ARMADILLO FOUND IN RHEA COUNTY, TENNESSEE
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Abstract
A nine-banded armadillo was found in Rhea County, Tennessee, about three and one-half miles west of Dayton on February 3, 1980. Whether it had migrated or been transported to this location is unclear.

Introduction
A nine-banded armadillo was found in Rhea County, Tennessee about three and one-half miles west of Dayton on February 3, 1980. It apparently had been run over by an automobile as one side of its shell was badly broken. Someone tossed it off of the main road into an old driveway, which prevented further damage. It was found by a local man and reported to Willard L. Henning, Curator of the Bryan College Museum.

Description and Discussion
The armadillo was a full grown specimen but not a large one. It weighed 8 pounds and 2 ounces, the head and body length was 15 inches, and the tail length was 13 inches. It was a female having three embryos about two and one-half inches long. Presumably there was a fourth embryo which probably was mashed by the impact of the car injury. The specimen is being prepared for mounting at the Bryan College Museum Collection.

Armadillo populations are reported from Texas to southern Kansas, and in Florida. A recent report indicates that they may occur in southern Georgia as far north as Columbus, Macon and Augusta. It is believed that this specimen was brought up from Florida and turned loose locally. Its activity during the middle of winter can be understood from reports that they do not hibernate, and the weeks prior to finding this specimen were weeks of mild weather of light freezes generally. This specimen could have scratched for its food in the wooded area.

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CHARACTERISTICS AND DETERMINANTS OF THE FISHERIES RESOURCES OF THREE COLD TAILWATERS IN TENNESSEE
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Abstract
Comparison of biological, water quality, and physical characteristics of Apalachia, Norris, and Chilhowee tailwaters indicates that the differences between these regulated streams and comparable but unregulated streams are due to a host of interrelated factors. Aquatic insect diversity is most strongly influenced by seasonal oxygen deficits. Fish species composition has been changed by altered temperature regimes and seasonal oxygen deficits. Standing crops of fish and aquatic insects are directly related to water mineral quality, substrate composition, and minimum instantaneous flows. Relatively infertile streams with adequate minimum flows can be as productive as more fertile streams with inadequate minimum flows.

Introduction
In the Tennessee Valley, there are 33 storage impoundments with hypolimnetic discharges and sufficient storage volume to cause the stream below the dam (reservoir tailwater) to differ significantly from both the upstream conditions in the same area and from associated factors which create an opportunity may also be the principal limiting factor for the same tailwater fishery. For example, a high ratio of reservoir storage volume to discharge volume will result in cold downstream temperatures suitable for trout management, but may also cause a serious oxygen depletion problem.

TVA initiated a series of tailwater investigations in 1972 with the objective of characterizing major reservoir tailwaters with respect to important ecosystem components. Once characterized, recommendations for the management and improvement of tailwater fisheries could be made. This report is the first in a series of tailwater evaluations and presents the results of surveys in Norris, Chilhowee, and Apalachia tailwaters. Information in this and subsequent reports should be helpful in fishery managers and others interested in improving this valuable and largely underutilized resource.

MATERIALS AND METHODS
Description of the Areas
The locations of Norris, Chilhowee, and Apalachia tailwaters are shown in Figure 1. This report deals only with the upper 10-35 miles or "trout managed" sections of the tailwaters. Although all three are cold tailwaters, their characteristics and the operation of the reservoirs from which they originate differ considerably.

Norris is a 13,759.6 hectare (34,200-acre) reservoir with a full pool volume of 318,386 hectometers (2,767,000,000 acre feet). Surface areas of 352.6 hectares (870.65 acres) are different. The reservoir is immediately below the dam, water from Apalachia Reservoir is impounded by Norris Dam and subsequently flows into the downstream section of Norris Reservoir. The tailwater extends for approximately 4 miles below the dam. Norris Dam

FIG. 1: Map Showing the Collection Sites on Norris, Chilhowee, and Apalachia Tailwaters

comparable reaches above the reservoir. Defined as that portion of a stream extending from the dam of its origin to the headwaters of a downstream reservoir or to its junction with a larger stream, these regulated and consequently unique Tennessee Valley streams have a total length of more than 300 miles and constitute an important component of the "Valley" fisheries resource.

Effects of reservoirs on downstream characteristics have been discussed by Armitage (1977), Brown et al. (1967), Churchill (1958), Crisp et al. (1973), LeBoutillier (1972), Little (1970), Neel (1963), Pfister (1954), Spence and Hynes (1971), Tarrell (1938), and others. Typical responses of streams to the storage and regulation of water which largely govern their flow include altered temperature regimes, extreme flow fluctuations, reduced turbidity, a general dampening of chemical fluctuations (e.g., alkalinity, pH, and nutrient concentrations), and in some cases seasonal dissolved oxygen deficits and increased concentrations of certain heavy metals. Biological responses attributable to these environmental changes typically include changes in the structure of fish and benthic macroinvertebrate communities and increased growth of benthic algae. The degree of difference between these tailwater communities and those found in unregulated streams is directly determined by the hydrologic changes listed above and is greatest in the cold tailwaters. Although these altered streams often present unique fish management opportunities (e.g., large-river trout fisheries in the Southeast), one or more of the

FIG. 2: Mean Monthly Flows: Norris, Chilhowee, and Apalachia Tailwaters, 1974

Although all three tailwaters are subject to radical changes

500

400

300

200

100

0

J F M A M J J A S O N D

0

250

500

750

1000

1250

1500

Norris

Chilhowee

Apalachia
Inflow over very short periods of time, the degree of fluctuation is dampened in Chilhowee tailwater because of a continuous minimum flow of 17.83 m³/s (650 ft³/s). Minimum flows in Norris and Apalachia tailwaters depend upon dam leakage and tributary inflow and are often less than 1.68 m³/s (60 ft³/s). All three tailwaters have extended high and low flow periods (Figure 2), the duration of which is determined primarily by hydroelectric and flood control needs. The only flows scheduled specifically for fisheries or recreational purposes are on Norris tailwater, where flows are reduced to less than two hours daily during late spring and summer months. Eutrophic conditions below the dam are less than 4 ppm, and on Apalachia where inflow summer both low and high flows are regularly scheduled for fishing and canoeing.

Depth of water level fluctuation in the three tailwaters is a function of stream width, gradient, and average maximum turbine discharge at the dam. For example, Norris Dam has an average maximum turbine discharge of 1,000 cfs compared to 11,000 cfs for Chilhowee. Norris tailwater has a range of water level fluctuation similar to that of Chilhowee because of a more narrow channel.

Stream substrates are quite different in each of the three tailwaters. Chilhowee's substrate is dominated by large boulders in pool areas, and boulders, rubble, and gravel, respectively, in shallow areas. Apalachia has extensive rubble and gravel shoals 6 to 12 miles below the powerhouse, but bedrock predominates in the upper section; with the exception of pockets of gravel and rubble and a few sand, gravel, and rubble shoals. Bedrock is the predominant substrate in Norris tailwater.

Because of extensive algal growths (primarily Cladophora sp.) covering much of the stream bottom, Norris tailwater has more aquatic vegetation than either Chilhowee or Apalachia. Chilhowee has extensive localized beds of Ulothrix and Potamogeton with random scatterings of algae such as Cladophora sp.; the more common aquatic plant in Apalachia tailwater is Ulothrix (Pfitzer 1960).

All three tailwaters are subject to intermittently high turbidity during low-flow periods whenever tributary streams are high and turbid.

Water Quality Measurements

TVA's Water Quality and Ecology Branch routinely monitors a number of water quality parameters in the discharge from the powerhouse. Water quality data in this report are based on that monitoring and additional limnological measurements taken concurrently with biological samples.

Benthic Fauna

Samples were taken quarterly during low-flow periods with an unpiloted Surber square-foot sampler from November 1971 through October 1972. All samples were preserved in the field in 10 percent Formalin, and after sorting in the laboratory were transferred to 20 percent containing 70 percent alcohol. Organisms were identified to genus with the exception of chironomids and annelids, which were identified to family and thus, respectively.

Each fish sample was collected through the cooperative efforts of TVA and Tennessee Wildlife Resources Agency (TWRA) biologists using black nets to isolate sample areas and fish contents to immobilize the fish. Some fish and the more common rough fish were weighed, measured, and identified in the field; others were preserved in 10 percent Formalin for laboratory identification.

RESULTS

Benthos

The three tailwaters showed distinct differences in diversities, dominant organisms, and standing crops of benthic macroinvertebrates. With just 25 and 30 taxa respectively, benthic faunal diversity was low in Norris and Chilhowee tailwater; this is further demonstrated by their identical mean annual diversity index (Hs) of 1.4 (Figure 3). Apalachia supported a much more diverse fauna (41 taxa; Hs = 3.25).

TABLE 1. Seasonal Comparisons of Mean Number of Taxa, Numbers, Weight, Volume, and Diversity

<table>
<thead>
<tr>
<th>Taxa</th>
<th># Taxa #/s/m²</th>
<th>Wh Vol.</th>
<th>H</th>
</tr>
</thead>
<tbody>
<tr>
<td>Norris</td>
<td>Fall 12 2,670.5 3,985 7.9 1.6</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Winter 13 2,394.3 2,162 6.2 2.1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Spring 10 11,199.4 13,439 30.6 0.8</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Summer 9 1,805.0 2,854 3.0 1.2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chilhowee</td>
<td>Fall 12 2,314.8 3,287 3.6 1.5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Winter 20 6,594.6 15,444 10.3 1.9</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Spring 15 2,432.7 8,997 9.7 1.8</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Apalachia</td>
<td>Fall 15 241.9 2,574 3.9 3.2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Winter 24 1,017.9 3,600 4.0 3.2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Spring 14 194.4 3,496 4.7 3.3</td>
<td></td>
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</tr>
</tbody>
</table>

Dominant organisms (Figure 4), differed considerably among the three tailwaters. Norris was dominated by chironomids and isopods during the fall and winter with chironomids increasing to approximately 99 percent during the spring and summer. Simulids were predominant in the Chilhowee samples at all seasons with their numbers highest during the summer. Because of extended high flows, no spring samples were taken on Chilhowee or Apalachia. Trichopterans were next in abundance, and chironomids and ephemerids were present in small numbers. Benthic organisms in Apalachia tailwater were more evenly distributed during all seasons sampled (in terms of percentage composition) than in Norris or Chilhowee. Trichopterans comprised 27 to 42 percent of the samples, and em- phemerophagous, gastropods, chironomids, simulids, and other taxa were well represented.

Standing crop estimates (Figure 3 and Table 1) were consistently lower in Apalachia than in Norris or Chilhowee tailwaters. Norris had the highest mean annual standing crop as measured by numbers and volume, but was lower in Chilhowee by possibly owing to a measurement or procedural error in the weight determinations. The absence of high seasonal peaks in productivity such as generally occur during the winter in Chilhowee and during the spring in Norris make Apalachia appear less productive in macroinvertebrate health than it actually is (Figure 5).

Fish

Examination of all recent data (Boles 1969 and unpublished data of TVA and TWRA) shows Chilhowee tailwater yielded 75 species, Apalachia yielded 66 species, and Norris tailwater (41 species) had the least complex piscine community (Table 2). Thirty-one species were common to the three tailwaters. Based on collections in 1974 alone, Apalachia has a more diverse fish assemblage than either Norris or Chilhowee (Figure 6).

TABLE 2. The Relative Abundance of Fish in Norris, Chilhowee, and Apalachia Tailwaters

<table>
<thead>
<tr>
<th>Common Name</th>
<th>Scientific Name</th>
<th>Norris</th>
<th>Chilhowee</th>
<th>Apalachia</th>
</tr>
</thead>
<tbody>
<tr>
<td>White sucker</td>
<td>Hypentelium nigricans</td>
<td>A</td>
<td>A</td>
<td>A</td>
</tr>
</tbody>
</table>

FIG. 3: A Comparison of Selected Characteristics of Benthic Fauna Communities in Norris, Chilhowee, and Apalachia Tailwaters, Nov. 1971 Through Oct. 1972

FIG. 4: Seasonal Percentage Composition of Macroinvertebrates by Numbers (November, 1971-October, 1972)

FIG. 5: Seasonal Comparative Characteristics of Macroinvertebrates Collected from Norris, Chilhowee, and Apalachia Tailwaters, November 1971-October, 1972

No Sample Taken

FIG. 6: Relative Abundance of Fish in Norris, Chilhowee, and Apalachia Tailwaters

Common Name: O = occasional; R = rare; A = abundant; C = common; E = extensive; B = benthic.
Rainbow trout, northern hog suckers, and sculpins (banded and/or motile) are abundant in all three tailwaters. Other dominant assemblages are carp, quillbacks, and logperch. Rainbow trout, brown trout, stonecoursers, and river chubs (Apalachea); and brown trout, longnose gar, carp, river chubs, logperch, gill darters, and banded darter in Chilhowee tailwater. Results of quantitative fish sampling in the fall of 1974 (Table 3, Figure 6) show Norris tailwater to have the highest standing crop (439 fish and 51 kg per hectare) and Apalachee the lowest (169 fish and 15 kg per hectare). Standing crop for Chilhowee is estimated at 289 fish and 16 kg per hectare.

**Rainbow trout, northern hog suckers, and sculpins were the most abundant species in the tailwater streams.**

**FIG. 6: A Comparison of Selected Characteristics of Fish Populations in Norris, Chilhowee, and Apalachee Tailwater, Fall, 1974**

**Water Quality**

With the exception of pronounced annual late summer and fall oxygen deficits in Norris, all three tailwaters have excellent water quality (Figure 7) which is minimally influenced by municipal and industrial discharges in both upstream areas and in the tailwaters proper. Concentrations of inorganics and buffering capacity, are higher in Norris than in Chilhowee and Apalachea, both of which have very soft water.

**DISCUSSION**

Although all three tailwaters exhibit impoundment effects, the manifestation and severity of these effects vary considerably. Compared with upstream areas (Cronum et al., 1973, TVA 1970), it is evident that physicochemical, physical, and biological characteristics of the Clinch River (Norris tailwater) are most changed, and those of the Hiwassee River (Apalachea tailwater) least affected. These changes can be related directly to upstream water quality and limnological and operational characteristics of the reservoir. Specific causal relationships for biological characteristics of these unique aquatic systems are more difficult to establish.
Lehnkuhl (1972) stressed altered temperature regimes as the principal cause of reduced benthic faunal diversity in the south Saskatchewan River below Gardiner Dam. Spence and Hynes (1971) attributed benthic faunal changes downstream of a relatively small impoundment to changes in available particulate organics and increased benthic algal growth as well as temperature. Brown, et al. (1967) in a study of three Arkansas tailwaters ascribed faunal differences to "complex ecological relationships." Differences in the nature and operation of Norris, Chilhowee, and Apalachia Reservoirs provide a good basis to hypothesize causes of faunal differences in these tailwaters.

Faunal assemblages of Apalachia tailwaters most nearly resemble communities from similar, but unregulated streams; correlations of contrasting abiotic conditions in Norris and Chilhowee with faunal differences between those tailwaters and Apalachia should serve as the basis for establishment of casual relationships. Using this rationale, one can analyze the relative importance of key determinants (assumed in this instance to be minimum flows, stream bed substrate, and seasonal dissolved oxygen levels) in causing observed effects. This approach is justified since mineral quality would have little effect on faunal community structure, and none of the tailwaters were ever shown to have high concentrations of heavy metals or other toxic substances.

Substrate composition is certainly important to both fish and benthic fauna; however, since both Norris and Apalachia have a preponderance of bedrock in their upper reaches, it must be assumed that the lower faunal diversities and numbers of taxa in Norris are not due to substrate alone. The same conclusion can be reached regarding minimum flow. Although Chilhowee tailwater has much more favorable conditions, minimum flows are almost identical in Norris (fewest taxa) and Apalachia (most taxa, highest diversity). Seasonally low dissolved oxygen concentration is the only major abiotic characteristic not shared by two or more of the tailwaters and consequently may be assumed to be largely responsible for the unique faunal community in Norris tailwater. This observation is in agreement with data reported for other tailwaters in North America.

In summary, this investigation of three cold tailwaters in Tennessee confirms the conclusions of others who recognize that tailwater biota are governed by the interaction of a number of complex ecological relationships, but further proposes that dissolved oxygen is the factor most limiting to the maintenance of diverse tailwater faunal assemblages. Other biological differences such as standing crops and seasonal abundances of fish and bottom fauna are more directly influenced by temperature, mineral quality, flow regimes, and substrate composition.

ACKNOWLEDGEMENTS

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LITERATURE CITED


