Batch spawning in five species of minnows (Cyprinidae) from Ontario, Canada

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Abstract
Batch spawning, the act of spawning more than once within a spawning season, is assessed in six species of minnows (Cyprinidae) from Ontario, Canada. The bimodal frequency distribution of egg size in mature specimens suggests that the following species are batch spawners: Blacknose Dace (Rhinichthys atratulus), Brassy Minnow (Hybognathus hankinsoni), Common Shiner (Luxilus cornutus), Creek Chub (Semotilus atromaculatus), and Hornyhead Chub (Nocomis biguttatus). However, there is no evidence that Northern Pearl Dace (Margariscus nachtriebi) is a batch spawner. Thus, we now have evidence that 11 of 39 cyprinid species in Ontario are batch spawners. Knowledge about the reproductive habits of these species should be integrated into the comprehensive standards for the protection of fish habitat in Ontario to ensure the survival of populations.

Key words: Cyprinidae; minnows; spawning; batch; Ontario

Introduction
Batch (or fractional) spawning is widespread among fishes (e.g., Conover 1985). The phenomenon is defined as spawning more than once during a spawning season as opposed to spawning only once in a relatively short period, hereafter, referred to as “conventional” spawning (Conover 1985). Batch spawning presents a problem to fisheries managers because it confounds or renders impossible any attempt to estimate total fecundity (e.g., Conover 1985). Batch spawning has been frequently reported in the minnows (Cyprinidae; e.g., Heins and Rabito 1986). The objective of this study was to report on the occurrence of batch spawning in some Ontario cyprinids through the examination of ovaries of mature individuals of six species: Blacknose Dace (Rhinichthys atratulus), Brassy Minnow (Hybognathus hankinsoni), Common Shiner (Luxilus cornutus), Creek Chub (Semotilus atromaculatus), Hornyhead Chub (Nocomis biguttatus), and Northern Pearl Dace (Margariscus nachtriebi).

Methods
In 2013–2015, minnows were captured with standard (40 × 20 cm) cylindrical wire traps set overnight from late April (ice out) to 30 June, a period when spawning of these fish is underway. Five of the six species were caught in Clarke Creek (45°06′N, 77°48′W) near Bancroft, Ontario. Hornyhead Chub was caught in an unnamed creek near Madoc, Ontario (44°30′N, 77°39′W).

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weighed to the nearest 0.01 g. A sample of the ovarian matrix was obtained by cutting out two small pieces, one from each ovary. Herrera and Fernandez-Delgardo (1994) and Al Saleh et al. (2012) found that the size of eggs is more or less independent of position in the ovaries of minnows. The samples were weighed (typically 0.05–0.15 g) and placed on a glass slide, covered with a drop of water, and the eggs were spread out with the flat of a scalpel. The sample was then examined under a microscope at 40× magnification and all eggs were counted and sorted into one of three size classes: 0.20–0.60 mm, 0.61–1.00 mm, and >1.00 mm. The slides had an underlying grid to help prevent double counting of eggs, and an ocular micrometer was used to measure eggs when size class was not obvious. The overall colour of eggs in each size class was noted.

The size classes correspond to the three categories in Powles et al. (1992) for the minnow Northern Redbelly Dace (Chrosomus eos): 1) “immature” (“recruitment” in Conover 1985), white-grey with no yolk; 2) “maturing” (or mid-sized), vitellogenic (acquiring yolk) and yellow or orange; and 3) “mature”, >1.00 mm and translucent, but with yellow hues. Eggs in the mature category were fully developed (Conover 1985; Powles et al. 1992). No mature eggs of any observed species were greater than 1.20 mm; thus, it is assumed that size at development stage of eggs of these species and that of C. eos eggs is comparable (Brassy Minnow, an exception, is discussed below). The subsamples typically contained 150–400 eggs. An estimate of total number of eggs and number in the three size categories was made by multiplying the weight of the ovary divided by weight of subsample times eggs counted in the subsample. Mid-sized eggs in the presence of mature eggs were deemed evidence of batch spawning.

Results
Most mature female Creek Chub, Common Shiner, Blacknose Dace, and Hornyhead Chub had hundreds of mid-sized eggs in the presence of mature eggs, supporting the hypothesis that they are batch spawners (Table 1). All Brassy Minnow specimens had relatively small eggs. The 12 Brassy Minnow females (caught between 4 May and 24 June in all three years) had GSI >10% and hundreds of vitellogenic eggs, but none >1.00 mm. However, five females had bimodal frequency distributions of egg size (Figure 1). Thus, Brassy Minnow appears also to be a batch spawner. Northern Pearl Dace is the anomaly in this group; the four mature females had essentially all eggs in the mature category (Figure 10,p) with negligible immature or mid-sized eggs. With this limited evidence, Northern Pearl Dace appears to be a conventional spawner.

Figure 1 shows selected frequency distributions of egg size (from the 100 measured eggs per specimen). The histograms were selected as typical of patterns observed for each species. Note that most (except for Northern Pearl Dace) show mid-sized eggs in the presence of mature (>1.00 mm) eggs.

| Table 1. Gonadosomatic index (GSI) and egg-size distribution in mature females of six Ontario cyprinids. |
|-------------------------------------------------|
| No. mature females | Mean standard length, cm | Mean GSI, % body weight | No. (%) of fish with mid-sized eggs | Egg-size distribution, means* (%) |
| Creek Chub (Semotilus atromaculatus) | 29 | 11.05 | 9.78 | 29 (100) | 2603/959/107 (100/36.8/4.1) |
| Common Shiner (Luxilus cornutus) | 22 | 8.40 | 10.56 | 22 (100) | 1587/427/480 (100/26.9/30.3) |
| Blacknose Dace (Rhinichthys atratulus) | 28 | 7.46 | 12.95 | 25 (89) | 1440/245/535 (100/17.0/37.2) |
| Brassy Minnow (Hybognathus hankinsoni) | 12 | 7.74 | 10.76 | — † | 3294/0/1028 (100/0/31.2) |
| Hornyhead Chub (Nocomis biguttatus) | 8 | 9.52 | 14.31 | 8 (100) | 2560/723/850 (100/28.2/33.2) |
| Northern Pearl Dace (Margariscus nachtriebi) | 4 | 7.90 | 15.87 | 0 | 775/757/28 (100/97.7/3.6) |

*Means of total no. eggs/mature eggs/mid-sized eggs. Mature eggs >1 mm, mid-sized 0.6–1.0 mm.
†Size categories of eggs of Brassy Minnow are an exception (see text for explanation).
Discussion

Batch spawning is reported frequently in the Cyprinidae and from locations as disparate as Spain (Herrera and Fernandez-Delgrado 1994), Iraq (Al Saleh et al. 2012), and Malaysia (Abiden 1986). Conventional spawning is also occasionally reported (e.g., Wang et al. 2014). This study adds five species to the six cyprinid species already documented as batch spawners in Ontario. These other species are: Blacknose Shiner (Notropis heterolepis; Roberts et al. 2006), Bluntnose Minnow (Pimephales notatus; Gale 1983), introduced Common Carp (Cyprinus carpio; Ivanov 1976), Fathead Minnow (Pimephales promelas; Gale and Buynak 1982), introduced Goldfish (Carassius auratus; Ivanov 1971), and Northern Redbelly Dace (Powles et al. 1992). Thus, 11 of the 39 Ontario cyprinids have been confirmed to be batch spawners.

This study suggests that Northern Pearl Dace is a conventional spawner. The evidence for batch spawning reported here is indirect because direct observation in the field is difficult (Conover 1985).

Ontario has developed comprehensive standards for the protection of fish habitat (e.g., Anonymous 2006). For example, timing restrictions force work in water away from periods when spawning or egg development may occur (Anonymous 2006). In systems with complex fish communities, this can mean that work is restricted to a few weeks in late summer. However, because of batch spawning, the reproduction of cyprinids may be prolonged; some species, for example, Fathead Minnow, spawn more than 15 times in a season (Gale and Buynak 1982). Such a prolonged spawning period suggests that even late summer restrictions may be inadequate to fully protect cyprinid populations.

The evolution of batch spawning has been interpreted according to three adaptive scenarios or hypotheses. It may be a “bet hedging” life history pattern.
(Morrowielo et al. 2012), whereby a variable post-hatch environment and consequent unpredictable mortality of young favour a reproductive effort that is spread out temporally, thus increasing the probability of survival of the progeny. Second, Schlosser (1998) and Matthews et al. (2001) suggest that fish in confined environments, such as streams, extend reproduction to minimize intraspecific competition for the developing young. Third, Coburn (1986) argues that developmental and ecological factors limit egg size to a certain minimum. Thus, fish with small adult body size, having smaller ovaries, compensate for less output by laying multiple clutches.

More basic research and data on cyprinid reproductive patterns are needed to verify these adaptive hypotheses.

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**Literature Cited**

Abiden, A.Z. 1986. The reproductive biology of a tropical cyprinid, *Hampala macrolepidota*, from Zoo Negra lake, Kuala Lumpur, Malaysia. Journal of Fish Biology 29: 381–391. https://doi.org/10.1111/j.1095-8649.1986.tb04954.x

Al Saleh, F., V. Hammond, A. Hussein, and R. Alhazza. 2012. On the growth and reproductive biology of asp, *Aspius vorax*, population from the middle reaches of Euphrates River. Turkish Journal of Fisheries and Aquatic Sciences 12: 149–156. https://doi.org/10.4194/1303-2712-v12_l17

Anonymous. 2006. MTO/DFO/MNR protocol for protecting fish habitat on provincial transportation undertakings. Fisheries and Oceans Canada, Ottawa, Ontario, Canada.

Coburn, M.M. 1986. Egg diameter variation in eastern North American minnows (Pisces: Cyprinidae): correlation with vertebral number, habitat and spawning behavior. Ohio Journal of Science 86: 110–120. Accessed 25 February 2020. https://kb.osu.edu/handle/1811/23141

Conover, D.O. 1985. Field and laboratory assessment of patterns in fecundity of a multiple spawning fish: the Atlantic Silverside *Menidia menidia*. Fishery Bulletin 83: 331–341. Accessed 25 February 2020. https://spoonfish.noaa.gov/sites/default/files/pdf-content/1985/833/conover.pdf

Gale, W.F. 1983. Fecundity and spawning frequency of the fathead minnow—a fractional spawner. Transactions of the American Fisheries Society 112: 398–402. https://doi.org/10.1577/1548-8659(1983)112<398:fasfo>2.0.co;2

Gale, W.F., and G. Buynak. 1982. Fecundity and spawning frequency of the fathead minnow—a fractional spawner. Transactions of the American Fisheries Society 111: 35–40. https://doi.org/10.1577/1548-8659(1982)111<35:fasfo>2.0.co;2

Heins, D.C., and J.A. Baker. 1993. Reproductive biology of the Brighteye Darter, *Etheostoma lynceum* (Teleostei: Percidae), from the Homochitto River, Mississippi. Ichthyological Exploration of Freshwaters 4: 11–20.

Heins, D.C., and F.G. Rabito, Jr. 1986. Spawning performance in North American minnows: direct evidence of multiple clutches in the genus *Notropis*. Journal of Fish Biology 28: 343–357. https://doi.org/10.1111/j.1095-8649.1986.tb05171.x

Herrera, M., and C. Fernandez-Delgado. 1994. The age, growth, and reproduction of *Chondrostoma polylepis willkommi* in a seasonal stream in the Guadalquivir River basin (southern Spain). Journal of Fish Biology 44: 11–22. https://doi.org/10.1111/j.1095-8649.1994.tb05181.x

Ivanov, Y.N. 1971. An analysis of the fecundity and intermittent spawning of lake Balkhash wild carp, *Cyprinus carpio*. Journal of Ichthyology 11: 666–673.

Ivanov, Y.N. 1976. The formation of ultimate fecundity in intermittent spawning fish with reference to Southern One Finned Greenling, *Pleurogrammus aronias*, and the wild goldfish, *Carassius auratus*. Journal of Ichthyology 16: 56–63.

Matthews, W.J., K.B. Gido, and E.D. Marsh-Matthews. 2001. Density-dependent overwinter survival and growth of Red Shiners from a southwestern river. Transactions of the American Fisheries Society 130: 478–488. https://doi.org/10.1577/1548-8659(2001)130<0478:ddosav>2.0.co;2

Morrowielo, J.R., N.R. Bond, D.A. Crook, and B.M. Wong. 2012. Spatial variation in egg size and egg number reflects trade-offs and bet-hedging in a freshwater fish. Journal of Animal Ecology 81: 806–817. https://doi.org/10.1111/j.1365-2656.2012.01961.x

Powles, P.M., S. Finucan, M. van Haafken, and R.A. Curry. 1992. Preliminary evidence for fractional spawning by the Northern Redbelly Dace, *Phoxinus eos*. Canadian Field-Naturalist 106: 237–240. Accessed 9 March 2020. https://www.biodiversitylibrary.org/page/34347457.

Roberts, M.E., B.M. Burr, M.R. Whiles, and V. Santucci. 2006. Reproductive ecology and food habits of the Blacknose Shiner, *Notropis heterolepis*, in northern Illinois. American Midland Naturalist 155: 70–83. https://doi.org/10.1674/0003-0031(2006)155<0070:reahf3.0.co;2

Schlosser, I.J. 1998. Fish recruitment, dispersal, and trophic interactions in a heterogeneous lotic environment. Oecologia 113: 260–268. https://doi.org/10.1007/s004420050377

Wang, J., F. Liu, X. Zhang, W.-X. Cau, H.-Z. Liu, and X. Gao. 2014. Reproductive biology of Chinese minnow, *Hemiculterella sauvagei*, 1888 in the Chishui River, China. Journal of Applied Ichthyology 30: 314–321. https://doi.org/10.1111/jai.12353

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