Southeastern Fishes Council Proceedings

Number 57 (2017)

September 2017

Life-history aspects of *Chrosomus oreas* (Mountain Redbelly Dace) in Catawba Creek, Virginia

Dezarai Thompson
Roanoke College, dathompson@mail.roanoke.edu

Shelby Hargrave
Roanoke College, slhargrave@mail.roanoke.edu

Gregory Morgan
Roanoke College, gjmorgan@mail.roanoke.edu

Steven L. Powers
Roanoke College, powers@roanoke.edu

Life-history aspects of *Chrosomus oreas* (Mountain Redbelly Dace) in Catawba Creek, Virginia

Abstract

Life-history aspects of *Chrosomus oreas*, Mountain Redbelly Dace, were identified using specimens collected monthly from Catawba Creek in Roanoke County, Virginia. *Chrosomus oreas* were found in depths up to 63.3 cm with a modest relationship between abundance and depth. The largest specimen examined was a female 64.68 mm standard length, 4.80 g eviscerated weight, and 36 months of age. The oldest specimens examined were 37 months of age suggesting a maximum lifespan of approximately three years. Spawning appears to occur from April to early July, with a mean of 243 oocytes (SD = 178) up to 1.61 mm diameter in gravid females. Males begin to reach sexual maturity by approximately one year of age and all males appear to be mature by two years of age. Females do not begin to reach sexual maturity until two years of age. The diet of *C. oreas* appears to be almost exclusively algae and detritus. Food intake largely mimics energetic investment in gonadic mass as it was lowest in August and generally increased until May. Weight of gut contents increases with size of specimen.

Keywords

Cyprinidae; nest associate; James River

Cover Page Footnote

Acknowledgments All specimens were collected under a Virginia Department of Game and Inland Fisheries Scientific Collecting Permit issued to S.L. Powers. Roanoke College provided equipment and resources necessary for this research. This study was conducted in part as undergraduate independent research projects at Roanoke College by D. Thompson, S. Hargrave, and G. Morgan.

INTRODUCTION

Chrosomus oreas, Mountain Redbelly Dace, inhabits upland streams of the Atlantic slope from the Potomac to the Pee Dee river systems of Virginia and North Carolina, the New River drainage of North Carolina, Virginia, and West Virginia, and sporadically in a few tributaries to the Tennessee and Big Sandy river drainages in Virginia (Jenkins and Burkhead 1994, Powers and Ceas 2000). The taxonomy of *C. oreas* has been dynamic, as it was included in the genus *Phoxinus* by several authors, but appears to be a member of the recently revised genus *Chrosomus* (Strange and Mayden 2009). Despite the abundance and conspicuousness of this brilliantly colored fish, little is known of its biology. It is considered an herbivorous to detritivorous spring spawning nest associate (Flemer and Woolcott 1966, Jenkins and Burkhead 1994, Pendleton et al. 2012, Peoples and Frimpong 2013), but little is known of its age and growth patterns or changes in its biology throughout its life or even a single year. The objective of this study was to document life-history aspects of *C. oreas* from specimens collected throughout the year through methods commonly utilized in stand-alone life-history studies.

MATERIALS AND METHODS

Chrosomus oreas were collected from Catawba Creek at VA Hwy 311 in Roanoke County, VA (37º 22’ 52.32” N, 80º 06’ 12.36” W) between November 2009 and October 2010 by sampling during daylight hours near the middle of each month using a Smith-Root LR-24 electrofisher and a 3.3-m x 1.3-m seine with 4.8-mm mesh. Catawba Creek is a third order stream with a drainage area of 88 km^2 at our study site and a wetted width on 9 November 2009 from 2.2-5.7 m at base flow of 0.23 m^3/second (http://waterdata.usgs.gov/va/nwis/). Water temperature was recorded during each collection with a non-mercury glass thermometer. A total of 255 specimens were collected following American Fisheries Society protocols (UFR Committee 2013), fixed in 10% formalin, rinsed with water, transferred into 45% isopropyl alcohol, and examined for this study. For collections from November 2009 to August 2010, water depth and current velocity at points of sampling were measured and recorded along with number of specimens captured from that particular microhabitat. Depth was measured with a meter stick, and current velocity was measured by timing a float along a meter stick. Number of specimens collected was regressed by least sum of squares against depth and current velocity to quantify how those two variables influence microhabitat use by *C. oreas* within Catawba Creek. Details on habitat and specimens examined are deposited at Roanoke College and available from the authors upon request.

Standard length (SL) of preserved specimens was measured to the nearest 0.01 mm using digital calipers. Total weight (TW) was measured by blotting the specimens dry and weighing to the nearest 0.001g on a digital balance. Eviscerated weight (EW) was measured by removing all internal organs and weighing to the nearest 0.001g on a digital balance. Regression by least sum of squares was performed for SL and EW to examine the relationship between length and somatic mass. A two sample t-test was used to test for a difference between male and female SL. A chi-square test was used to test for a skewed sex ratio. All statistical analyses were performed using Minitab 17 Statistical Software (Minitab, Inc., State College, PA) with alpha equal to 0.05.

Specimens were aged by removing at least 10 scales from the dorsolateral portion of the body, mounting them on a slide, and examining them under 40x magnification for annuli (see Bond 1996). Scales were examined until a clear consensus number of annuli was identified by two observers. Specimens less than 12 months of age were counted as 0+, specimens 12-23 months were counted as age 1+, specimens 24-35 months were counted as age 2+, and specimens 36 months or greater were counted as age 3+. The proportion of total specimens collected represented by each age class was calculated to approximate the age-class distribution of the population. A t-test of age in months was used to test differences in lifespan among sexes.

Gonads were examined to determine sex, removed from each specimen, and weighed to the nearest 0.001g. Gonadosomatic Index (GSI) was calculated for all specimens by dividing gonad weight by EW and multiplying by 100. One-way analysis of variance was performed to test for differences in GSI among specimens of the same sex collected from different months. In gravid females, fully yolked, mature oocytes were counted, and five representative oocytes were measured to provide an approximation of ova size and number (Heins and Baker 1988). Regression of SL as a predictor of number of mature oocytes was performed to test the influence of specimen size on fecundity. Due to GSI values peaking in June, declining precipitously in July, and reaching a minimum mean value in August, we used June as the month of spawning for estimating age of specimens.

The anterior third of the gastrointestinal tract was dissected and its contents were removed and weighed using a digital balance and recorded to the nearest 0.001 g. Weight of gut contents for specimens with empty guts was recorded as zero. Unidentified organic matter was noted as being present or absent in an individual specimen. Regression by least sum of squares was performed for SL and weight of gut contents to test the influence of size on feeding. A one-way analysis of variance for weight of gut contents by month of collection was performed to test for changes in amount of food consumed throughout the year.

RESULTS

Minimum water temperature was 3° C recorded in January and February, and maximum was 27° C recorded in July. A total of 73 data points representing depth and velocity of water at seine hauls, set and kicks, or nettings of shocked fish were recorded. Number of specimens collected in a single event ranged from 0 to 26 (mean 3.4), depth ranged from 11.7-63.3 (mean = 32.2) cm, and velocity ranged from 0 to 0.28 (mean = 0.11) m/sec. Number of specimens increased with depth (r^2 = 11.6%, P = 0.003) and is described by the model number of specimens = 0.18(depth) -2.43. Number of specimens decreased with current velocity (r^2 = 5.8%, P = 0.041) and is described by the model number of specimens = 5.42 – 18.33(velocity). A multiple regression including both depth and velocity was only slightly better at explaining number of specimens (r^2 = 13.6%) and velocity was no longer significant (P = 0.2).

Eviscerated weight increased with SL (r^2 = 87.59%, $P < 0.001$) and is described by the model lnEW = 3.15 (lnSL) – 5.11. Females were larger than males ($P < 0.001$). The mean size of females was 44.70 mm SL (SD = 12.00), and the mean size of males was 38.30 mm SL (SD = 11.70). All specimens examined had zero to three annuli. The smallest specimen examined (19.70 mm SL) was collected in November, had zero annuli and appeared to be five months of age (Fig. 1). The largest specimen examined (64.68 mm SL, 4.80 g EW) was a female collected in June, had three annuli and appeared to be 36 months of age. The oldest specimens had three annuli and appeared to be 37 months of age. Standard length increased with age in months (r^2 = 84.2%, $P < 0.001$) and is described by the model SL = 1.19 (age in months) + 21.68. Of the 255 specimens examined, 41.2% were age 0+, 29.8% were age 1+, 27.1% were age 2+, and 2% were age 3+. Mean lifespan was greater ($P < 0.001$) for females (19.18 months, SD = 9.13) than males (14.21 months, SD = 9.18), but sex ratio was not significantly different from 1:1 (P = 0.8).

Monthly GSI was not uniform for females ($P < 0.001$) with GSI values highest during June (June = 14.70, SD = 11.81) and lowest during February and March (February = 1.08, SD = 1.61; March = 0.99, SD = 1.00) (Fig. 2). Monthly GSI did not differ significantly for males (P = 0.087), but the highest mean monthly values were found from April to July (July = 2.09, SD = 0.78) and the lowest mean value was for October (October = 0.26, SD = 0.53) (Fig. 3). Individual GSI was highest in May for females (31.8) and males (6.11). Elevated GSI values generally persisted during the spring months for both males and females.

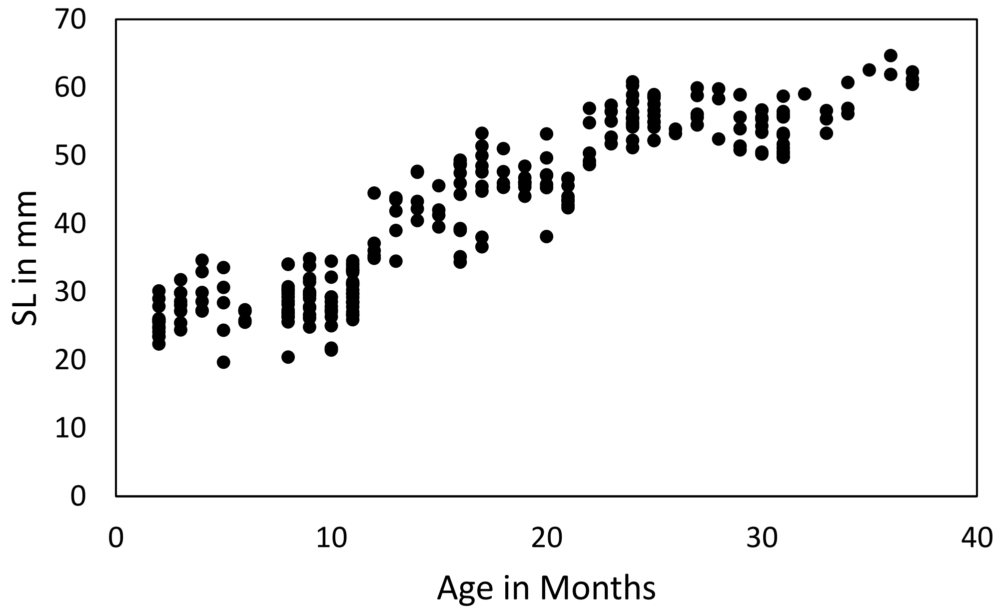

Figure 1. Standard length (SL) in mm versus hypothesized age in months for *Chrosomus oreas*.

The smallest sexually mature male (GSI = 4.4) was 34.07 mm SL, collected in February, and was eight months of age (Fig. 4). Of the 30 males collected from April to July, 70% were sexually mature. Only 25% of males approximately one year of age were sexually mature, but 100% of males approximately two and three years of age were sexually mature. The smallest female with mature oocytes was 22 months of age and had a SL of 45.29 mm. Of the 46 females collected from April to July, 28.3% had mature oocytes. Females less than approximately two years of age had no mature oocytes, while 54.2% of females approximately two years of age or greater had mature oocytes from April to July. For those same months, 50% of females approximately two years of age had elevated GSI and 40% of females approximately 3 years of age had elevated GSI (Fig. 5). Mature oocytes were up to 1.61 mm in diameter and numbered from 8 to 610 (mean = 243, SD = 178). Number of mature oocytes and SL were significantly correlated ($P = 0.004$) with a modest r^2 of 17.6%.

Unidentified organic matter was the only contents found in the gastrointestinal tracts of specimens. Weight of gut contents was not uniform across all months ($P = 0.044$) with the highest mean weight of gut contents (0.143 g, SD = 0.056) in May and lowest in August (0.018 g, SD = 0.025). The relationship between SL and weight of gut contents was significant ($P < 0.001$) and had a modest r^2 value of 31.3%. Of the specimens examined, 49.4% contained no gut contents.

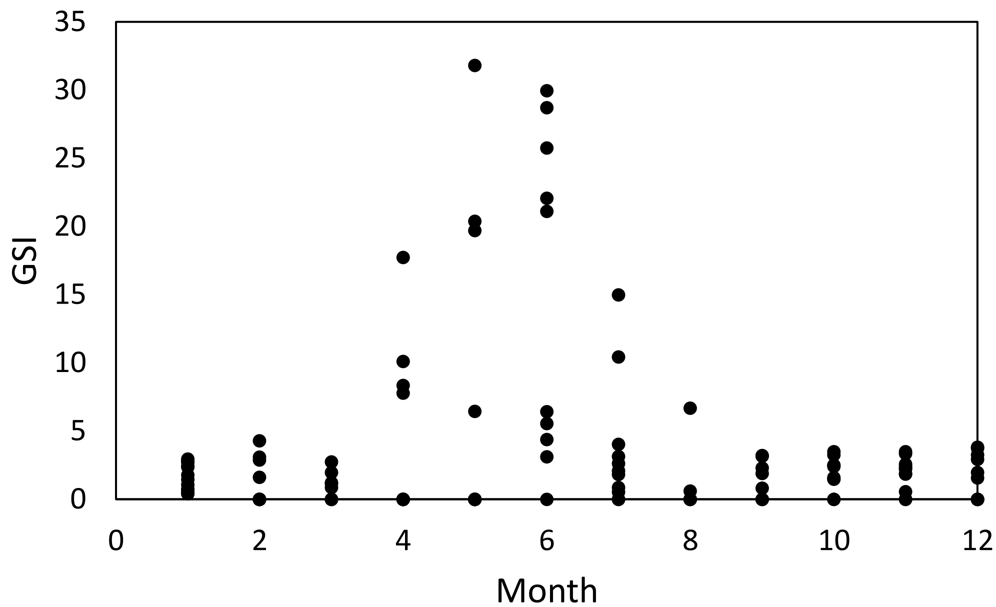

Figure 2. Gonadosomatic index (GSI) by month of collection (1 = January, 2 = February, etc.) for female *Chrosomus oreas*.

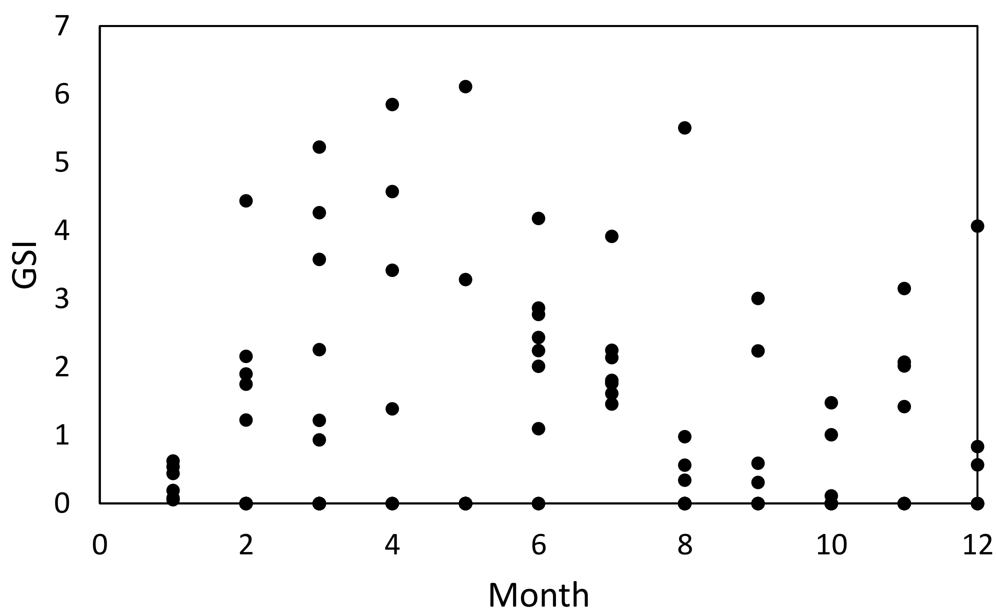

Figure 3. Gonadosomatic index (GSI) by month of collection (1 = January, 2 = February, etc.) for male *Chrosomus oreas*.

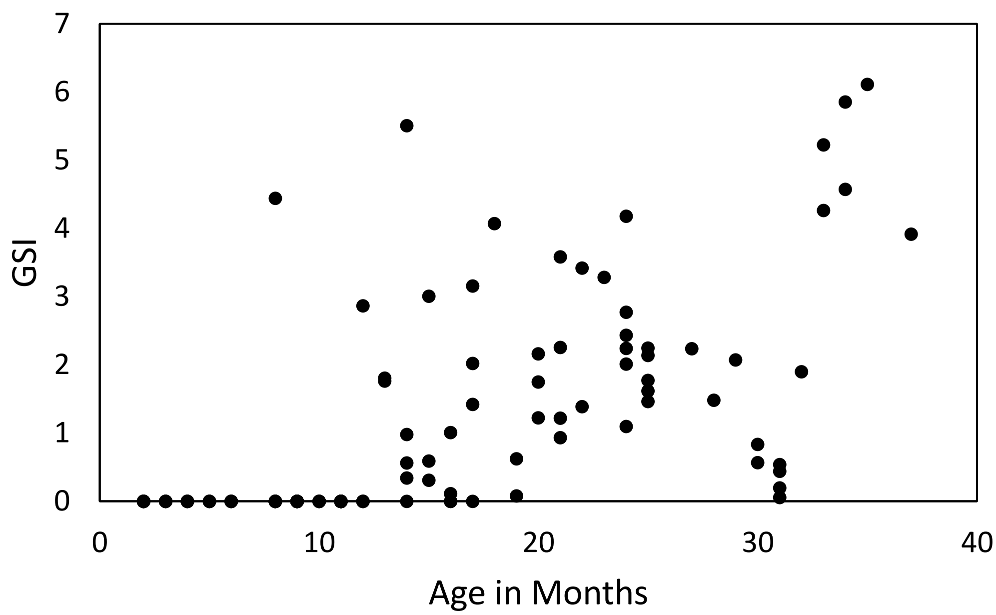

Figure 4. Gonadosomatic index (GSI) by hypothesized age in months for male *Chrosomus oreas*.

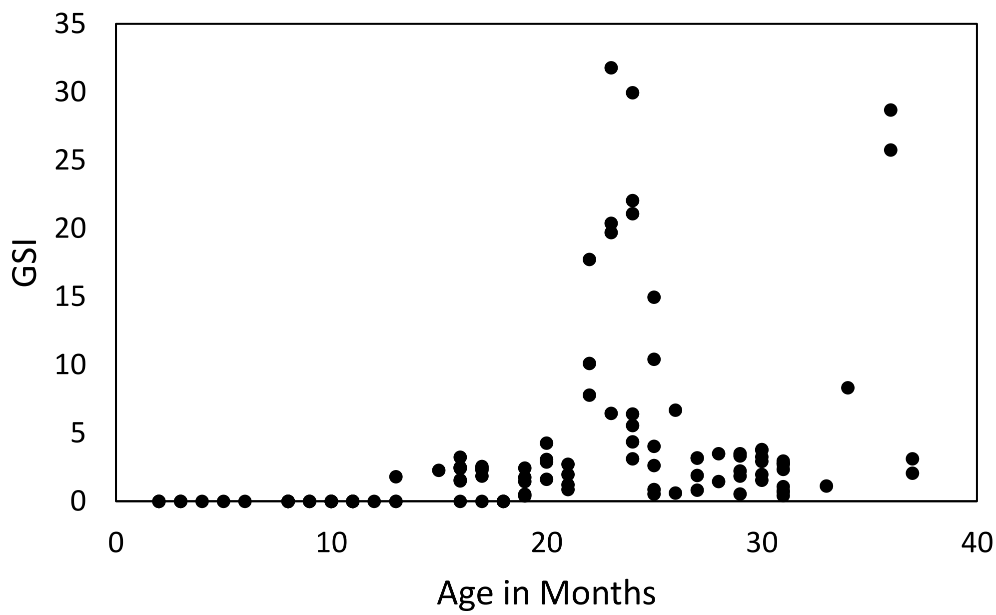

Figure 5. Gonadosomatic index (GSI) by hypothesized age in months for female *Chrosomus oreas*.

DISCUSSION

The modest positive relationship between depth and abundance of *C. oreas* and minor negative relationship between current velocity and abundance suggests *C. oreas* are most often found in deeper, slower pools of Catawba Creek. Similarly, *C. cumberlandensis*, Blackside Dace, also avoids the fastest currents and highest gradient streams within its range preferring slower pools in streams with riffle:pool ratios less than or equal to 60:40 (Starnes and Starnes 1981). The overall habitat and increased abundance of *C. oreas* in slower water habitats is consistent with the preferred microhabitats of *C. cumberlandensis* as identified by Mattingly and Black (2013). The mean of 3.4 specimens per collecting event is also comparable to density estimates for *C. cumberlandensis* (Black et al. 2013).

The largest specimen examined (64.68 mm SL) for this study is similar in size to the maximum size of 66 mm SL reported by Jenkins and Burkhead (1994). Placement on scales suggested annuli form near the end of winter to early spring. The oldest specimens had three annuli, were 60.48-62.31 mm SL, and were estimated to be 37 months of age suggesting that the maximum age for this species is approximately three years. *Chrosomus oreas* appear to grow to approximately 44.50 mm SL in their first year, to 60.84 mm SL in their second year and show little growth in their third year before reaching maximum size. The age and growth of *C. oreas* is similar to that of other *Chrosomus* as Starnes and Starnes (1981) reported decreasing growth rates throughout a maximum lifespan of three years and size of 65.5 mm for *C. cumberlandensis*. Settles and Hoyt (1978) reported a shorter maximum lifespan of 30 months and similar maximum size of 65 mm SL for *C. erythrogaster*, Southern Redbelly Dace. Hamed et al. (2008) reported four age classes and a maximum SL of 65.5 mm in *C. tennesseensis*, Tennessee Dace, suggesting slightly slower growth and a longer maximum lifespan. Clinch Dace, *Chrosomus* sp. cf. *saylori* appear to live to a maximum age of just over 2 years and reach a maximum size of 61.4 mm SL (White and Orth 2013).

The large proportion (41.18%) of age 0+, modest proportion of 1+ (29.80%) and 2+ (27.06%), and small proportion of 3+ (1.96%) specimens suggest low survivorship during the first year of life, but high survivorship to maximum lifespan after this early susceptibility. This relatively high survivorship of large specimens contrasts with higher proportions of 0+ specimens reported for other *Chrosomus* species (Settles and Hoyt 1978, Starnes and Starnes 1981, Hamed et al. 2008). These contrasting demographics may be due to a relative dearth of piscivorous fishes in Catawba Creek as the only piscivore collected with *C. oreas* during this study was *Ambloplites rupestris* (Rafinesque), Rock Bass, which is more of a generalist predator than a strict piscivore (Jenkins and Burkhead 1994).

Females (mean SL = 44.70 mm) are significantly ($P < 0.001$) larger than males (mean SL = 38.30 mm) as suggested by Jenkins and Burkhead (1994). The difference in mean size among sexes may be due to the difference in lifespan, as females appear to outlive males (female mean age = 19.18 months, male mean age = 14.21 months, $P < 0.001$). *Chrosomus cumberlandensis* females similarly outlive their male counterparts (Starnes and Starnes 1981). This differential survival appears to be common among Cyprinidae and has been attributed to males having an increased behavioral energetic cost during and following spawning increasing their post-spawning mortality (Reed 1955, Meffe et al. 1988, Jolly and Powers 2008).

Males appear to begin reaching sexual maturity at approximately one year of age and are all sexually mature by two years of age, while females do not begin reaching sexual maturity until they are approaching two years of age. Considerable variation exists within *Chrosomus* regarding age at maturity. Starnes and Starnes (1981) reported that *C. cumberlandensis* reaches sexual maturity by one year of age, while *C. erythrogaster* and *C. tennesseensis* begin to reach sexual maturity by one year of age, but many are not mature until their second year (Settles and Hoyt 1978, Hamed et al. 2008). White and Orth (2014) reported age at maturity as 2 years for Clinch Dace. The number of oocytes in *C. oreas* increases as SL increases (r^2 = 17.6%, P = 0.004). Similar, but more strongly correlated size and fecundity relationships were found in *C. erythrogaster*, *C. cumberlandensis,* and *C. tennesseenis* (Settles and Hoyt 1978, Starnes and Starnes 1981, Hamed et. al. 2008).

Elevated female GSI values from April to June declining precipitously in July suggests a spawning season in spring and early summer for *C. oreas* with water temperatures 14-18^{o} C, with spawning activity tailing off as water temperatures reach a maximum level of 27^{o} C in July. Similarly, *C. erythrogaster*, *C. cumberlandensis*, *C. tennesseensis,* and Clinch Dace all appear to spawn from April to late June or early July in similar water temperatures (Settles and Hoyt 1978, Starnes and Starnes 1981, Hamed et al. 2008, White and Orth 2014). Considerable variation in the size of *C. erythrogaster* and *C. tennesseensis* in their first fall is likely due to being spawned at opposite ends of this relatively long spawning season (Settles and Hoyt 1978, Hamed et al. 2008). Similarly, an extended spawning season may also explain the substantial range in SL of age 0+ specimens in this study.

Feeding is not uniform across all months (P = 0.044) and appears to be least intense during late summer and fall months (from August to November) as indicated by overall lower values for weight of gut contents. Minimum mean mass of gut contents was found in August (0.018 g), and there was a general trend of increasing values for mass of gut contents to a peak of 0.143 g in May. *Chrosomus cumberlandensis* also appears to have dramatic changes in feeding throughout the year with generally more algae consumed in spring and early summer months than fall and winter (Starnes and Starnes 1981). This change in feeding throughout the year largely mimics energy requirements for gamete production as found in other cyprinids (Jolly and Powers 2008, Holder and Powers 2010).

The gut contents of specimens were exclusively unidentified organic matter. Observation of aquarium held specimens also revealed ingestion of attached, filamentous algae during fall 2010. These results are consistent with Flemer and Woolcott's (1966) findings that the bulk of *C. oreas* diet consists of filamentous algae, diatoms and desmids. Jenkins and Burkhead (1994) also identified *C. oreas* as an herbivore and algivore. Other *Chrosomus* also appear to be largely herbivorous and detritivorous. *Chrosomus erythrogaster* and *C. cumberlandensis* feed mostly on microscopic algae, but opportunistically consume other available food items (Phillips 1969, Starnes and Starnes 1981). Clinch Dace appear to have a contrasting diet feeding mostly on macroinvertebrates (White and Orth 2013).

REFERENCES

Black, T. R., J. E. Detar, and H. T. Mattingly. 2013. Population densities of the threatened Blackside Dace, *Chrosomus cumberlandensis*, in Kentucky and Tennessee. Southeastern Naturalist. 12(4):6–26.

Bond, C. E. 1996. Biology of Fishes. Second Edition. Saunders College Publishing, Fort Worth, TX. 750 pp.

Flemer, D. A., and W. S. Woolcott. 1966. Food habits and distribution of the fishes of Tuckahoe Creek, Virginia, with special emphasis on the Bluegill, *Lepomis m. macrochirus* Rafinesque. Chesapeake Science 7(2): 75–89.

Hamed, M. K., F. J. Alsop III, and T. F. Laughlin. 2008. Life history traits of the Tennessee Dace (*Phoxinus tennesseensis*) in northeast Tennessee. American Midland Naturalist 160(2); 289–299.

Heins, D. C., and J. A. Baker. 1988. Egg sizes in fishes: do mature oocytes accurately demonstrate size statistics of ripe ova? Copeia 1988(1): 238–240.

Holder, D. S., and S. L. Powers. 2010. Life-history aspects of the Rainbow Shiner, *Notropis chrosomus* (Teleostei: Cyprinidae), in northern Georgia. Southeastern Naturalist 9(2): 347–358.

Jenkins, R. E., and N. M. Burkhead. 1994. Freshwater Fishes of Virginia. American Fisheries Society. Bethesda, MD. 1079 pp.

Jolly, D. M., and S. L. Powers. 2008. Life-history aspects of *Notropis xaenocephalus* (Coosa Shiner) (Actinopterygii: Cyprinidae) in northern Georgia. Southeastern Naturalist 7(3): 449–458.

Mattingly, H. T., and T. R. Black. 2013. Nest association and reproductive microhabitat of the threatened Blackside Dace, *Chrosomus cumberlandensis.* Southeastern Naturalist. 12(4):49–63.

Meffe, G. K., D. L. Certain, and A. L. Sheldon. 1988. Selective mortality of post-spawning Yellowfin Shiners, *Notropis lutipinnis* (Pisces: Cyprinidae). Copeia 1988(4):853–858.

Pendleton, R. M., J. J. Pritt, B. K. Peoples, and E. A. Frimpong. 2012. The strength of *Nocomis* nest association contributes to patterns of rarity and commonness among New River, Virginia cyprinids. American Midland Naturalist 168(1):202–212.

Peoples, B. K., and E. A. Frimpong. 2013. Evidence of mutual benefits of nest association among freshwater cyprinids and implications for conservation. Aquatic Conservation: Marine and Freshwater Ecosystems 23(6):911–923.

Phillips, G. L. 1969. Diet of minnow *Chrosomus erythrogaster* (Cyprinidae) in a Minnesota Stream. The American Midland Naturalist 82(1):99–109.

Powers, S. L., and P. A. Ceas. 2000. Ichthyofauna and biogeography of Russell Fork (Big Sandy River - Ohio River). Southeastern Fishes Council Proceedings 41:1–13.

Reed, R. J. 1955. Phases of the life history of the Rosyface Shiner, *Notropis rubellus,* in Northwestern Pennsylvania. Copeia 1957(4):286–290.

Settles, W. H., and R. D. Hoyt. 1978. The reproductive biology of the Southern Redbelly Dace, *Chrosomus erythrogaster* Rafinesque, in a spring-fed stream in Kentucky. The American Midland Naturalist 99(2):290–298.

Starnes, L. B., and W. C. Starnes. 1981. Biology of the Blackside Dace, *Phoxinus cumberlandensis.* The American Midland Naturalist 106(2):360–371.

Strange, M. R., and R. L. Mayden. 2009. Phylogenetic relationships and a revised taxonomy for northern American cyprinids currently assigned to *Phoxinus* (Actinoterygii: Cyprinidae). Copeia 2009(3): 494–501.

UFR (Use of Fishes in Research) Committee. 2013. Guidelines for the use of fishes in research. American Fisheries Society. Bethesda, Maryland.

White, S. L., and D. J. Orth. 2013. Ontogenetic and comparative morphology of Clinch Dace, *Chrosomus* sp. cf. *saylori*. Copeia 2013(4):750–756.

White, S. L., and D. J. Orth. 2014. Reproductive biology of Clinch Dace, *Chrosomus* sp. cf. *saylori*. Southeastern Naturalist. 13(4):735–743.