Seasonal Variation in Population Characteristics of Gizzard Shad

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ABSTRACT

The gizzard shad (*Dorosoma cepedianum*) is an important species in midwestern lakes and reservoirs, which has both positive and negative effects on sport fisheries. This study was conducted to document seasonal variation in population characteristics (i.e., catch rates, condition, size and age structure, and growth) of gizzard shad in Glen Elder Reservoir, Kansas. Fish were sampled monthly from June 1999 to May 2000 using experimental gill nets. Catch rates were highest during the spring (March, April, May) for all year classes, except the 1998 year class where catch per unit effort was highest during the fall (September, October, November). This resulted from recruitment of the 1998 year class to the sampling gear. Recruitment of the 1998 year class to the gill nets was also reflected by a skewed age distribution and a decline in proportional stock density (PSD) from 89 during the spring to 59 in the fall. Mean relative weight (W*r*) exceeded 80 for all year classes and seasons and was generally highest during the spring. Growth of gizzard shad was similar to that of other midwestern and southern populations. Fish grew rapidly during the first year of life, and most of their annual growth was attained during late spring and early summer.

INTRODUCTION

The gizzard shad (*Dorosoma cepedianum*) comprises a major portion of the fish biomass in central U.S. reservoirs and lakes (Noble 1981) and plays an important functional role in lentic ecosystems. Since larval and juvenile gizzard shad are often the primary prey for sport fish, their abundance may greatly influence growth of piscivores (Michaletz 1998). Gizzard shad may also enhance recruitment of sport fish by increasing growth rates or functioning as a predatory buffer (Donovan et al. 1997); conversely, larval gizzard shad can compete with other age-0 fishes for zooplankton resources which can result in poor recruitment of sport fishes (Dettmers and Stein 1992, DeVries and Stein 1992, Stein et al. 1995). Several studies have also shown that gizzard shad recycle nutrients within the water column and transport nutrients from the benthos to limnetic phytoplankton communities (DeVries and Stein 1992, Schaus et al. 1997). Thus, the gizzard shad is an important component of lentic food webs that has direct and indirect effects on sport fish populations. Understanding seasonal variation in population dynamics is important not only for developing monitoring programs, but also for gaining insight on the mechanisms regulating sport fish growth and recruitment.

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Many population assessment and management decisions are based on information collected during a single sampling period; however, the biases associated with seasonal variations in population indices such as catch per unit effort (CPUE), size structure, and condition should be considered. A recent study was conducted to assess various gears for sampling shad (*Dorosoma* spp.) in reservoir systems (Boxrucker et al. 1995). Although the efficiency of various gears and variations in population characteristics of gizzard shad collected with those gears has been extensively studied (Van Den Avyle et al. 1995), we are aware of no published information on the seasonal variation of population indices of gizzard shad. These data are essential for understanding biases associated with current population assessment techniques that may ultimately influence prey-fish management in reservoir systems.

The purpose of this study was to describe the population dynamics of the gizzard shad in a large Kansas reservoir. Our objectives were to examine seasonal variability in abundance, size structure, condition, age structure, and growth of gizzard shad.

METHODS

This study was conducted on Glen Elder Reservoir, a 5,093-ha reservoir in northwestern Kansas (Mitchell County). The primary use of the reservoir is for flood protection; however, it also provides important recreational opportunities for anglers. The sport fish community is dominated by white bass (*Morone chrysops*), channel catfish (*Ictalurus punctatus*), walleye (*Stizostedion vitreum*), and white crappie (*Pomoxis annularis*). Similar to other Kansas reservoirs, gizzard shad is the dominant prey species.

Gizzard shad were sampled monthly from six sites using 45.7-m × 1.8-m experimental gill nets (9.2-m panels with 25.4-mm, 38.1-mm, 50.8-mm, 63.5-mm, and 76.2-mm bar measure mesh) from June 1999 to May 2000. Samples were not collected during December 1999 due to ice cover. Gill nets were fished at two-hour intervals to reduce mortality of sampled fishes. Length (mm; total length) and weight (g) were measured for all fish, and scales were removed from 10 fish per centimeter length group for age and growth analysis. Months were grouped into seasons based on water temperature: summer (June, July, August), fall (September, October, November), winter (January, February), spring (March, April, May). All variables were summarized by year class and season, except for mean-length-at-capture, which was summarized on a monthly basis.

Catch per unit effort was estimated as the number of fish collected per gillnet hour. Size structure was assessed using proportional stock density (PSD; Anderson and Neumann 1996). Ninety-five percent confidence intervals were determined for PSD values using data provided by Gustafson (1988). Condition was assessed using relative weight (W*r*; Anderson and Neumann 1996) for year classes with ≥ 5 individuals. Age structure was assessed by extrapolating the age data to the entire sample using an age-length key during each season (DeVries and Frie 1996). We used the direct proportion method to estimate mean back-calculated length at age because the body length-scale radius relationship was weak ($r = 0.73$; $P = 0.0001$) and it facilitated comparisons with other studies. Mean total annual mortality was estimated using catch curves for each season (Ricker 1975). Differences in CPUE and W*r* among seasons and in mean-length-at-capture among months were assessed using repeated-measures analysis of variance (Milliken and Johnson 1992, Littell et al. 1996). Multiple comparisons were conducted using least square means. An alpha level of 0.05 was used to determine statistical differences.

RESULTS

We collected 1,008 gizzard shad varying in length from 158 mm to 426 mm. Catch per unit effort of gizzard shad was highly variable and was generally highest during spring for all year classes; however, CPUE of age-1 gizzard shad (i.e., 1998 year class sampled in 1999) was highest during the fall (Table 1). Pooled catch rates were significantly higher ($P \leq 0.05$) during the fall and spring compared to summer and winter. Size structure was higher during the summer (PSD ± 95% confidence interval; 89 ± 6) and winter (69 ± 14) compared to the fall and spring (59 ± 10;

both seasons). The reduction in PSD following summer reflects recruitment of the 1998 year class to our sampling gear.

Mean W*r* exceeded 80 for all year classes and seasons (Table 1). We did not observe any consistent seasonal trends in mean W*r*. For example, the 1998 year class exhibited a significantly higher W*r* during the summer and winter months, while the 1995 year class had the highest W*r* during the spring and fall. Mean W*r* was generally higher during the spring for all year classes except the 1998 year class. When all year classes were pooled, we found that mean W*r* was highest during the summer and spring.

Age and growth analysis was conducted on 535 gizzard shad varying in age from age 1 to age 7. Over 70% of the sampled fish were less than age 3 and our samples were dominated by fish from the 1997 year class (Table 1). However, the highest proportion of fish during the fall (45.6%) were from the 1998 year class. Mean back-calculated lengths at age ($mean_{(age)} \pm$ standard error; $125_{(1)} \pm 5$; $228_{(2)} \pm 11$; $309_{(3)} \pm 10$; $334_{(4)} \pm 7$; $352_{(5)} \pm 2$; $377_{(6)} \pm 2$; $388_{(7)} \pm 0.0$) indicated that growth of gizzard shad was rapid during the first two years of life and then declined to approximately 20 mm/year. Although cohorts were not sampled throughout a complete growing season, it appears that most of their annual growth was accomplished during late spring or summer and was dependent on age (Figure 1). For example, mean back calculated length at age 1 for the 1998 year class averaged 110 mm and mean length reached 215 mm by September. This accounted for over 90% of their annual growth during 1999. Similarly, growth rates for the 1997 year class were fastest during the summer months (i.e., July, August). We also found that mean length of the 1998 year class declined during late fall and winter (i.e., November, January), but the differences were not significant ($P > 0.05$). Total annual mortality averaged 49% (SE = 7.1).

Table 1. Mean catch per unit effort (CPUE; number / gill net hour), mean relative weight (W*r*), and age structure (relative frequency; %) of gizzard shad collected from Glen Elder Reservoir during June 1999 to May 2000 by year class and for all year classes pooled. Numbers in parentheses represent the coefficient of variation [CV = (standard error × 100) / mean] for CPUE and standard error for W*r* Values with different letters indicate a significant difference among seasons ($P \leq 0.05$).

		Year class						
Variable	Season[a]	1998	1997	1996	1995	1994	1993	Pooled
CPUE	Summer	0.30 (53.3)	0.49 (36.3)^{x}	0.27 (6.0)	0.07 (46.2)^{x}	0.01 (57.1)	0.0 (0)	2.54 (7.2)^{x}
	Fall	1.08 (65.3)	0.34 (38.8)^{x}	0.27 (48.1)	0.19 (36.8)^{xy}	0.02 (57.1)	0.03 (50.0)	7.47 (57.1)^{y}
	Winter	0.21 (28.6)	0.33 (24.2)^{x}	0.03 (33.3)	0.03 (100.0)^{x}	0.01 (100.0)	0.0 (0)	1.77 (74.0)^{x}
	Spring	0.69 (53.6)	1.31 (48.9)^{y}	0.46 (67.7)	0.28 (35.7)^{y}	0.06 (50.0)	0.02 (100.1)	11.56 (35.6)^{y}
W*r*	Summer	97.2 (3.1)^{x}	85.8 (0.7)^{xy}	88.1 (1.1)^{x}	81.9 (1.8)^{x}	[b]	[b]	88.3 (0.8)^{x}
	Fall	82.5 (0.6)^{y}	85.6 (1.3)^{xy}	85.6 (1.1)^{y}	94.2 (1.7)^{y}	[b]	[b]	84.9 (0.5)^{y}
	Winter	89.2 (2.3)^{z}	84.9 (0.8)^{x}	82.7 (2.2)^{y}	82.4 (1.0)^{z}	[b]	[b]	86.5 (0.9)^{xy}
	Spring	88.9 (0.8)^{z}	87.1 (0.8)^{y}	88.1 (1.7)^{x}	95.4 (2.1)^{y}	[b]	[b]	88.4 (0.5)^{x}
Age structure	Summer	22.6	48.9	23.6	3.4	1.4	0.0	
	Fall	45.6	21.3	14.2	12.9	3.3	2.0	
	Winter	33.3	26.3	5.0	5.0	3.3	0.0	
	Spring	31.5	44.9	9.9	11.6	0.7	1.0	

[a] Samples collected in 1999 were summer (June, July, August) and fall (September, October, November), and in 2000 they were winter (January, February) and spring (March, April, May).

[b] Sample size insufficient to estimate W*r* (i.e., < 5 individuals).

DISCUSSION

We found that catch rates of gizzard shad were highest during the spring and fall. In Kansas reservoirs, gizzard shad larvae reach peak densities during May but may appear as early as late April (Willis 1987). Therefore, high catch rates during the spring are likely due to inshore spawning movements of adult gizzard shad. Van Den Avyle et al. (1995) found that 25-mm mesh gill nets were selective for gizzard shad greater than 170 mm. Thus, high catch rates during the fall reflects recruitment of the 1998 year class to our sampling gear and is corroborated by a low PSD and skewed age distribution during the fall months.

Condition of gizzard shad was similar to studies conducted in Kansas (Willis 1987), Alabama (DiCenzo et al. 1996), and Missouri reservoirs (Michaletz 1998). Larval gizzard shad primarily consume zooplankton and phytoplankton (Cramer and Marzolf 1970), but after their first summer, they feed almost exclusively on detritus (Pierce et al. 1981, Mundahl and Wissing 1987). Most of the fish collected during this study were likely feeding on detrital food resources, which explains the similarity in condition among year classes within a season. Mean *Wr* was generally higher during the spring compared to the other seasons. Relative weight has been shown to be positively correlated with gonadal somatic index for many species such as northern pike (*Esox lucius*, Neumann and Willis 1995) and gizzard shad (Willis 1987). Thus, higher condition in the spring is probably the result of gonadal development.

Growth of gizzard shad is an extremely important factor influencing growth of sport fish (Michaletz 1998). Few studies have examined growth of gizzard shad in Kansas reservoirs; however, Willis (1987) found that gizzard shad in Melvern Reservoir exhibited slow growth compared to other midwestern and southern reservoirs. We found that gizzard shad in Glen Elder Reservoir grew faster than fish in Melvern Reservoir, and growth was most similar to populations in Missouri reservoirs (Michaletz 1998) and the Mississippi River (McInerny and Held 1995). In addition, it appears that most growth occurs during late spring and early summer and ceases during late fall. Similar results were reported by McInerny and Held (1995) who found that gizzard shad stopped growing once water temperatures reached 9°-11°C.

The results of this study provide a better understanding of how population indices of gizzard shad vary among seasons. Understanding seasonal variability will allow fisheries scientists to assess gizzard shad populations with an awareness of the biases associated with a one-time sample and allow for more efficient prey-species management. Furthermore, our results provide important information for future comparative studies on gizzard shad populations.

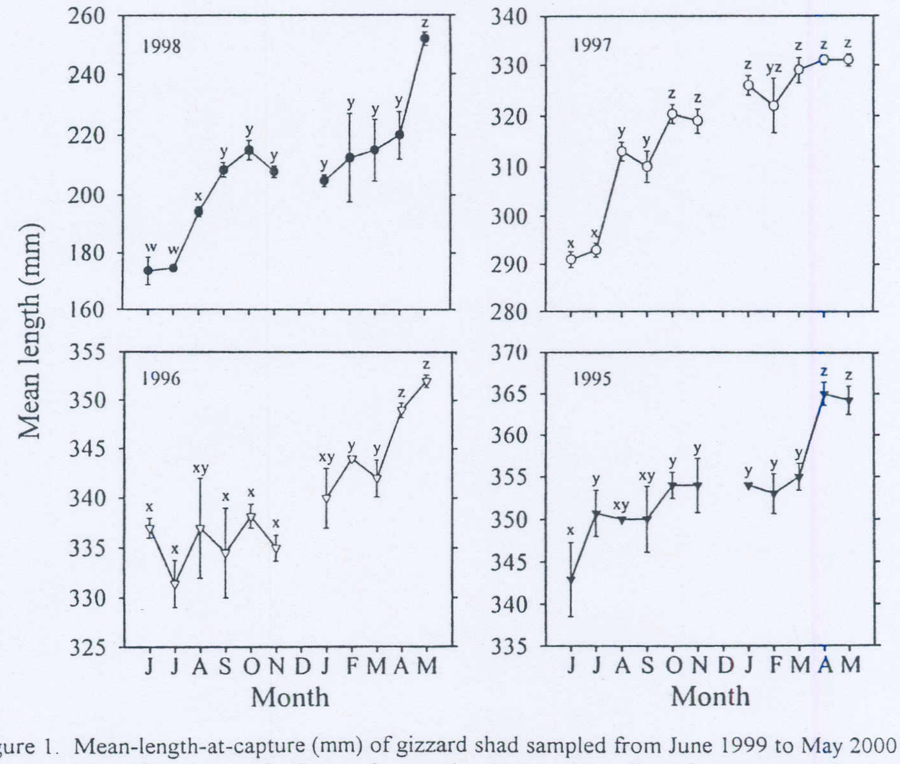

Figure 1. Mean-length-at-capture (mm) of gizzard shad sampled from June 1999 to May 2000 in Glen Elder Reservoir, Kansas, by month and year class. Error bars represent one standard error and values with different letters indicate a significant difference in mean length ($P \leq 0.05$) within a year class.

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