

Comparison of Larval Myomere Counts Among Species of *Nocomis* in Virginia (Actinopterygii: Cyprinidae)

Terre D. Green and Eugene G. Maurakis, Science Museum of Virginia, 2500 West Broad Street, Richmond, VA 23220, and Department of Biology, University of Richmond, Richmond, VA 23173

ABSTRACT

Larval myomere counts of *Nocomis platyrhynchus* were made using a dissecting light microscope equipped with polarizing filters, and then compared to those of the three other species of *Nocomis* (*Nocomis leptocephalus*, *Nocomis micropogon*, and *Nocomis raneyi*) found in Virginia. Average preanal myomere counts for *N. platyrhynchus* (26.9) were significantly different from those of the other three species (*N. raneyi* = 28.7; *N. micropogon* = 26.0; and *N. leptocephalus* = 25.9). This is especially important as larvae of *N. leptocephalus*, the only other species of *Nocomis* syntopic with *N. platyrhynchus* in the upper New River drainage, can now be distinguished from those of *N. platyrhynchus*. Larvae of *N. raneyi* also can be distinguished from those of other species of *Nocomis* in Virginia based on preanal myomere counts. However, larvae of *N. platyrhynchus* and *N. raneyi* cannot be distinguished from each other based on total myomeres (42.0 versus 41.7). Larvae of *N. platyrhynchus* can be distinguished from those of three of its nest associates (*Lythrurus ardens*, *Notropis rubellus*, and *Phoxinus oreas*), but not from *Campostoma anomalum* and *Luxilus chrysocephalus* using myomere counts.

INTRODUCTION

Nocomis (Cyprinidae) is composed of seven species in three species-groups: *Nocomis biguttatus* with *Nocomis asper* and *Nocomis effusus*; *Nocomis leptocephalus*; and *Nocomis micropogon* with *Nocomis platyrhynchus* and *Nocomis raneyi* (Lachner and Jenkins, 1971; Maurakis et al., 1991). Of these, four species (*N. leptocephalus*, *N. micropogon*, *N. platyrhynchus* and *N. raneyi*), representing two species-groups, are found in Virginia. *Nocomis leptocephalus* occurs in the New, Potomac, Rappahannock, York, James and Roanoke River drainages. *Nocomis micropogon* is distributed in the Potomac, Rappahannock, York and James River drainages. *Nocomis platyrhynchus* is endemic to the New River drainage, and *N. raneyi* occurs in the James and Roanoke River drainages in Virginia (Jenkins and Burkhead, 1994) (Table 1).

Total, preanal, and postanal myomeres of larval *N. leptocephalus*, *N. micropogon*, and *N. raneyi* have been counted and compared by Maurakis et al. (1992). Currently, however, there is no information on the numbers of myomeres of larvae of *N. platyrhynchus*. The objective of this study is to present information on myomere counts of larval *N. platyrhynchus*, and compare them to counts of the other three species of *Nocomis* in Virginia, as well as nest associates of *N. platyrhynchus*.

TABLE 1. Rivers of Virginia containing *Nocomis leptocephalus*, *Nocomis micropogon*, *Nocomis platyrhynchus*, and *Nocomis raneyi*.

Species	River					
	New	Potomac	Rappahannock	York	James	Roanoke
<i>leptocephalus</i>	X	X	X	X	X	X
<i>micropogon</i>		X	X	X	X	
<i>platyrhynchus</i>	X					
<i>raneyi</i>					X	X

MATERIALS EXAMINED

The state, drainage, larvae (L), eggs (E), collection number (ANSP, Academy of Natural Sciences of Philadelphia; and EGM, Eugene G. Maurakis), locality, and collection date for *N. leptocephalus*, *N. micropogon*, *N. platyrhynchus*, and *N. raneyi* are:

Nocomis leptocephalus. Georgia: Savannah, (L), ANSP 140977, Columbia Co., Reed Cr., Rt. 28, 3.4 km N of jct. with Co. Rt. 26 near Martinez, 26 June 1976. North Carolina: Savannah, (L), EGM-NC-210, Jackson Co., Horsepasture R., U.S. Rt. 64, 2.2 km NE of Cashiers, 10 June 1988. Virginia: Roanoke, (L), ANSP 134421, Montgomery Co., Roanoke R. at Elliston, 13 June 1975.

Nocomis micropogon. Virginia: Potomac, (L), EGM-VA-254, Loudoun Co., Caectin Dr., Co. Rt. 633, 0.2 km from Co. Rt. 665 jct. near Lovettsville, 25 May 1990.

Nocomis platyrhynchus. Virginia: New, (L), EGM-VA-416, Montgomery-Floyd Co. line, Little R., 1 km upstream of State Rt. 8 bridge on dirt road, 16 May 1998. New, (E), EGM-VA-417, Montgomery Co., Little R., Co. Rt. 693 and 613 junction, about 8 km W of Riner, 16 May 1998.

Nocomis raneyi. Virginia: James, (L), EGM-VA-260, Craig Co., Johns Cr., Co. Rt. 632 at Maggie, 13 June 1990.

MATERIALS AND METHODS

Naturally-spawned eggs were collected with an aquarium dipnet from spawning areas of active nests of each of the four *Nocomis* species. Eggs were transported in tagged plastic jars to the laboratory where they were reared at room temperature (22°C) to fully scaled juveniles. Larvae were sampled at each of three larval stages (protolarval, mesolarval, and metalarval) following terminology in Fuiman (1982), and preserved in Bouin's fixative.

Preanal and postanal myomeres of larvae of each of the four species of *Nocomis* were counted using a dissecting light microscope equipped with polarizing filters. A vertical line was drawn at the posterior end of the anus, and any myomere that intersected this line was counted as preanal according to methods in Fuiman (1982). Total myomeres were calculated by adding preanal and postanal myomeres of each specimen. Eggs of *Nocomis platyrhynchus* were measured using a metric rule under the microscope.

Differences in average numbers of each of preanal, postanal, and total myomeres of larvae among the four species were determined with a General Linear Model and Duncan's Multiple Range Test (SAS, 1985).

TABLE 2. Average (range) preanal, postanal, and total myomeres of *Nocomis leptcephalus*, *Nocomis micropogon*, *Nocomis raneyi* and *Nocomis platyrhynchus*. Underscored means do not differ significantly ($p = 0.05$).

Myomere	Mean (range)				F value	Pr > F
	<i>leptocephalus</i> (n = 21)	<i>micropogon</i> (n = 24)	<i>platyrhynchus</i> (n = 53)	<i>raneyi</i> (n = 25)		
Preanal	<u>25.86 (24-28)</u>	<u>26.04 (24-28)</u>	26.88 (25-29)	28.72 (27-31)	42.69	0.0001
Postanal	<u>12.24 (11-13)</u>	<u>12.50 (11-14)</u>	15.09 (14-18)	13.00 (11-15)	78.52	0.0001
Total	<u>38.10 (36-41)</u>	<u>38.54 (36-41)</u>	<u>41.96 (40-45)</u>	<u>41.72 (39-44)</u>	73.97	0.0001

TABLE 3. Preanal myomere modes and means of *Nocomis leptcephalus*, *Nocomis micropogon*, *Nocomis platyrhynchus*, and *Nocomis raneyi*.

Species	Mode							\bar{x}	
	24	25	26	27	28	29	30		31
<i>leptocephalus</i>	2	5	9	4	1	-	-	-	25.86
<i>micropogon</i>	2	4	10	7	1	-	-	-	26.04
<i>platyrhynchus</i>	-	2	17	22	10	2	-	-	26.88
<i>raneyi</i>	-	-	-	4	6	9	5	1	28.72

When myomere counts were unavailable (e.g. *Lythrurus ardens*), an adjusted vertebral count (total minus one vertebrae) was used as a prediction of myomeres using methods of Fuiman (1982). Vertebral counts of *Phoxinus oreas* were determined from radiographs and were not adjusted as our counts of both myomeres and vertebrae included final elements. Specimens were exposed at 30kV and 5mA for 45 seconds.

RESULTS

Average total myomere counts of *N. leptcephalus* (\bar{x} = 38.10) and *N. micropogon* (\bar{x} = 38.54) are significantly lower than those for *N. raneyi* (\bar{x} = 41.72) and *N. platyrhynchus* (\bar{x} = 41.96) (Table 2). Preanal as well as postanal counts of *N. raneyi* (\bar{x} = 28.72, 13.00) and *N. platyrhynchus* (\bar{x} = 26.88, 15.09) differ significantly from those of *N. leptcephalus* (\bar{x} = 25.86, 12.24) and *N. micropogon* (\bar{x} = 26.04, 12.50) (Table 2). The modal preanal and total myomere counts for all four species are consistent with their respective mean values (Tables 3 and 4). Eggs of *N. platyrhynchus* averaged 2.1 mm in diameter, ranging = 2.0-2.2 mm.

TABLE 4. Total myomere modes and means of *Nocomis leptocephalus*, *Nocomis micropogon*, *Nocomis platyrhynchus*, and *Nocomis raneyi*.

Species	Mode										\bar{x}
	36	37	38	39	40	41	42	43	44	45	
<i>leptocephalus</i>	4	2	7	5	2	1	-	-	-	-	38.10
<i>micropogon</i>	1	5	5	8	3	2	-	-	-	-	38.54
<i>platyrhynchus</i>	-	-	-	-	7	11	18	13	2	2	41.96
<i>raneyi</i>	-	-	-	1	3	7	6	7	1	-	41.72

TABLE 5. Actual and predicted preanal, postanal, and total myomeres of larvae of nest associates of *Nocomis platyrhynchus*.

	Preanal	Postanal	Total
<i>Campostoma anomalum</i>	26-29	11-14	37-43
<i>Luxilus chrysocephalus</i>	26-27	12-14	38-41
<i>Lythrurus ardens</i> *	18-20	17-20	36-40
<i>Notropis rubellus</i>	19-23	15-18	34-41
<i>Phoxinus oreas</i> *	21-23	17-19	38-41
\bar{x}	22.1	17.4	39.5

* Myomere counts of *L. ardens* predicted from vertebral counts of Snelson (1972) using methods in Fuiman (1982), and myomeres predicted for *P. oreas* from our vertebral radiographs.

DISCUSSION

Nocomis platyrhynchus can be distinguished from other species of *Nocomis* in Virginia based on preanal, postanal, and total myomere counts with one exception. This is especially significant as *N. leptocephalus* is the only *Nocomis* species that occurs with *N. platyrhynchus* in the New River. *Nocomis platyrhynchus* cannot be separated from *N. raneyi* with total myomere counts. That larvae of *N. raneyi* also can be distinguished from those of *N. leptocephalus* and *N. micropogon* based on preanal and postanal myomere counts is consistent with results reported by Maurakis et al. (1992). Myomere counts of larval *N. platyrhynchus* are consistent with those of vertebrae ($\bar{x} = 40.6$, range = 39-42, mode = 41) in adults reported by Lachner and Jenkins (1971).

Larvae of *N. platyrhynchus* can be distinguished from those of some of its nest associates (i.e., species that congregate and may spawn over a nest but do not contribute to its construction) by myomere counts (Table 5). Lobb and Orth (1988) and Maurakis (1999) reported *Campostoma anomalum*, *Luxilus chrysocephalus*, *Lythrurus ardens*, *Notropis rubellus*, and *Phoxinus oreas* as nest associates of *N. platyrhynchus*. Larvae of *N. platyrhynchus* can be separated easily from those of *L. ardens* based on preanal myomeres as *N. platyrhynchus* has 25 to 29, and Snelson (1972) reported precaudal vertebra counts for *L. ardens* to be 18-20. *Notropis rubellus* can be distinguished from *N. platyrhynchus* based on preanal myomeres (range = 19-23,

Fuiman and Heufelder, 1982). Larvae of *P. oreas* may be differentiated from *N. platyrhynchus* by preanal myomeres as adult *P. oreas* have precaudal vertebra counts of 21-23. *Nocomis platyrhynchus* cannot be distinguished from *C. anomalum* on the basis of myomere counts. However, they can be distinguished by egg diameter (*N. platyrhynchus*, \bar{x} = 2.1 mm; range = 2.0-2.2; n = 10; *C. anomalum*, range = 2.3-2.4 mm, Auer, 1982), as well as by their spawning location. *Nocomis platyrhynchus* spawns in a trough on the upstream slope of the nest whereas *C. anomalum* spawns in pits on this slope. Larvae of *L. chrysocephalus* cannot be distinguished from those of *N. platyrhynchus* based on numbers of preanal, postanal and total myomeres of Fuiman and Heufelder (1982) or egg diameter (range = 2.0-2.3 mm) reported by Auer (1982).

Maurakis et al. (1992) indicated that the increased resolutions of scanning electron microscopy and compound light microscopy are superior to that of dissecting light microscopy for identification and enumeration of actual numbers of myomeres in larvae. They proposed that myomere counts made with dissecting light microscopy alone are not accurate where the actual number of myomeres is required. However, in this study, due to the great divergence in preanal, but particularly total myomere means and modes in *N. leptocephalus* and *N. platyrhynchus*, dissecting light microscopy is adequate for distinguishing larvae of the two species in the New River drainage.

ACKNOWLEDGEMENTS

This study was funded in part by grants awarded to T. D. Zorman by the Undergraduate Research Committee of University of Richmond, to E. G. Maurakis by the Small Research Fund Committee of the Virginia Academy of Science, and the Science Museum of Virginia. We sincerely thank Frank Schwartz, University of North Carolina, for making radiographs of *Phoxinus oreas*.

LITERATURE CITED

- Auer, N. A. (ed.). 1982. Identification of larval fishes of the Great Lakes basin with emphasis on the Lake Michigan drainage. Great Lakes Fishery Commission, Ann Arbor, MI 48105. Special Pub. 82-3:744 pp.
- Fuiman, L. A. 1982. Correspondence of myomeres and vertebrae and their natural variability during the first year of life in yellow perch, pp. 56-59. In C. F. Bryan, J. V. Conner, and F. M. Truesdale (eds.). The 5th Ann. Larval Fish Conf. La. Coop. Fish. Res. Unit and School of Forestry and Wildl. Mgt. La. St. Univ., Baton Rouge, LA.
- Fuiman, L. A. and G. R. Heufelder. 1982. Family Cyprinidae, carps and minnows. pp. 242-249, 270-276. In N. A. Auer (ed.). 1982. Identification of larval fishes of the Great Lakes basin with emphasis on the Lake Michigan drainage. Great Lakes Fishery Commission, Ann Arbor, MI 48105. Special Pub. 82-3:744 pp.
- Jenkins, R. E. and N. M. Burkhead. 1994. Freshwater Fishes of Virginia. Amer. Fish. Soc. Bethesda, MD. 1079 p.
- Lachner, E. A. and R. E. Jenkins. 1971. Systematics, distribution, and evolution of the chub genus *Nocomis* Girard (Pisces, Cyprinidae) of eastern United States, with descriptions of new species. Smiths. Contr. Zool. 85: 1-97.
- Lobb, M. D. and D. J. Orth. 1988. Microhabitat use by the Bigmouth chub *Nocomis platyrhynchus* in the New River, West Virginia. Am. Midl. Nat. 120(1):32-40.

- Murakias, E. G., W. S. Woolcott, and M. H. Sabaj. 1991. Reproductive-behavioral phylogenetics of *Nocomis* species-groups. *Am. Midl. Nat.* 126: 103-110.
- Murakias, E. G., W. S. Woolcott, G. P. Radice, and W. R. McGuire. 1992. Myomere counts in larvae of three species of *Nocomis* (Pisces: Cyprinidae).
- SAS Institute, Inc. 1985. SAS User's Guide: statistics. Version 5. SAS Institute, Cary, NC. 956 p.
- Snelson, F. F., Jr. 1972. Systematics of the subgenus *Lythrurus*, genus *Notropis* (Pisces: Cyprinidae). *Bull. Florida State Mus.* 17(1):1-92.