$). Additionally, the difference in GW estimated with each equation was greater for larger smallmouth bass ($F_{1,1246} = 1,533.11$, $P < 0.001$; Fig. 2).

Collectively, our results provide important information relative to estimating the predation potential of smallmouth bass on other organisms. By quantitatively defining the relationship between GW and TL for smallmouth bass, we have provided the basis for further evaluation of gape limitation, extent of predation, and magnitude of predatory impacts in systems where bass are present or may be introduced (*sen-*

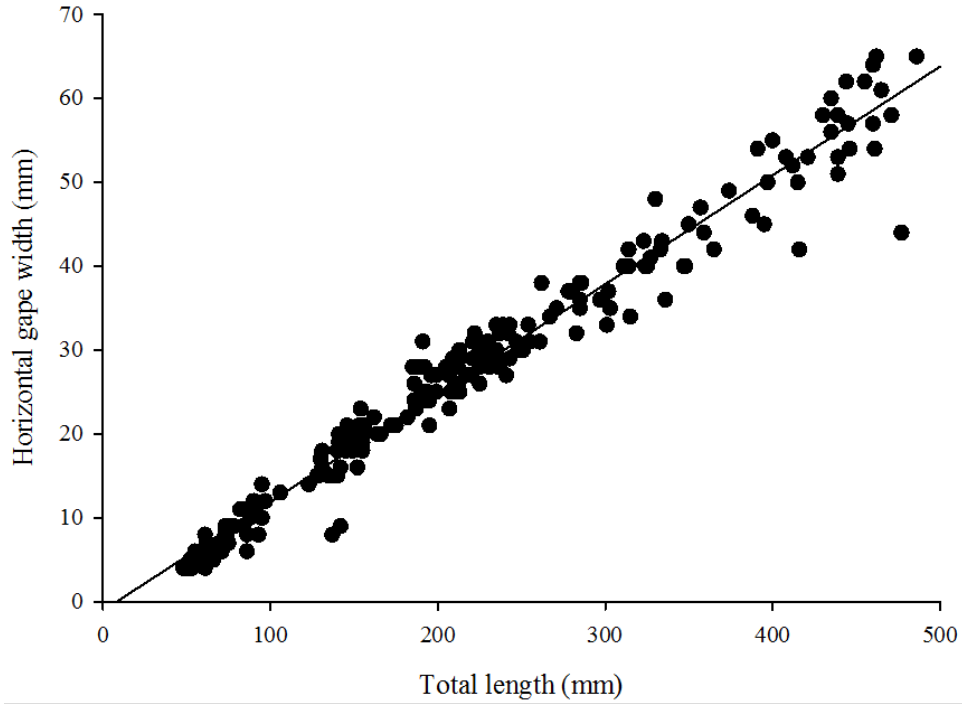


Figure 1. Scatterplot and trend line depicting the empirical relationship between maximum horizontal gape width and total length of smallmouth bass collected from Clear Lake, Marshall County, South Dakota, USA, August–September 2013.

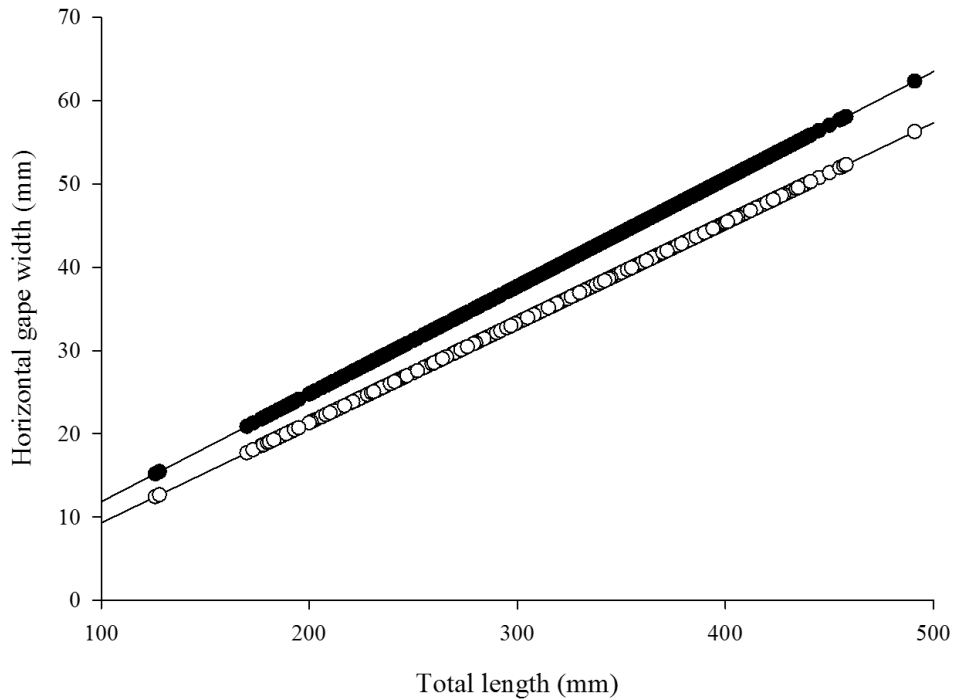


Figure 2. Predicted horizontal gape widths of smallmouth bass derived from gape width (GW):total length (TL) relationships for smallmouth bass (filled circles; $GW = 0.13[TL] - 1.05$) and butterfly peacock bass (open circles; $GW = 0.12[TL] - 2.69$). Note the greater divergence in estimated gape width at larger total length.

su Slaughter and Jacobson 2008). Furthermore, our results demonstrate that previous studies applying the GW:TL relationship for butterfly peacock bass to smallmouth bass may have substantially underestimated the extent of predation and magnitude of predatory impacts of smallmouth bass. For example, Wuellner et al. (2010) estimated GW of smallmouth bass using the published relationship for butterfly peacock bass to compare the sizes of gizzard shad (*Dorosoma cepedianum*) consumed between smallmouth bass and walleye (*Sander vitreus*) and to make inferences regarding the extent of competitive interactions between smallmouth bass and walleye in Lake Sharpe, South Dakota. Owing partially to differences in gape limitation, smallmouth bass consumed a narrower length range of gizzard shad than walleye, which may have reduced the potential for interspecific competition for available prey resources. However, our findings suggested that actual smallmouth bass gape limitations were underestimated using the relationship for butterfly peacock bass. Thus, a larger length range of gizzard shad was vulnerable to predation by smallmouth bass, indicating that the sizes of shad consumed may be more similar between the two predators than previously thought.

We anticipate that application of this relationship will be useful in assessing predatory and competitive interactions between smallmouth bass and other fishes and are continuing work to estimate the upper size limit of prey available for consumption by various sizes of smallmouth bass. Further work also is underway to estimate relationships between prey body depth and smallmouth bass GW, with specific application to estimating relative vulnerability (Hambright 1991) of yellow perch and other prey items (e.g., crayfish) to predation by smallmouth bass across a broad range of TL.

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LITERATURE CITED

- Bacula, T. D. 2009. Smallmouth bass seasonal dynamics in northeastern South Dakota glacial lakes. Thesis. South Dakota State University, Brookings, USA.
- Brown, T. G., B. Runciman, S. Pollard, A. D. A. Grant, and M. J. Bradford. 2009. Biological synopsis of smallmouth bass (*Micropterus dolomieu*). Canadian Manuscript Report of Fisheries and Aquatic Sciences 2887, Nanaimo, British Columbia, Canada.
- Clady, M. D. 1974. Food habits of yellow perch, smallmouth bass, and largemouth bass in two unproductive lakes in northern Michigan. *American Midland Naturalist* 91:453–459.
- Easton, R. S., and D. J. Orth. 1992. Ontogenetic diet shifts of age-0 smallmouth bass (*Micropterus dolomieu* Lacepède) in the New River, West Virginia, USA. *Ecology of Freshwater Fish* 1:86–98.
- Gangl, R. S., K. L. Pope, and D. W. Willis. 1997. Seasonal trends in food habits and growth of smallmouth bass in Lake Poinsett, South Dakota. South Dakota Department of Game, Fish and Parks, Fisheries Division Report 97-5, Pierre, USA.
- Hambright, K. D. 1991. Experimental analysis of prey selection by largemouth bass: Role of predator mouth width and prey body depth. *Transactions of the American Fisheries Society* 120:500–508.
- Hill, J. E., L. G. Nico, C. E. Cichra, and C. R. Gilbert. 2004. Prey vulnerability to peacock cichlids and largemouth bass based on predator gape and body depth. *Proceedings of the Annual Conference of the Southeastern Association of Fish and Wildlife Agencies* 58:47–56.
- Jackson, D. A. 2002. Ecological impacts of *Micropterus* introductions: the dark side of black bass. Pages 221–234 in D. P. Phillip and M. S. Ridgway, editors. *Black bass: ecology, conservation, and management*. American Fisheries Society, Bethesda, Maryland, USA.
- Lawrence, J. M. 1958. Estimated sizes of various forage fishes largemouth bass can swallow. *Proceedings of the Annual Conference of Game and Fish Commissioners* 114:59–69.
- Liao, H., C. L. Pierce, and J. G. Larscheid. 2002. Diet dynamics of the adult piscivorous fish community in Spirit Lake, Iowa, USA, 1995–1997. *Ecology of Freshwater Fish* 11:178–189.
- Norton, S. F., and E. L. Brainerd. 1993. Convergence in the feeding mechanics of ecomorphologically similar species in the Centrarchidae and Cichlidae. *Journal of Experimental Biology* 176:11–29.
- SAS Institute. 2010. SAS/STAT user's guide. Cary, NC: SAS Institute.
- Slaughter, J. E., IV, and B. Jacobson. 2008. Gape:body size relationship of flathead catfish. *North American Journal of Fisheries Management* 28:198–202.
- Werner, E. E., and D. J. Hall. 1974. Optimal foraging and the size selection of prey by bluegill sunfish (*Lepomis macrochirus*). *Ecology* 55:1042–1052.
- Wuellner, M. R., S. R. Chipps, D. W. Willis, and W. E. Adams, Jr. 2010. Interactions between walleye and smallmouth bass in a Missouri River reservoir with consideration of the influence of temperature and prey. *North American Journal of Fisheries Management* 30:445–463.

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