Growth of Introduced *Stizostedion* Hybrids in Cherokee Reservoir, Tennessee

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Abstract: Growth of introduced *Stizostedion* hybrids (*S. vitreum x S. canadense*) was examined from July 1983 to December 1985. Hybrids averaged 296 and 442 mm TL at ages I and II. Condition factors (K) of hybrids increased with age, while relative weights (W_r) were within the acceptable range (95–105) for all but 3 months of the first 2 years following introduction. Both condition indices decreased sharply during the spring and early summer. Reduced abundance of small shad due to winter mortality and altered predator-prey relationships during spring and early summer may seasonally impact condition of hybrid *Stizostedion*.

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Walleye (*S. vitreum*) and sauger (*S. canadense*) developed reproducing populations in Cherokee Reservoir, Tennessee, following impoundment. These species, while never extremely abundant, suffered severe declines from 1951 to 1963 and were functionally extirpated by the early 1970s (Heuer and Tomljanovich 1980).

The decline and subsequent extirpation of walleye and sauger in Cherokee Reservoir was attributed to the cumulative effects of (1) loss of spawning habitat; (2) temperature and water level fluctuations resulting from operation of the John Sevier Steam-Electric Plant located at the reservoir headwaters; and (3) decline in water quality in the upper Holston River (Edrington et al. 1979). Edrington et al. (1979) further stated that restoration of the *Stizostedion* fishery would be unlikely until reservoir conditions approximated those in the early years following impoundment.

Initial introductions of a female walleye and male sauger hybrids during the 1970s indicated this hybrid exhibited better growth and survival than introduced

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walleye in small eutrophic impoundments (Smith and Carline 1983). In 1982, the Tennessee Wildlife Resources Agency (TWRA) and the Tennessee Valley Authority (TVA) began a cooperative effort to introduce *Stizostedion* hybrids into Cherokee Reservoir, Tennessee. The introduction was designed as partial mitigation for the loss of the *Stizostedion* fishery and to evaluate the feasibility of hybrid introductions for maintaining a percid fishery.

The purpose of this study was to evaluate *Stizostedion* hybrid introductions in Cherokee Reservoir to provide pertinent information for future management of this hybrid. The study objectives included: (1) an assessment of growth and condition of young-of-year and yearling hybrids and (2) comparisons of growth with hybrids and parental types in other reservoirs.

Methods

Cherokee Reservoir is a TVA multi-purpose impoundment located on the main stem of the Holston River in eastern Tennessee. The reservoir, impounded in 1941, is operated for flood control, hydro-electric power generation, and recreation. The reservoir has a surface area of 12,222 ha, a maximum depth of 46 m, and 745 km of shoreline at full pool (328 m above mean sea level). Reservoir water levels and surface area fluctuate greatly between summer and winter due to extreme fall drawdown.

The Holston River contains large amounts of industrial, municipal, and domestic effluents, which, when combined with seasonal contributions of decaying aquatic macrophytes, create eutrophic conditions in the reservoir. The reservoir begins to stratify in early spring and hypolimnetic anoxia is commonplace by summer. Epilimnetic temperatures remain above 25° C until fall turnover, after which the reservoir is isothermal.

During the period from 1982 to 1985, TWRA introduced 410,000 fry and 327,400 fingerling *Stizostedion* hybrids (hereafter referred to as hybrids) into Cherokee Reservoir (Table 1). Both fry (10 days post-hatch, <10 mm total length (TL)) and fingerlings (25–50 mm TL) were propagated at TWRA's Eagle Bend Hatchery with broodstock obtained from local reservoirs.

Bi-weekly collection trips were made from June to October in 1983 and 1984;

Table 1. *Stizostedion* hybrids stocked in Cherokee Reservoir, Tennessee, 1982–1985.

Year	Fry	Fingerling	Total
1982		48,600	48,600
1983	30,000	101,400	131,400
1984	380,000	93,900	473,900
1985		83,500	83,500
Total	410,000	327,400	737,400

monthly collections were made from November to May of those years and from June to December in 1985. Sampling was conducted between sunset and sunrise and was restricted to the upper half of the reservoir. Hybrids were collected by shoreline seining, electrofishing, and monofilament gill nets with mesh-sizes (bar) of 12.7, 19.1, 25.4, and 31.8 mm.

All hybrids were examined in samples with <30 individuals, while a random sample of 30 individuals was analyzed for months when collections exceeded this number. Total length (mm) and weight (g) were recorded for each hybrid.

Examination of scale samples from all hybrids used in this study indicated than annulus deposition occurred during May of each year. Therefore, all hybrids collected from the date of introduction through May of the following year were defined as young-of-year (YOY), whereas individuals collected from June through May of the second year following introduction were considered yearlings. The mean total length of hybrids during May of each of the 2 years following introduction was considered to the length at age I and II.

A coefficient of condition was computed with the Fulton formula (Bagenal 1978). Relative weight (Wege and Anderson 1978) was calculated for hybrids with a standard weight table developed by TVA (Ed Scott, TVA, unpubl. data) for walleye in TVA tributary reservoirs. Length-weight relationships (Ricker 1975) were calculated for both YOY and yearling hybrids.

Student's *t*-test and a one-way analysis of variance (ANOVA) (Sokal and Rohlf 1981) were used to test for differences in growth and condition among cohorts and age groups. Differences in slopes of length-weight relationships were evaluated using an F-test (Sokal and Rohlf 1981). All tests were evaluated at the $\alpha = 0.05$ level of significance.

Results and Discussion

A total of 665 YOY and yearling hybrids was used to evaluate growth and condition from June 1983 to December 1985. Growth was rapid throughout the first 6 months following introduction with hybrids from 1983, 1984, and 1985 cohorts averaging 279, 293, and 244 mm TL, respectively, by December. These lengths were not significantly different ($P > 0.05$). Little growth occurred during the winter and spring, with the 1983 and 1984 cohorts reaching lengths of 281 and 317 mm TL at age I. Both of these cohorts attained approximately 90% of their first year growth by December.

Growth of the 1985 cohort during the first summer and fall appeared to be less than that of hybrids during the same period of previous years. The majority of YOY hybrids collected during 1983 and 1984 were collected with gill nets. Approximately 90% of YOY hybrids collected during 1985 were obtained by electrofishing, which more effectively sampled the entire cohort and not just larger individuals that were more susceptible to capture in gill nets. Additionally, during the summer and fall 1985, reservoir levels remained approximately 7 meters below normal. This reduced the reservoir surface area by 25% and young hybrids were less dispersed than in previous years, again allowing for more effective sampling. YOY hybrids collected during winter 1985 and spring 1986 had total lengths similar to those of YOY hybrids during the same seasons of previous years suggesting that growth was not impaired during 1985 (TVA, unpubl. data).

Yearling hybrids exhibited rapid growth during the summer and fall with the 1982, 1983, and 1984 cohorts averaging 429, 401, and 409 mm TL, respectively, by December. These values were not significantly different ($P > 0.05$). Summer and fall growth accounted for 90% of the total second year growth of the 1983 cohort which reached 442 mm TL at age II.

Length at age was used to compare growth of Cherokee Reservoir hybrids to that of hybrids and parental types in other impoundments (Table 2). Early growth of hybrids in Cherokee Reservoir was similar to that of hybrids in Ohio reservoirs; however, growth of Ohio hybrids ceased in October, while Cherokee hybrids continued to grow until December. This additional period of growth resulted in a greater length at each age for Cherokee Reservoir hybrids. Mean lengths at age I for both the 1983 (281 mm TL) and 1984 (318 mm TL) cohorts exceeded the value of 271 mm TL determined by Humphreys (1984) for the 1982 cohort of hybrids. Growth of hybrids in Cherokee Reservoir exceeded that of both parental types in other Tennessee reservoirs.

Length-weight relationships calculated for YOY and yearling hybrids are as follows: $\log W = -5.44 + 3.15 \log L$ ($r^2 = 0.980$) and $\log W = -6.22 + 3.46 \text{ Log } L$ ($r^2 = 0.937$). Slopes of these relationships were > 3.0, indicating that both YOY and yearling hybrids exhibited allometric growth. Slopes of the 2 relationships were significantly different ($P < 0.001$) indicating that yearling hybrids gained more body weight per length increment than did YOY hybrids.

Differences in monthly condition factors and relative weights among each cohort were not significant ($P > 0.05$). Therefore, these values were combined as weighted means to illustrate the trend in hybrid condition during the first 2 years following introduction (Fig. 1). Condition of hybrids improved during the first 9 months following stocking, with the greatest increase occurring during the winter

Table 2. Published growth estimates of *Stizostedion* hybrids (H), walleye (W), and sauger (S) in selected impoundments.

Source	Location	Total Length (mm)	
		Age I	Age II
Present Study	Cherokee, TN (H)	296	442
Stroud (1948)	Norris, TN (H)	199	350
Smith and Carline (1983)	Pleasant Hill, OH (H)	236	380
Scott (1976)	Center Hill, TN (W)	267	421
Libbey (1969)	Dale Hollow, TN (W)	264	409
Hassler (1957)	Norris, TN (S)	213	337
Fitz (1968)	Melton Hill, TN (S)	228	338

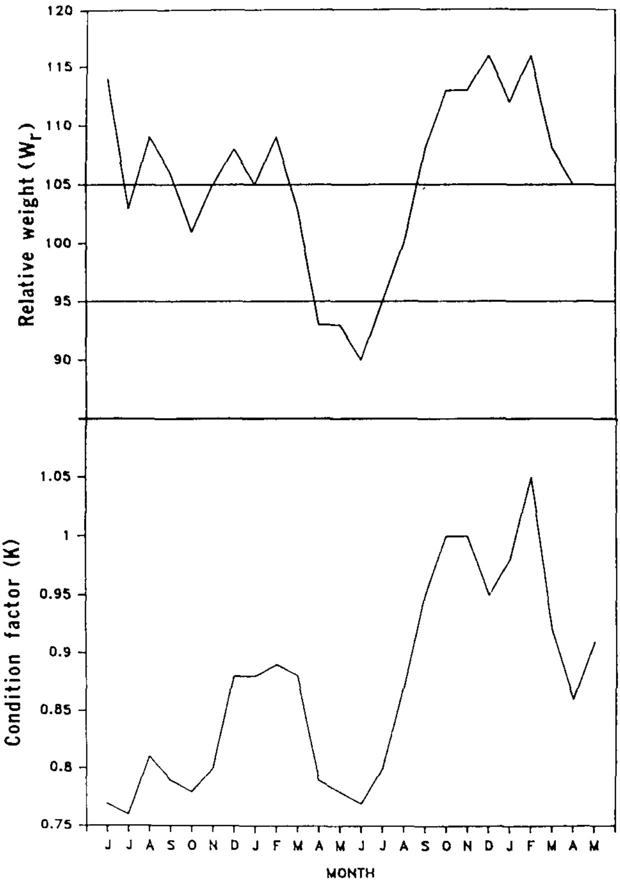

Figure 1. Weighted mean coefficient of condition and relative weight of *Stizostedion* hybrids from Cherokee Reservoir, Tennessee, July 1983–December 1985 (horizontal lines indicate acceptable range of relative weights)

months. During the spring and early summer of the year following introduction, condition factors declined but quickly recovered as summer progressed. Condition factors remained high throughout the second year until spring, when condition factors again decreased. Relative weights of hybrids remained within or above the acceptable range (95–105) for all but 3 months of the first 2 years after introduction.

Both condition factor and relative weight declined during the late spring and early summer (Fig. 1). This decline was evident in both YOY and yearlings; however, the magnitude of decrease in condition was less severe in the yearlings. Food habits data from a related study (Woodward 1987) indicated a decrease in the frequency of fish in the diet of YOY hybrids during the late spring with a concurrent increase in the consumption of benthic invertebrates. Previous studies have shown that piscivorous fish which are forced to utilize zooplankton, insects, or other macro-invertebrates will exhibit reduced growth and condition (Humphreys 1984). Extremely cold winters result in die-offs of temperature sensitive threadfin shad in many Tennessee reservoirs. While abundance of cold-stressed shad and increased food conversion efficiency at optimal temperatures may account for the increase in hybrid condition during the winter months, these die-offs resulted in a marked decrease of small shad by the spring. Until YOY shad were again available following the spring spawn, young hybrids were forced to use alternative prey resulting in a decline in condition. Hybrid condition rapidly improved as shad abundance increased.

The similar but less severe decrease in condition of yearling hybrids suggested that factors other than prey availability may have affected condition. As with YOY fish, there was a decrease of fish in the diet of yearling hybrids. However, they were not as influenced by declines in threadfin shad since they could utilize larger gizzard shad if necessary.

The thermal tolerance of both gizzard and threadfin shad is such that these species can readily inhabit areas of the reservoir that have temperature characteristics which prohibit all but temporary occupation by mesothermal fishes such as walleye, sauger, or their hybrids (Griffith 1978). Until shad abundance is such that these forage fish are widely dispersed throughout the reservoir, hybrids may have to occupy undesirable habitat to capture prey. Kelso (1972) found that walleye which were forced to inhabit areas with temperatures at the upper limit of their range of tolerance had severely reduced food conversion efficiency which resulted in generally poorer condition. Rapidly warming water temperatures in spring and early summer could create a similar situation for hybrids in Cherokee Reservoir.

Seasonal fluctuations in prey abundance and altered predator-prey relationships appeared to have little deleterious effects on hybrid growth and condition during the first 2 years following introduction. Yearling hybrids continued to grow during the early summer but were characterized by poor condition. However, as prey abundance increased, condition rapidly improved. The findings of this study indicated that hybrids may be suitable for establishing put-grow-and-take percid fisheries in non-coolwater impoundments. Additional study should address growth and survival of older hybrids to further evaluate the potential of this sportfish to sustain quality recreational fisheries.

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