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Channel Catfish Reproductive Traits in the Lower Platte River, Nebraska, USA

Mackenzie Zwiener

Jonathan J. Spurgeon

Mark Pegg

NOTES

CHANNEL CATFISH REPRODUCTIVE TRAITS IN THE LOWER PLATTE RIVER, NEBRASKA, USA—Reproductive traits including fecundity, egg diameter, and condition of freshwater fishes influence offspring survival and abundance and may provide insight regarding timing of reproduction (Winemiller and Rose 1992, Johnston and Leggett 2002). Fish size (i.e., length or weight) may influence the number of eggs produced by an individual female (i.e., fecundity; Michaletz 1998). Larger individuals may, thus, disproportionately contribute to year-classes through increased fecundity if egg and larval survival is similar or greater than those from smaller reproductive females (Gwinn et al. 2015). Likewise, maternal fish size may influence egg diameter and offspring survival, whereby larger egg diameters are associated with greater parental care and increased egg quality (Sargent et al. 1987). Variation in egg diameter within and between individuals in a population may also indicate phenotypic plasticity in reproductive timing. For instance, intra-individual variation in egg diameter may indicate protracted spawning behavior (Pope et al. 1996). Inter-individual variation in egg diameter may indicate differences in sexual maturity and provide insight regarding timing of spawning (Hamel et al. 2015). Understanding relationships between fish size and reproductive traits is important for managing exploited fish populations where relaxed fishing regulations stemming from inaccurate reproductive information may lead to unintended consequences, including over-fishing and reduced population sustainability (Gwinn et al. 2015, Barneche et al. 2018).

Channel catfish (*Ictalurus punctatus*) is an important recreational and commercial species in North America (Michaletz and Dillard 1999, Arterburn et al. 2002, Kwak et al. 2011). Populations of channel catfish in large-river systems are susceptible to overharvest when information regarding population dynamics is missing or not representative of the population (Mestl 1999). Growth and recruitment overfishing have occurred when harvest restrictions are either absent or too relaxed to protect individuals until reproduction occurs (Pitlo 1997). Information regarding the relationships between fish size and measures of fecundity and reproductive condition [e.g., egg diameter or gonadal somatic index (GSI)] can help inform harvest restrictions. Excessive exploitation can shift size- and age-structure of a catfish population to smaller and younger individuals which may influence reproductive output of the population (Pitlo 1997, Mestl 1999). Variability in fecundity may exist among populations, and published information regarding fecundity and how fecundity changes with length and weight is limited to a few case studies for channel catfish (Jearld and Brown 1971, Raibley and Jahn 1991, Hubert 1999). When data for a population are limited or non-existent, substituting fecundity information from another population may be appropriate; however, such data may not fully represent the reproductive traits of channel catfish among systems. Therefore, our objective was to quantify fecundity, egg diameter, and GSI of female channel catfish and assess their relationships to fish total length and weight within a large-river system in the Great Plains, USA.

The Platte River flows approximately 500 river kilometers (rkm) across Nebraska, USA before its confluence with the Missouri River. The lower Platte River, defined as 0–160 rkm, is undammed with limited channelization or bank armoring (Hamel et al. 2015). The system is highly braided with a network of shifting sandbars along its length. Mean annual discharge is 204 $m^3 s^{-1}$ [one standard error (SE) = 11; min = 82 $m^3 s^{-1}$; max = 459 $m^3 s^{-1}$; USGS Gauge 06805500, Louisville, NE].

We collected channel catfish from an annual fishing tournament on the lower Platte River, NE, USA (Latitude: 41.422320; Longitude: –96.541064) in May 2015. Anglers harvested channel catfish from approximately 20 rkms of the lower Platte River. We measured total length (TL; mm), weighed (g), and tagged (T-bar anchor tags) each fish and removed intact egg sacs from females using a fillet knife as fish were harvested. We placed egg sacs into freezer bags labelled with the fish's identification number before transporting bags back to the lab for processing. We stored egg sacs in a chest freezer until processing occurred (Kelso and Rutherford 1996). We gradually thawed each egg sac at room temperature prior to processing. Once completely thawed, we weighed each egg sac to the nearest 0.01 g using a digital scale. We separated eggs by flushing with water while gently brushing using forceps. We subsampled 75 eggs each from the anterior, medial, and posterior regions of the egg sac for a total egg count of 225 eggs from each channel catfish. We measured the diameter (µm) of all 225 eggs for each female with a dissecting scope reticule set at a 2x magnification. We removed all excess water and weighed (g) the subsample of 225 eggs using a digital scale. We estimated fecundity of each female channel catfish (*F*) using the following formula:

$$F = \frac{W_{total} * N_{sub}}{W_{sub}}$$

where *Wtotal* is the total weight of the egg sac, *Nsub* is the number of eggs subsampled (i.e., 225), and *Wsub* is the weight of subsampled eggs. We calculated GSI to assess the relative reproductive condition for female channel catfish (Pope et al. 2010). We calculated GSI using the following formula:

$$GSI = \frac{W_{sac}}{W_{fish}} \text{ x } 100$$

where *Wsac* is the total weight of the egg sac, and *Wfish* is the total weight of the fish. We used linear regression to relate fish size (i.e., TL, weight) to fecundity, egg diameter, and GSI. We used an analysis of variance (ANOVA) to test for differences in egg diameter between the anterior, medial, and posterior sections of the egg sac. We performed all statistical analyses using Program R (R Core Team 2016), and statistical significance was determined at $\alpha = 0.05$.

Female channel catfish (n = 23) total lengths varied between 420 and 710 mm (560 ± 15 mm; mean ± 1 SE) and weight varied between 1,400 and 9,244 g (4,385 ± 396 g). Mean fecundity was 16,068 ± 2,215 eggs per female (range = 4,966 – 46,710 eggs per female). Mean number of eggs per kg of body mass was 3,577 ± 236 eggs kg^{-1} (range = 1,963 – 6,004 eggs kg^{-1}). Female channel catfish had a mean GSI value of 3.76% (± 0.36). Channel catfish egg diameter varied between 0.27 and 1.53 mm (1.04 ± 0.003 mm). No relationship existed between the number of eggs per kg of body mass and total length ($F_{1,\ 21}$ = 0.04, P = 0.85) or weight ($F_{1,21}$ = 0.75, P = 0.40). A positive relationship existed between channel catfish fecundity and total length ($F_{1,21}$ = 30.48, P < 0.001; Fig. 1A) and weight ($F_{1,21}$ = 83.19, P < 0.001; Fig. 1B). Egg diameter was not linearly related to channel catfish length ($F_{1,21}$ = 2.76, P = 0.11; Fig. 1C) or weight ($F_{1,21}$ = 3.84, P = 0.06; Fig. 1D). Female channel catfish GSI was not related to length ($F_{1,21}$ = 1.33, P = 0.26; Fig. 1E) or weight ($F_{1,21}$ = 2.37, P = 0.14; Fig. 1F). Mean egg diameter did not differ between the anterior, medial, or posterior sections of channel catfish egg sacs ($F_{2,66}$ = 0.04, P = 0.96).

Channel catfish total fecundity and the relationships of total fecundity with both length and weight in the lower Platte River appeared similar to other river and reservoir systems in the Midwestern United States (Hubert 1999). The fecundity per kg of body mass for channel catfish in the lower Platte River, however, differed from previous studies. Channel catfish total fecundity has been estimated between 1,052 to 64,629 eggs per female (Muncy 1959, Jearld and Brown 1971, Raibley and Jahn 1991), and Jearld and Brown (1971) found a positive linear relationship between channel catfish length and fecundity in an Oklahoma reservoir. An increase in the number of eggs produced by larger individuals may result in more offspring produced, particularly if survival of offspring is similar or better compared to offspring produced by smaller individuals (Hsieh et al. 2010; Gwinn et al. 2015, Barneche et al. 2018). Channel catfish fecundity per kg of body mass has been estimated at 8,800 eggs kg^{-1} for individuals 0.45–1.80 kg, and 6,600 eggs kg^{-1} for fish >1.8 kg (Clemens and Sneed 1957, Hubert 1999). We did not observe a decrease in fecundity per kg of body mass, suggesting female channel catfish across the size range we observed in the lower Platte River may be allocating similar energy expenditures to reproductive output (i.e., isometric scaling of body mass and reproductive output; Barneche et al. 2018). Management strategies aimed at protection of larger channel catfish in the lower Platte River and possibly rivers throughout the Great Plains may enhance fish abundances through increased fish production (Eder et al. 2016).

Channel catfish reproductive condition as described by GSI as well as the relative egg diameter in the lower Platte River may be lower than in other Midwest systems. For instance, previous studies suggest 7–15 % of total body weight of mature females was comprised of eggs (Muncy 1959, Jearld and Brown 1971, Hubert 1999). The GSI values we found in our study were 46 – 75% lower compared to previous studies (Muncy 1959, Jearld and Brown 1971, Hubert 1999). Channel catfish GSI values have been estimated in the Nemaha and Niobrara rivers in Nebraska and averaged 15.5% (Mahoney 1982). Peak GSI values occurred in June in the Nemaha River at 15.6% and in July in the Niobrara at 15.4% (Mahoney 1982). Timing of sampling may influence mean GSI values as eggs develop. Our collections occurred immediately prior to the spawning window (i.e., July, Hrabik et al. 2015) in the Platte River when water temperatures averaged 25° C. As such, GSI values should have been at or near the maximum yearly value as water temperatures during our study were similar to those previously conducted in other Nebraska rivers (i.e., Mahoney 1982; water temperature = 24–29° C). Egg diameter of channel catfish in other studies varied between 1.78 and 2.90 mm (Mahoney 1982), which is larger than egg diameters observed in the lower Platte River. Egg diameter may be an important factor in the survival of developing embryos (Moyle and Cech 2004) and may influence survival of larval fishes (Hsieh et al. 2010). Further investigation into the relationships between egg diameter and survival may enable more refined predictions (e.g., stock-recruit models) regarding recruitment of channel catfish within the lower Platte River.

We have provided baseline information for reproductive traits of channel catfish in the lower Platte River. Future shifts in reproductive traits including fecundity, egg diameter, and GSI based on harvest strategies or environmental change can now be assessed. Information regarding the proportion of fish spawning in a given year, timing of first reproduction, and periodicity of spawning (e.g., annual or biannual) would provide valuable future lines of inquiry. Debate exits regarding the reproductive contribution of large females in maintaining sustainable abundances of exploited fishes (Barneche et al. 2018; Andersen et al. 2019). Our results suggest larger female channel catfish produce more eggs compared to smaller individuals and protection may be a management option if monitoring efforts detect declines in channel catfish abundances. Decisions regarding sustainable management of channel catfish populations in rivers such as the lower Platte River may benefit from considering the greater fecundity associated with larger female channel catfish.

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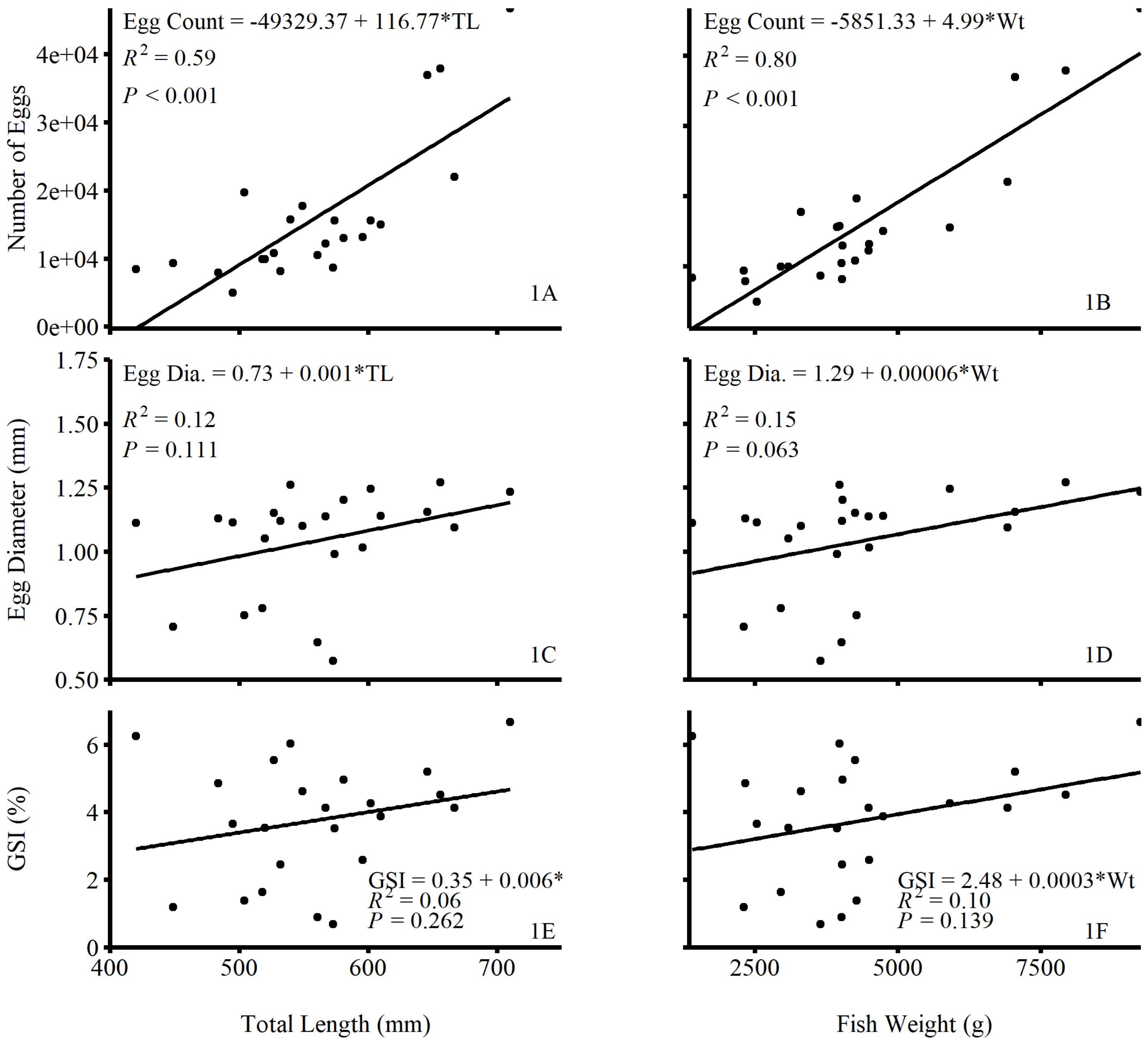

Figure 1. Egg count (1A, 1B), egg diameter ("Dia."; 1C, 1D), and gonadal somatic index (GSI; 1E, 1F) of channel catfish in the lower Platte River and their relationships to total length (mm; left column) and weight (g; right column).