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Morphological correlates of swimming activity in wild largemouth bass (*Micropterus salmoides*) in their natural environment

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Abstract

Individual variation in morphology has been linked to organismal performance in numerous taxa. Recently, the relationship between functional morphology and swimming performance in teleost fishes has been studied in laboratory experiments. In this study, we evaluate the relationship between morphology and swimming activity of wild largemouth bass (*Micropterus salmoides*) during the reproductive period, providing the first data derived on free-swimming fish not exposed to forced swim trials in the laboratory. Sixteen male largemouth bass were angled from their nests, telemetered, and subsequently monitored by a whole-lake acoustic hydrophone array with sub-meter accuracy. Additionally, eleven morphological measurements were taken from digital images of each fish. A principal components analysis of the morphological measurements described 79.8% of the variance. PC1 was characterized by measures of overall body stoutness, PC2 was characterized by measures of the length and depth of the caudal region, and PC3 characterized individuals with relatively large anterior portions of the body and relatively small caudal areas. Of these variables, only PC3 showed significant relationships to swimming activity throughout the parental care period. PC3 was negatively correlated with multiple measures of swimming activity across the parental care period. Furthermore, swimming performance of individual male bass was noted to be repeatable across the parental care period indicating that this phenomenon extends beyond the laboratory.

Keywords: Behaviour; Biotelemetry; Largemouth bass; Morphology; Reproduction

1. Introduction

As a behaviour, locomotion is required for survival by most animal species (Ricklefs and Miles, 1994; Domenici and Blake, 1997; Plaut, 2001; Vincent et al., 2005; Husak, 2006), and individual variation in locomotory performance is often correlated with individual variation in morphological characteristics in a variety of taxa (Garland, 1984; Brana, 2003; Fitzpatrick et al., 2005; Husak, 2006). In fish, functional morphology has been shown to relate to variation in the swimming ability of individuals (Kolok, 1992a; Pettersson and Hedenstrom, 2000; Boily and Magnan, 2002; Standen et al., 2002; Lauder and Drucker, 2004; Fisher et al., 2005; Blake et al., 2005; Ohlberger et al., 2006). It has been postulated that increased swimming ability associated with morphological differences may be advantageous in many situations such as predator prey interactions, arduous migrations, defending territories or offspring, and habitat use (Fuiman, 1994; Wintzer and Motta, 2005; Gibb et al., 2006; Ohlberger et al., 2006). Unfortunately, most assessments of the relationship between swimming performance and morphology have been confined to the laboratory partially due to the difficulty of accurately quantifying swimming ability in the wild (Hawkins and Quinn, 1996; Farrell et al., 1998; Martínez et al., 2001; Ojanguren and Brana, 2003; Lee et al., 2003; MacNutt et al., 2006).

Recent advances in biotelemetry have allowed researchers to record movements of animals in the field with fine resolution, especially in the aquatic environment (Lucas and Baras, 2000;

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Cooke et al., 2004a; Cooke et al., 2004b). The advent of three dimensional acoustic positioning systems has allowed researchers unprecedented capabilities to monitor the behaviour of wild individuals over extended time periods (Lucas and Baras, 2000; Cooke et al., 2004a; Cooke et al., 2004b; Cooke et al., 2005). Transmitters can be positioned with sub-meter accuracy every few seconds (Niezgoda et al., 2002; Cooke et al., 2005), and currently the use of these systems is limited to a handful of locations around the world (Niezgoda et al., 2002; Cooke et al., 2005). One such telemetry array has been used to monitor the behaviour of largemouth bass (*Micropterus salmoides*) year round in a Canadian lake (Cooke et al., 2005), and provides a unique opportunity to assess fish morphology and performance relationships in the wild.

This study aimed to relate fish morphology to swimming activity of largemouth bass. For several reasons that will become apparent, we focused on the reproductive period. When water temperatures reach 14 °C in spring, male largemouth bass move to the littoral zone and construct nests (saucer shaped depressions in the substrate) in which egg deposition and fertilization occur (Kramer and Smith, 1962). After spawning, the male largemouth bass becomes sole parental care giver by actively guarding the nest from possible brood predators as well as fanning the brood to provide proper oxygenation and prevent sedimentation (Kramer and Smith, 1962). To successfully raise the brood, these male largemouth bass will continue to provide parental care until the brood becomes independent, which can often require one month (Kramer and Smith, 1962; Ridgway, 1988). The parental care period is recognized as one of the most stressful and energetically costly times of a male bass's life due to the fact that the male is extremely active making movements in a localized area above and adjacent to the nest (Cooke et al., 2002) and cannot forage normally to replenish energy lost in said movements (Hinch and Collins, 1991; Mackereth et al., 1999; Cooke et al., 2002). As such, we believed that individual variation in morphology as it related to locomotory performance as well as overall body condition would affect the swimming ability of a male largemouth bass during the reproductive period. Individuals characterized by morphometric measures that correlated with improved hydrodynamics and increased propulsion were expected to exhibit higher swimming speeds than other fish. Also, due to the energetic constraints during the parental care period, it was expected that individuals that were characterized by morphology that indicated increased body condition and pre-spawn energy stores would be more active than others. Also, we predicted that largemouth bass swimming behaviour in the wild would be repeatable throughout the parental care period as has been noted in laboratory studies on this species (Kolok, 1992b).

2. Methods

2.1. Study site

This study was carried out from May 1st to June 5th, 2005 on Warner Lake, eastern Ontario (44°31′N, 76°20′W). Warner Lake is an 8.3 ha research lake wholly enclosed on Queen's University Biological Station (QUBS) property and is the site of a telemetric ecological observatory. The lake shoreline is characterized by extensive littoral zone featuring fallen timber and some submergent and emergent macrophyte growth. Further details on the lake structure and community can be found in Suski (2000) and Hanson et al. (2007). The backbone of the ecological observatory is a fixed underwater acoustic telemetry array, and system details can be found in Niezgoda et al. (2002) and Hanson et al. (2007). Briefly, 13 permanently moored hydrophones configured in optimal geometry monitor telemetered fish movements throughout the lake. Hydrophones are connected to two on shore, multi-port MAP_600 (Lotek Wireless Inc.) receivers through fixed cabling. The system relies upon code division multiple access (CDMA) technology that encodes data transmitted from tags and allows for sub-meter positioning due to the elimination of signal collision events and subsequent data loss. Sub-meter positioning of transmission events results from previous differential GPS surveys (±0.2 m) of hydrophone locations (Niezgoda et al., 2002). Positions calculated with as few as four hydrophones show sub-meter accuracy within the footprint of the array and accuracy of greater than 1 m outside of the footprint. As more hydrophones are added to each position solution, error significantly decreases (Niezgoda et al., 2002). Received data are stored on flash cards on site and later transferred to a personal computer for processing.

2.2. Study animals

Starting on May 9th, 2004, snorkel surveys of the littoral zone were conducted daily to locate largemouth bass (*M. salmoides*) that were actively guarding nests. Upon locating an active bass nest (one that contained a guarding male and eggs), the snorkeler placed a numbered PVC tile near the nest and recorded nest location, nest depth, and number of eggs within the nest (visual, categorical assessment ranging from low of 1 to high of 5; Suski and Philipp 2004). A total of 16 males, each located guarding 1-day-old eggs, were used in this study. These fish were collected by angling the day after original location of the nest. Each fish was briefly angled (<10 s) from the nest and placed in a cooler of fresh lake water. Individuals were then removed from the cooler and held flat on a spatially referenced tray and digitally photographed (Sony DSC-P1, 3.3 megapixel) from 1 m directly above. Fish were also measured for total length (mean±SD, 415.7±33.0 mm, range, 320–447 mm) and gape (to the nearest mm measured by opening the mouth with calipers) before being returned to the cooler. Subsequently, fish were placed in a foam lined surgery trough that was filled with fresh lake water for transmitter attachment. Acoustic transmitters (Model CTP-M11-25, 11 mm×25 mm, mass 23.9 g, signal transmission rate 2.5 s, Lotek Wireless Inc.) were externally attached to the nesting largemouth bass by a wire passed through the dorsal musculature (approximately 2 mm below the dorsal fin) using two hypodermic needles (21 gauge, 1.5″) (Cooke, 2003). Applied transmitters weighed less than 2–3% of the body weight so as to avoid an effect of the tag on individual behaviour (Winter, 1983; Brown et al., 1999). A rubber backing plate was positioned on the opposite side of the fish to prevent injury from the wire. Fish were then released within 5 m of the nest. The total amount of