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ABSTRACT

Sixty-eight species and 46,460 individuals of fishes in 11 families were taken in 298 collections made from 1968-2000 in the Dan River, located in the Blue Ridge and Piedmont provinces in Virginia and North Carolina, and these serve as the material for this study of fish longitudinal distribution. Most common was the Cyprinidae with 21 species and 29,254 specimens taken, followed by Centrarchidae (12; 4617), Percidae (7; 3429), Ictaluridae (9; 3072), and Catostomidae (11; 3029). Six additional families included eight species that comprised 6.6% (3059 specimens) of all individuals collected. Twelve additional species not collected in this study are known to occur in the Dan River or Kerr Reservoir. The river is located in four physiographic-province subdivisions: Uplands, Blue Ridge Escarpment, Inner Piedmont, and Fault Basin; the Escarpment showed a pronounced division into an Upper- and a Lower-Gorge. Analyses of the longitudinal distribution of fishes in the Dan River revealed that the most diverse river region (with 86.8% of the species) was the downstream-most (Fault Basin), the least diverse (with 25.0% of the species) was the headwaters (Uplands); the other regions fell on this trend-line. Two major fish associations were noted: one cluster contained three groups of species related by distribution and abundance in the upper reach of the river, and another cluster contained six groupings that were prevalent in the middle and lower reaches. A number of species recorded in the upper reach of the river dropped out downstream, where they were replaced by a larger number of other species. Most fishes were widely distributed in the river, but several, especially *Exoglossum maxillingua, Thoburnia hamiltoni,* and *Cottus caeruleomentum*, were restricted. The first capture of *Rhinichthys cataractae* in the Dan River is reported here.

INTRODUCTION

Changes in abundance and/or composition (addition of species, replacement of species, or both) of fish species in streams between headwaters and lower reaches is known as longitudinal succession. In North America, a number of authors [e.g., Harrel et al. (1967) in Oklahoma, Jenkins and Freeman (1972) in Virginia, Matthews (1986) in Arkansas] have reported a gradual addition of species downstream. Burton and Odum (1945), however, reported that longitudinal succession in mountain streams in Virginia was characterized by a replacement, rather than by an addition, of species, but their sampling methods were critiqued by Lachner and Jenkins (1971), Matthews (1986), and Jenkins and Burkhead (1994). Maurakis et al. (1987) also noted a replacement of species downstream in steeper-gradient streams of the upper Rappahannock River (Blue Ridge Province) in Virginia, as well as in the lower (Coastal Plain) extreme of this river. Cicerello and Butler (1985) observed an addition of species in the middle section of a tributary of the Cumberland River and a replacement of species in the lower section. Balon and Stewart (1983) noted that distributions of fishes in a river system in Africa occurred in distinct headwaters, foothills, floodplain, and river mouth zones, with some fading into, and overlapping of, ichthyofaunas of adjacent zones.

Stream order has been used more often in North America than any other variable to study the longitudinal distribution of fishes, with the following hypothesis: if assemblages of fishes correspond to stream order, or to pronounced changes in stream size or geomorphology, marked qualitative and/or quantitative changes in the fish fauna should occur at discrete locations between stream headwaters and lower reaches (Matthews, 1986). However, from the results of a study of 23 small streams in the eastern and central United States, Matthews (1986) concluded that differences in microhabitats, rather than of stream order, influenced fish longitudinal succession. In sum, it appears that longitudinal succession is complicated and can be evidenced in a number of ways, and that it depends on the stream or stream type and no doubt on other variables.

Here we examine the relationship of the distribution of fishes to river kilometer locations and to habitat in the Dan River of Virginia and North Carolina, based on data collected by us in a river survey from 1992 to 1998 and by others from 1968 to 2000. We studied the Dan River because it is relatively pristine in the upper reaches, is of moderate size, is ichthyologically rich, contains one Virginia-listed threatened and three North Carolina-listed endangered and two of-special-concern fish species (Rohde et al., 1998), and the ichthyofauna of this river in its entirety has not been studied previously. This study of the Dan River continues the work on the distribution and status of the fishes of this region by Rohde and Arndt (1991, 1994) and Rohde et al. (1998).

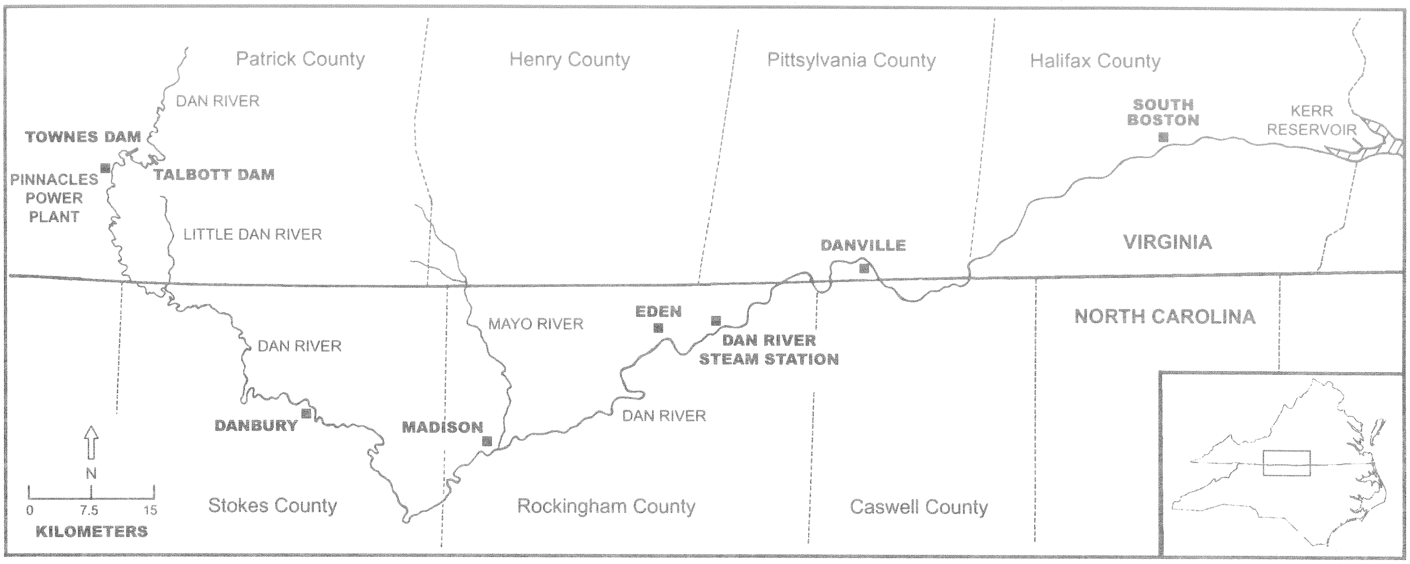

Figure 1. The Dan River in Virginia and North Carolina, showing locations mentioned in the text.

LOCATION OF THE DAN RIVER

The Dan River is located in the Blue Ridge/Piedmont provinces of Virginia and North Carolina (Fig. 1). It originates in Patrick County, VA, and flows south for some 60 river kilometers (rkm) before it crosses into NC in northwestern Stokes County. It then flows to the southeast across most of Stokes County, turns sharply to the northeast, and crosses most of Rockingham County in NC. After a run of 120 rkm it enters VA in southern Pittsylvania County, and after a short run in this state it reenters NC, flows east and north and then quickly reenters VA in Halifax County, and ends, finally, in Kerr Reservoir, created by a dam on the Roanoke (Staunton) River. The Dan River from its origin to its junction with the Roanoke River at Kerr Reservoir is 320 rkm long, and it drains some 6,600 km^2. The Roanoke River discharges into Albemarle Sound on the Atlantic Coastal Plain of northeastern NC.

METHODS

We used data from 298 collections made at 42 sites (Fig. 2) from 1968-2000, as follows: 32 collections made at 23 sites by Rohde and Arndt during 1992-98; 120 collections made by the VA Department of Game and Inland Fisheries (VDGIF) in 1992-1998; three by Paul L. Angermeier of Virginia Polytechnic Institute and State University (VPI) in 1989-1990; one by the NC

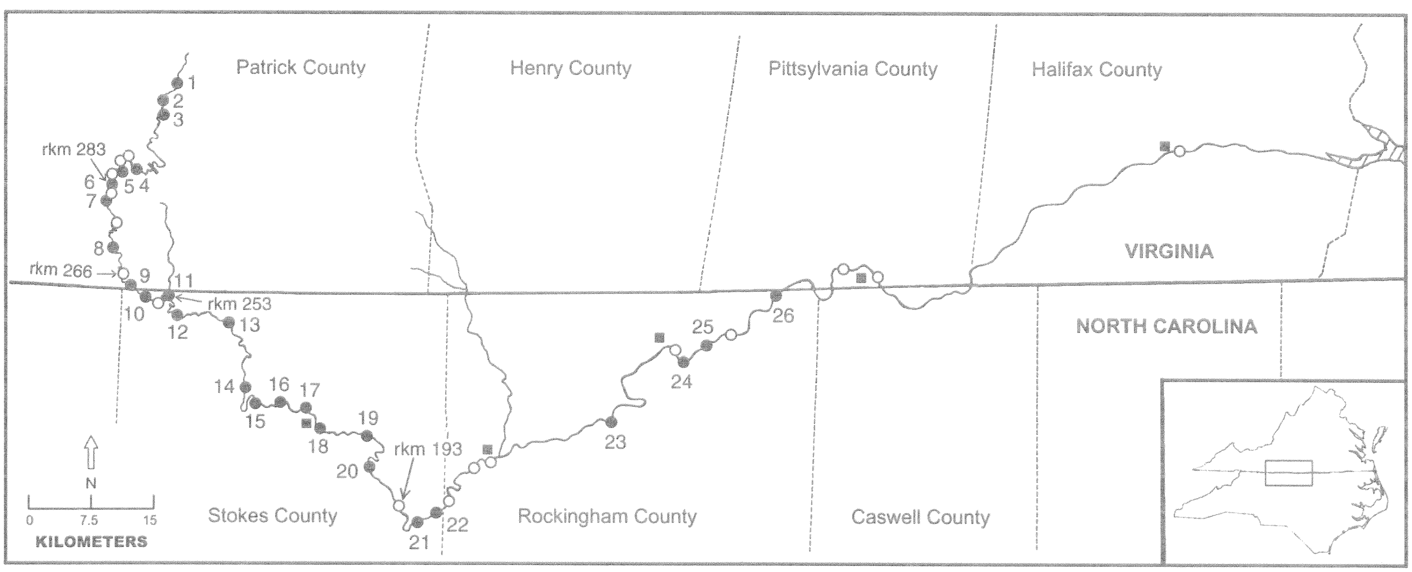

Figure 2. The Dan River showing sites sampled: a numbered black dot indicates a site used in similarity analyses, an open circle indicates an additional site sampled.

Wildlife Resources Commission (NCWRC) in 1990; 126 by biologists of the Duke Power Company (DPC) during 1977-2000; 13 by Edward F. Menhinick of the University of North Carolina-Charlotte from 1968-85; and three by the North Carolina Division of Environmental Management in 1986. Additional collections have been made in Virginia and these records have been plotted by Jenkins and Burkhead (1994).

We made 23 of our collections with a Coffelt BP-6 backpack electroshocker and seine (3.0 or 4.6 m in length, 1.2 m deep, 0.64 cm mesh) into which the shocked fishes drifted or swam. At each site, we electrofished from bank to bank and along river sections from 43 to 213 m (mean 122 m) long. Total sampling time per site per visit ranged from 50 to 190 min (mean 110.2 min), and continued until we believed that sampling had been comprehensive in all microhabitats and until no additional species was collected. We made nine of our collections with only a seine (3.0 to 6.1 m long, 1.2 m deep, 0.64 cm mesh). We sampled only during normal low-water conditions from Jul-Sep, and in Nov. Most fishes were preserved in 10% formalin and later identified and counted. We deposited preserved specimens in the North Carolina State Museum of Natural Sciences in Raleigh. Scientific names follow Robins et al. (1991), except for *Moxostoma collapsum* (Jenkins and Burkhead, 1994), *Cottus caeruleomentum* (Kinziger et al., 2000), and *Percina nevisense* (Goodin et al., 1998). All collections made by others were made with a backpack shocker, except those made by VPI biologists who used a boat electroshocker, from Jun-Nov.

Collections were made from near the headwaters at rkm 317 downstream to rkm 23; only three sites were sampled in the lower 98 rkm of the river from Danville, VA to Kerr Reservoir.

All sites were chosen on the basis of ease of access (bridge crossings or boat ramps). Overall, from 1 to 36 collections were made at a given site. We used U. S. Geological Survey 15-min topographic maps and a map tracer to determine mean gradient and river kilometer locations.

To determine longitudinal distribution of species we used data from all collections made by electroshocker, boat electroshocker, and seine, at sites located from rkm 23 to rkm 317. For analysis of similarity of fishes, we used data only from sites sampled with a backpack electroshocker and only where a similar effort had been expended. These data were obtained from one collection each from 26 sites located from rkm 120 to rkm 317 (Fig. 2). We used Morisita's index with Horn's modification (Horn, 1966) and the Community Analyses System 4.2 software (Bloom, 1992) to determine faunal similarities between sites and to determine the locations of faunal breaks. A value of 1.00 in this index indicates that all elements are present in the same numbers in two compared areas. Matthews (1986) considered a value in this index of less than 0.5 to indicate a break in the distribution of the fauna.

Seventeen sites (Table 1) were scored on 1, 2 Aug and 2 Oct 1998 during low water conditions for eight physicochemical characteristics: water temperature, dissolved oxygen concentration, conductivity, pH, river width, river depth, current speed, and substrate composition (percent of sand, gravel, rubble, and boulder/bedrock). Temperature, dissolved oxygen, conductivity, and pH were measured once per site. Stream width was measured at each site along three transects usually located from 10 to 20 m apart. Depth, current, and substrate measurements were made along each transect at 2-m intervals.

Table 1. Physicochemical values recorded at 17 Dan River sites on 1-2 Aug and 2 Oct 1998. Depths and widths that varied are given as mean and range. Cond =conductivity in microohms; DO=dissolved oxygen.

Rkm	Date 1998	T (°C)	DO (ppm)	Cond	pH	Mean Width(m) (range)	Mean Depth(cm) (range)	Mean Current (m/sec)	Substrate (%) sand	gravel	rubble	boulder
313	1 Aug	19	5.4	37	8.4	6.3(5-8)	26.4 (10-54)	0.12 (0.009-0.39)	18.8	37.5	31.2	12.5
312	1Aug	17.9	7.5	38	7.8	7.3 (6-9)	24 (9-44)	0.17 (0.003-0.50)	29.4	35.3	35.3	0
285	1 Aug	19.6	7.9	42	7.7	7.7(6-9)	22.3 (7-46)	0.19 (0.02-0.37)	5.6	55.5	22.2	16.7
282	1 Aug	20.2	7.2	42	7.5	11	40.8 (16-64)	0.3 (0.04-0.79)	0	23.8	52.4	23.8
280	1 Aug	21	8.1	42	7.4	15	28.8 (15-44)	0.37 (0.14-0.89)	0	33.3	57.1	9.5
270	1 Aug	21.7	8	42	7.5	18	25.7 (10-42)	0.42 (0.17-0.72)	23.8	47.6	28.6	0
261	1 Aug	22.6	7.3	44	7.5	12 (11.5-12.5)	44.8 (17-87)	0.37 (0.006-0.76)	14.3	42.8	42.8	0
249	1 Aug	23.4	7.5	43	7.5	20.7 (14-24)	34.6 (12-50)	0.38 (0.08-0.9)	19	47.6	23.8	9.5
240	1 Aug	25.2	7.7	45	8.1	26	30.6 (10-55)	0.39 (0.05-0.78)	9.5	42.8	33.3	14.3
217	2 Oct	20	---	---	7.7	32 (30-33)	27.3 (12-56)	0.39 (0.1-0.68)	6	36	46	12
214	2 Aug	22.2	7.6	48	7.4	31	30.9 (8-54)	0.61 (0.04-1.42)	12.8	51.1	21.3	14.9
207	2 Oct	18.5	---	---	7.8	49	34.3 (11-79)	0.27 (0.006-0.92)	16.1	37.5	23.2	23.2
199	2 Aug	23.4	7.2	51	7.5	50	40.5 (10-100)	0.44 (0.02-1.43)	14.8	51.8	18.5	14.8
193	2 Aug	24	6.3	51	7.4	29	53.6 (14-84)	0.38 (0.3-0.53)	64	36	0	0
174	2 Oct	21	---	---	7.3	27	72.4 (26-140)	0.3 (0-0.53)	15.2	54.5	21.2	9.1
170	2 Oct	20	---	---	7.6	31	54.4 (23-97)	0.34 (0.01-0.54)	83.3	14.3	2.4	0
156	2 Oct	20	---	---	7.3	53	77.8 (33-130)	0.14 (0.006-0.29)	60	20	4	16

Substrate types present were categorized as: sand (particles <0.3 cm in diameter); gravel (0.3-8.0 cm); rubble (8.0-30.0 cm); and boulder/bedrock (>30.0 cm). Width, depth, and current are summarized as averages of all measurements taken on the three transects at each individual site. Substrate types are presented as percentages combined for all sites in a given geologic section.

RESULTS AND DISCUSSION

Description of Study Area

The Dan River originates at an elevation of 939 m in the Uplands of the Blue Ridge Province, upstream of the Blue Ridge Escarpment crest (Hack, 1982). The river runs for 8 rkm in these Blue Ridge Uplands at a relatively steep gradient (11 m/rkm) before it enters a 46 rkm-long gorge it has cut through the Escarpment. The gorge is divisible into an upper gorge (rkm 312-284) ca. 250 m wide and a lower gorge (rkm 283-266) ca. 730 m wide. The river in the upper gorge is narrow and convoluted and has a steeper gradient (13 m/rkm) than in the Uplands, a result of cutting through the weaker rocks of the Blue Ridge Escarpment. The river in the lower gorge is less convoluted.

In the upper portion of the gorge are two man-made impoundments, completed for the Pinnacles Hydroelectric Project (owned by the City of Danville, VA) in 1938 by construction of Talbott Dam and, some 9 rkm downstream, Townes Dam. The Project has been in operation since about 1940 (Burkhead and Jenkins, 1991). All river discharge from Townes Dam has historically been diverted through a viaduct to a powerhouse at rkm 283. River flow below the powerhouse fluctuates widely. Because of this water diversion, the 5 rkm from Townes Dam to the powerhouse has usually been dewatered, except for limited natural flow from local tributaries and springs. To safeguard the biota in this reach, however, the City of Danville agreed in 1994 to maintain a minimum flow of 6 ft^3/sec. The impoundments have been stocked with game fishes over the years, but records are lacking.

Below the gorge the river meanders 71 rkm to the southeast through the Inner Piedmont Province, a region comprised of metamorphosed sedimentary and volcanic rocks of Upper Precambrian to Lower Paleozoic age (Gair and Slack, 1979). At rkm 190, it curves sharply to the northeast; this is ca. 6 rkm downstream of its entry to the Dan River-Danville Basin, a fault basin of soft sedimentary rocks of Upper Triassic age (Thayer, 1970). These rocks have been eroded more than have the adjacent harder crystalline rocks, and this has resulted in a lowland in the Piedmont Province (Thayer, 1970). From this basin to Kerr Reservoir the river traverses a gently rolling topography of Piedmont sands and silts. The river is in a generally forested watershed, although some land is in pasture, hayfields, and, especially further downstream, more actively-cultivated cropland. In 1728, the river near the Halifax-Pittsylvania County line was described by William Byrd, a surveyor, as "a charming river" and "exceedingly beautiful" with crystal clear water (Ausband, 1991). Today, the middle and lower Dan River is turbid for much of the year and Jenkins and Burkhead (1994) noted that it sometimes appears to be plowable. Six obvious barriers to fish movements are present in this section: four dams within the Danville city limits effectively block upstream migration of fishes from Kerr Reservoir, a fifth dam is located upstream at the Duke Power Steam Electric Station at Eden, NC, and a sixth dam is located further upstream in Madison, NC.

River Sections

Uplands (rkm 320-312) (two sites measured, rkm 313, 312)–Mean gradient of these 8 rkm was ca. 11 m/rkm (Fig. 3). Current averaged 0.17 m/sec (SD 0.11); mean width averaged

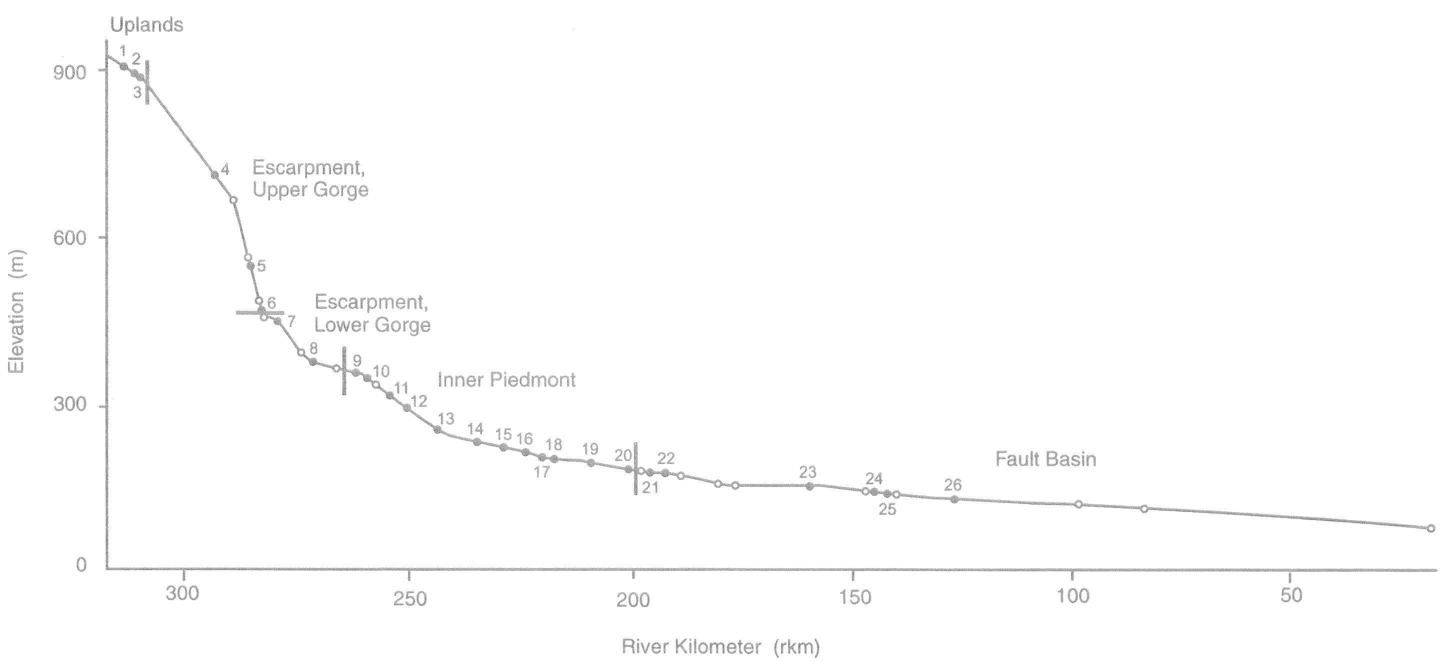

Figure 3. Gradient profile (highly exaggerated) of the Dan River. Sampled sites as defined in Fig. 2.

6.8 m (SD 1.47); average depth was 25.2 cm (SD 13.53); substrate was gravel (36.4%), rubble (33.3%), sand (24.2%) in pools, and some boulders (6.1%); and river-edge habitat was mixed pasture and hardwood forest (Table 1).

Escarpment (rkm 312-266) (four sites measured, rkm 285, 282, 280, 270)–The Escarpment is subdivisible into two distinct sections based on geomorphology: an upper section from rkm 312 to rkm 284 which is narrow and convoluted (hereafter, Upper Gorge), and a lower section from rkm 283 to rkm 266 which is wider and less convoluted (Lower Gorge). Mean gradient in the Upper Gorge was 13 m/rkm. At the Upper Gorge site (rkm 285), river width was 7.7 m (SD 1.53), depth 22.3 cm (SD 10.25), current 0.19 m/sec (SD 0.12), and the substrate was of gravel (55.5%), rubble (22.2%), boulders (16.7%), and sand (5.6%). In the Lower Gorge, mean gradient was ca. 5 m/rkm, mean width 14.7 m (SD 3.04), mean depth 31.8 cm (SD 11.86), with a substrate of rubble (46.0%), gravel (34.9%), with many boulders (11.1%), and occasional sand (7.9%), and mean current during low water levels was 0.38 m/sec (SD 0.19). Riparian habitat was primarily mature hardwood forest.

Inner Piedmont (rkm 265-197) (seven sites measured, rkm 261, 249, 240, 217, 214, 207, 199)–Gradient in this reach averaged ca. 2 m/rkm. Current averaged 0.40 m/sec (SD 0.29), width 30.8 m (SD 13.38), depth 32.6 cm (SD 15.90), with a substrate of gravel (43.9%), rubble (29.5%), sand (12.7%), boulders (11.5%), and outcrops of bedrock (2.4%). The water became increasingly more turbid downstream (personal observations). Riverside habitat was mixed farmland and hardwood forest.

Fault Basin (rkm 196-0) (four sites measured, rkm 193, 174, 170, 156)–Gradient averaged ca. 0.6 m/rkm. Current averaged 0.29 m/sec (SD 0.14), width 49.4 m (SD 19.76), depth 63.4 cm (SD 24.64), and a substrate primarily of sand (57.2%) and gravel (30.6%), with rubble (7.2%), boulders (3.2%), and bedrock (1.6%). The water was usually turbid (personal observations). River-edge habitat bordered a wide floodplain on which was present mixed farmland and mature deciduous forest.

Species Occurrence and Abundance

Sampling by us and others yielded 46,460 fish specimens of 68 species recorded from rkm 23 to 317 (Table 2).

Twenty-one species of cyprinids comprised 30.9% of the 68 species and 63.0% (29,254 individuals) of the total specimens (Table 2). The six most abundant cyprinids (and comprising a total of at least 75% of all members of this family recorded) in decreasing order of abundance were *Clinostomus funduloides* (8509 specimens), *Nocomis leptocephalus* (4848), *Luxilus cerasinus* (2905), *Cyprinella analostana* (2560), *Notropis chiliticus* (2504), and *Lythrurus ardens* (2143). Twelve species of centrarchids comprised 17.6% of the total species and 9.9% (4617 specimens) of the total specimens; most abundant were *Lepomis auritus* (2936 specimens) and *Lepomis macrochirus* (873). Seven species of percids were recorded and comprised 10.3% of the total species and contained 7.4% (3429 specimens) of all individuals taken; the most abundant percids were *Percina roanoka* (1439 specimens) and *Etheostoma flabellare* (1260). Nine species of ictalurids comprised 16.2% of the total species and 6.6% (3072 specimens) of the total specimens; the most abundant were *Noturus insignis* (1977 specimens) and *Ameiurus brunneus* (688). Eleven species of catostomids comprised 16.2% of the total fish species and 6.5% (3029 specimens) of the total specimens taken. *Moxostoma erythrurum* (1407 specimens), *Catostomus commersoni* (423), *Scartomyzon cervinus* (295), and *Moxostoma pappillosum* (281) were the most abundant suckers. The remainder of the fish species collected included eight species in six families, and these comprised 6.6% (3059 specimens) of all individuals taken.

Additional Fishes Known from the Dan River

Twelve additional species, not collected in our study, have been reported from the Dan River or Kerr Reservoir by Jenkins and Burkhead (1994) or in personal communications. Four, *Dorosoma petenense, Alosa aestivalis*, *Morone americana*, and *Aplodinotus grunniens,* are known only from Kerr Reservoir but potentially could move into the Dan River (Jenkins and Burkhead, 1994; Dan Wilson, VDGIF, pers. comm. 2001). Four others, *Alosa pseudoharengus*, *Erimyzon oblongus*, *Ameiurus nebulosus*, and *Esox niger*, are known from a few records from the lower Dan River and Kerr Reservoir (Jenkins and Burkhead, 1994). One record of *Pimephales notatus* taken in the Dan River in 1951 (Jenkins and Burkhead, 1994) represents an apparently unsuccessful introduction since none has been taken recently. One specimen of *Ictalurus furcatus* was taken and released at rkm 249 on 23 September 1988 (Charles Smith, Guilford College, pers. comm., 1994) and two specimens of *Pylodictis olivaris* were captured at rkm 68 near Milton, Caswell County, NC in 1993 (Brad Hammers, NCWRC, pers. comm., 1997). A reproducing population of *Morone saxatilis* occurs in Kerr Reservoir and some regularly migrate upstream as far as a dam in Danville (Jenkins and Burkhead, 1994).

Longitudinal Succession

The occurrence of a longitudinal succession of fishes is evident and is described in the accounts of the following river sections. Fishes which we believe to have been introduced into the upstream reservoirs and to have escaped into flowing portions of the river in the Upper Gorge are not considered in this section.

Section rkm 317-312: Uplands

Seventeen species were collected at three sites between rkm 317-312 in the headwaters above the Blue Ridge Escarpment crest (Table 3). Of these, all (three) species of salmonids taken, namely *Oncorhynchus mykiss* (3 specimens taken), *Salmo trutta* (11), and *Salvelinus fontinalis* (3), have been introduced. *Salvelinus fontinalis* may be native to the upper Dan River (Jenkins and Burkhead, 1994), but if so, this population has no doubt been genetically swamped by introduced individuals. One specimen of *Lepomis auritus* was taken here.

Most abundant here, and comprising a combined total of at least 75% of the total specimens taken, were *Clinostomus funduloides* (1947 specimens; mean number/collection = 389.4), *Luxilus cerasinus* (653; 130.4), and *Nocomis leptocephalus* (189; 37.8). Mean catch (= mean number per collection) of the other 10 species taken here ranged from 0.2 to 32.2 (Table 4).

Table 2. Phylogenetic list of fishes captured in the Dan River, 1968-2000, and number of each taken.

Taxon	Total	% of Total
Lepisosteidae		<0.1
Lepisosteus osseus	2	
Clupeidae		0.3
Dorosoma cepedianum	145	
Cyprinidae		63.0
Campostoma anomalum	188	
Carassius auratus	4	
Clinostomus funduloides	8509	
Cyprinella analostana	2560	
Cyprinella lutrensis	13	
Cyprinus carpio	100	
Exoglossum maxillingua	245	
Luxilus albeolus	1154	
Luxilus cerasinus	2905	
Lythrurus ardens	2143	
Nocomis leptocephalus	4848	
Nocomis raneyi	873	
Notemigonus crysoleucas	77	
Notropis amoenus	159	
Notropis chiliticus	2504	
Notropis hudsonius	287	
Notropis procne	76	
Phoxinus oreas	1890	
Rhinichthys atratulus	357	
Rhinichthys cataractae	1	
Semotilus atromaculatus	361	
Catostomidae		6.5
Carpiodes cyprinus	41	
Catostomus commersoni	423	
Hypentelium nigricans	150	
Hypentelium roanokense	233	
Moxostoma collapsum	132	
Moxostoma erythrurum	1407	
Moxostoma macrolepidotum	21	
Moxostoma pappillosum	281	
Scartomyzon ariommus	40	
Scartomyzon cervinus	295	
Thoburnia hamiltoni	6	
Ictaluridae		6.6
Ameiurus brunneus	688	
Ameiurus catus	30	
Ameiurus melas	4	
Ameiurus natalis	2	
Ameiurus nebulosus	23	
Ameiurus platycephalus	183	
Ictalurus punctatus	145	
Noturus gilberti	20	
Noturus insignis	1977	
Esocidae		<0.1
Esox americanus	2	
Salmonidae		3.4
Oncorhynchus mykiss	435	
Salmo trutta	1005	
Salvelinus fontinalis	154	
Poeciliidae		<0.1
Gambusia holbrooki	3	
Cottidae		2.8
Cottus caeruleomentum	1313	
Centrarchidae		9.9
Ambloplites cavifrons	6	
Ambloplites rupestris	3	
Lepomis auritus	2936	
Lepomis cyanellus	139	
Lepomis gibbosus	30	
Lepomis gulosus	8	
Lepomis macrochirus	873	
Lepomis microlophus	130	
Micropterus dolomieu	21	
Micropterus salmoides	363	
Pomoxis annularis	19	
Pomoxis nigromaculatus	89	
Percidae		7.4
Etheostoma flabellare	1260	
Etheostoma nigrum	33	
Etheostoma podostemone	590	
Etheostoma vitreum	53	
Percina nevisense	53	
Percina roanoka	1439	
Stizostedion vitreum	1	
Number of species	68	
Number of specimens	46,460	

Table 3. Fish species, and number of each, taken at sampling sites on the Dan River, 1968-2000, excluding fishes stocked in the reservoirs. Data taken from sites in bold type were used for similarity analyses. Lines separate fishes in each river section. Table 3 continued on next page.

		Uplands				Upper Gorge					Lower Gorge			
Species rkm:	**317**	**313**	**312**	**297**	290	287	**286**	284	**283**	282	**280**	274	**270**	266
Clinostomus funduloides	335	1314	298	436	82	1200	1926	2273	6	30	7	358	122	55
Luxilus cerasinus	19	542	92	4	29	165	175	586	1	9	16	76	89	37
Nocomis leptocephalus	49	112	28	238	164	717	916	611	18	34	23	37	52	30
Phoxinus oreas	1	58	29	201	1	319	654	538	1	8		21	2	23
Rhinichthys atratulus	1	7	1	153	32	68	28	50	4	8	2	1	1	1
Semotilus atromaculatus	11	30	14	2		84	140	50				3	1	19
Catostomus commersoni	4	19	8	70	5	74	81	78	1	2	1		2	5
Salvelinus fontinalis	1	1	1	132	10	2		6	1					
Salmo trutta	3	5	3	440	202	122	73	139	3	2	2	1	3	
Campostoma anomalum		8			1		1							1
Notropis chiliticus		51	52				11	596	2	19	24	62	50	59
Hypentelium nigricans		2				3	1	7	5	1	4		4	
Hypentelium roanokense		24	11			5	7	32				6	11	26
Noturus insignis		8	6	1	89	298	194	129	2		1		11	
Oncorhynchus mykiss		3		227	180			14	3		1	1		
Lepomis auritus		1						7						
Etheostoma flabellare		149	12	62	129	115	79	115	6	3	23	22	128	1
Thoburnia hamiltoni					1			2	2		1			
Ambloplites cavifrons					1			1						
Etheostoma podostemone					16			19			1	1	4	
Cyprinella analostana						1								
Rhinichthys cataractae						1								
Scartomyzon cervinus						1	3	59	26	1	10	3	13	2
Exoglossum maxillingua							3	172	4		1	9	22	6
Luxilus albeolus								1		3		1	4	4
Noturus gilberti								1					5	4
Cottus caeruleomentum								222	205	16	184	156	437	1
Percina roanoka											2	4	24	2
Lythrurus ardens													17	2
Etheostoma nigrum													1	15
Nocomis raneyi														
Notropis procne														
Micropterus dolomieu														
Etheostoma vitreum														
Percina nevisense														
Ameiurus melas														
Ameiurus platycephalus														
Moxostoma erythrurum														
Micropterus salmoides														
Scartomyzon ariommus														
Moxostoma pappillosum														
Ameiurus brunneus														
Notropis amoenus														
Cyprinus carpio														
Carassius auratus														
Cyprinella lutrensis														
Carpiodes cyprinus														
Moxostoma collapsum														
Ameiurus catus														
Ameiurus nebulosus														
Ictalurus punctatus														
Esox americanus														
Lepomis cyanellus														
Lepomis gibbosus														
Lepomis macrochirus														
Lepomis microlophus														
Pomoxis annularis														
Pomoxis nigromaculatus														
Gambusia holbrooki														
Notemigonus crysoleucas														
Ameiurus natalis														
Notropis hudsonius														
Lepomis gulosus														
Moxostoma macrolepidotum														
Ambloplites rupestris														
Dorosoma cepedianum														
Lepisosteus osseus														
Stizostedion vitreum														
Number of specimens	424	2334	555	1966	942	3175	4292	5708	290	136	303	762	1003	293
Number of species	9	17	13	12	15	16	16	24	17	13	17	17	22	19
Number of collections	1	2	2	9	7	32	36	36	1	1	1	2	2	1

Table 3. Continued.

	Inner Piedmont													Fault Basin															
Species rkm:	**261**	**259**	257	**253**	**249**	**240**	**231**	**224**	**221**	**217**	**214**	**207**	**199**	193	**190**	**186**	183	174	170	**156**	139	**138**	**135**	131	**120**	98	84	23	Total
Clinostomus funduloides	5	20	7		1	6	26	1			1																		8509
Luxilus cerasinus	10	460	77	39	40	166	23	3	12	2	115	6	17	38	3	36					2	3	5	3	5				2905
Nocomis leptocephalus	88	153	132	117	76	207	129	16	190	50	253	70	33	52	7	22	2	1	10	6	8	17	89	19	72				4848
Phoxinus oreas		24	4				1				3										1	1							1890
Rhinichthys atratulus																													357
Semotilus atromaculatus		2	4																			1							361
Catostomus commersoni	9	4	7		2	1			1	1	1			1				4			3	5	26	6	2				423
Salvelinus fontinalis																													154
Salmo trutta		2	1	2																			1		1				1005
Campostoma anomalum	2	5	5		24	29	1	1	28	11	11	2	56							1			1						188
Notropis chiliticus	23	105	182	125	57	102	141	25	69	12	210	78	138	102	27	176	2					4							2504
Hypentelium nigricans	1	6	7			1	3	1			3	2	10	26	1	13		4		1	1	3	23	7	10				150
Hypentelium roanokense	12	30	12	7	2	6	4	5	7	13	2	5	1	2									2	1					233
Noturus insignis	16	100	57	33	41	143	73	152	206	70	159	73	78	16		9		1	1	1	1	3	5						1977
Oncorhynchus mykiss		4																											435
Lepomis auritus			1	2	6	4	4	8	27	5	30		9	110	8	4	1	158	6	13	764	754	405	372	210	4	13	10	2936
Etheostoma flabellare	52	121	75	19	8	31	3	19	34	4	29	4		2	2	10	1			1			1						1260
Thoburnia hamiltoni																													6
Ambloplites cavifrons																					1	2	1						6
Etheostoma podostemone	8	37	42	4	36	36	33	60	70	28	92	30	11	39	1	13	2			2			5						590
Cyprinella analostana		8			24	16	119	7	28	6	97	2	4	354	37	385	3	3	61	61	171	279	545	237	98	2	10	2	2560
Rhinichthys cataractae																													1
Scartomyzon cervinus	1	16	45	7	14	19	4	13	1	3	21	1	14	2							1	4	11						295
Exoglossum maxillingua	1	16	6		3	2																							245
Luxilus albeolus		50	57		12	3	6	14	16		32	20	25	50	1	67		9	1	46	143	220	256	78	35				1154
Noturus gilberti		5	3	1							1																		20
Cottus caeruleomentum	38	40	9	5																									1313
Percina roanoke	4	41	24	22	41	92	125	163	194	88	295	114	126	10		41							26		1				1439
Lythrurus ardens	47	649	161	31	167	122	96	6	95	2	126	2		76	11	77	19			38	158	165	17	35	24				2143
Etheostoma nigrum		10	5																			1		1					33
Nocomis raneyi		9	4		7	12	1	41	3	2	23		9	75	16	96		7		6	27	52	379	69	31		4		873
Notropis procne		22	4																	5	4	10	24	3	4				76
Micropterus dolomieu		1	1								2					1				1		4	7	3			1		21
Etheostoma vitreum		16	19	4	2	1	5		4		1												1						53
Percina nevisense		7				1	10		5		10			6							1		11	1	1				53
Ameiurus melas			1															2				1							4
Ameiurus platycephalus			2		1	2		2	28		19		8	22	1			10		2	27	22	16	8	13				183
Moxostoma erythrurum					1		1	1	1	4	23			47		5		134	1		267	377	272	188	78	5	2		1407
Micropterus salmoides					1			1			1			8				20		1	57	102	64	80	21	3	3	1	363
Scartomyzon ariommus						3	1	7	1	7	8	4	1										8						40
Moxostoma pappillosum									24		16		3	56		10		25	1	17	6	22	59	2	36	1	3		281
Ameiurus brunneus									1	5	5	12	27	27		4	2	13		1	61	129	172	24	180	3	22		688
Notropis amoenus										1						1					74	38	4	7	34				159
Cyprinus carpio											1							6			20	14	7	23	19		3	7	100
Carassius auratus														2									1		1				4
Cyprinella lutrensis														2				4			3	1			3				13
Carpiodes cyprinus														1		1		1			8	2	12	2	3		8	3	41
Moxostoma collapsum														27							3	12	62	8	6		5	9	132
Ameiurus catus														1							10	6	1				9	3	30
Ameiurus nebulosus														5				2			7	3	4		1	1			23
Ictalurus punctatus														9				10			47	44	10	2	11		4	8	145
Esox americanus														1								1							2
Lepomis cyanellus														3				1	1		37	66	8	3	20				139
Lepomis gibbosus														1				2			9	9		5	3	1			30
Lepomis macrochirus														3	4			14			188	290	98	163	86	7	2	18	873
Lepomis microlophus														1							38	48	15	25	3				130
Pomoxis annularis														3				4			4	3	2	2			1		19
Pomoxis nigromaculatus														1							11	30	15	27	1		4		89
Gambusia holbrooki																	2								1				3
Notemigonus crysoleucas																		2			4	26	6	1	38				77
Ameiurus natalis																			1					1					2
Notropis hudsonius																				1	48	34	143	25	33		3		287
Lepomis gulosus																					3	4		1					8
Moxostoma macrolepidotum																						5					11	5	21
Ambloplites rupestris																						2	1						3
Dorosoma cepedianum																							38	22	5	12	66	2	145
Lepisosteus osseus																								1				1	2
Stizostedion vitreum																											1		1
Number of specimens	317	1963	954	420	566	1005	809	546	1045	314	1590	425	570	1181	119	971	34	437	83	204	2218	2819	2859	1455	1090	39	175	69	46460
Number of species	16	29	29	16	22	23	22	21	23	19	30	16	18	36	13	19	9	24	9	18	37	44	45	36	34	10	20	12	68
Number of collections	1	7	2	1	2	3	3	1	2	1	6	1	2	10	1	3	1	8	1	3	19	30	22	18	14	1	1	1	298

Table 4. Relative abundance (number of specimens/number of collections) of fishes taken in this Dan River study, 1968-2000, for each individual river region. Values for species that in total comprise the top 75% most-abundant species/region are identified in bold type.

Species	Uplands	Upper Gorge	Lower Gorge	Pied-mont	Fault Basin
Campostoma anomalum	1.60	0.02	0.12	5.47	0.02
Clinostomus funduloides	**389.40**	**49.31**	**72.25**	2.09	
Luxilus cerasinus	**130.40**	7.99	**28.50**	**30.31**	0.71
Nocomis leptocephalus	**37.80**	**22.05**	**24.25**	**47.31**	2.29
Notropis chiliticus	20.60	5.06	**27.00**	**39.59**	2.34
Phoxinus oreas	17.60	**14.28**	6.88	1.00	0.02
Rhinichthys atratulus	1.80	2.76	2.12		
Semotilus atromaculatus	11.00	2.30	2.88	0.19	0.01
Catostomus commersoni	6.20	2.57	1.38	0.81	0.35
Hypentelium nigricans	0.40	0.09	1.75	1.06	0.67
Hypentelium roanokense	7.00	0.37	5.38	3.31	0.04
Noturus insignis	2.80	5.92	1.75	**37.53**	0.28
Oncorhynchus mykiss	0.60	3.51	0.62	0.19	
Salvelinus fontinalis	0.60	1.25	0.12		
Salmo trutta	2.20	**8.13**	1.38	0.16	0.02
Lepomis auritus	0.20	0.06		3.00	**21.29**
Etheostoma flabellare	32.20	4.17	22.88	12.47	0.13
Cyprinella analostana		0.01		9.72	**16.90**
Exoglossum maxillingua		1.46	5.25	0.88	
Luxilus albeolus		0.01	1.50	7.34	**6.81**
Rhinichthys cataractae		0.01			
Scartomyzon cervinus		0.52	6.88	4.97	0.13
Thoburnia hamiltoni		0.02	0.38		
Noturus gilberti		0.01	1.12	0.31	
Cottus caeruleomentum		1.85	**124.88**	2.88	
Ambloplites cavifrons		0.02			0.03
Etheostoma podostemone		0.29	0.75	**15.22**	0.47
Lythrurus ardens			2.38	**47.00**	4.66
Etheostoma nigrum			2.00	0.47	0.02
Percina roanoka			4.00	**41.53**	0.59
Cyprinus carpio				0.03	0.74
Nocomis raneyi				3.47	5.73
Notropis amoenus				0.03	1.19
Notropis procne				0.81	0.38
Moxostoma erythrurum				0.97	**10.34**
Moxostoma pappillosum				1.34	1.79
Scartomyzon ariommus				1.00	0.06
Ameiurus brunneus				1.56	4.80
Ameiurus melas				0.03	0.02
Ameiurus platycephalus				1.94	0.91
Micropterus salmoides				0.09	2.71
Micropterus dolomieu				0.12	0.13
Etheostoma vitreum				1.62	0.01
Percina nevisense				1.03	0.10
Lepisosteus osseus					0.02
Dorosoma cepedianum					1.09
Carassius auratus					0.03
Cyprinella lutrensis					0.10
Notemigonus crysoleucas					0.58
Notropis hudsonius					2.16
Carpiodes cyprinus					0.31
Moxostoma collapsum					0.99
Moxostoma macrolepidotum					0.16
Ameiurus catus					0.22
Ameiurus natalis					0.02
Ameiurus nebulosus					0.17
Ictalurus punctatus					1.09
Esox americanus					0.02
Gambusia holbrooki					0.02
Ambloplites rupestris					0.02
Lepomis cyanellus					1.04
Lepomis gibbosus					0.22
Lepomis gulosus					0.06
Lepomis macrochirus					**6.56**
Lepomis microlophus					0.98
Pomoxis annularis					0.14
Pomoxis nigromaculatus					0.67
Stizostedion vitreum					0.01
Number of species	17	27	26	39	59
Number of specimens	3313	16,083	2787	10,524	13,753
Number of collections	5	120	8	32	133

Thirteen of the 14 native species taken here, as well as the (introduced) salmonids, are all fishes typically found in headwaters. The exception is *Lepomis auritus*, which, while it is native in the lower river, has been introduced into this upper reach. All fishes except *Campostoma anomalum* and *L. auritus* generally occurred throughout the Upper Gorge downstream as far as rkm 284.

Section rkm 297-284: Gorge, Upper

All 17 species recorded in the headwaters on the Uplands were found in the Upper Gorge, including the dewatered portion, as well as an additional 10 species (Table 3).

Clinostomus funduloides was the most abundant species (5917 specimens; mean catch 49.31) here, followed by *Nocomis leptocephalus* (2646; 22.05) and *Phoxinus oreas* (1713; 14.28) (Table 4). The three salmonid species mentioned previously were most abundant (1547 specimens total) in the constricted portion of the river located between rkm 297-284. *Exoglossum maxillingua* and *Cottus caeruleomentum* were restricted to that reach of river between rkm 286 and 240. The first record of *Rhinichthys cataractae* in the Dan River was taken at rkm 287.

Section rkm 283-266: Gorge, Lower

First recorded at rkm 280 was *Percina roanoka* (2 specimens). Its appearance coincided with a decrease in river gradient below the Pinnacles Power Plant. *Salvelinus fontinalis* and *Thoburnia hamiltoni* were not collected below rkm 283 and rkm 280, respectively (Table 3).

Most abundant in this section were *Cottus caeruleomentum* (999 specimens; mean catch 124.88), *Clinostomus funduloides* (578; 72.25), *Luxilus cerasinus* (228; 28.50), *Notropis chiliticus* (216; 27.00), and *Nocomis leptocephalus* (194; 24.25) (Table 3, 4).

Section rkm 261-253: Inner Piedmont, Upper

Just below the VA/NC border and downstream of the gorge we recorded an additional seven species: *Nocomis raneyi* (9 specimens taken), *Notropis procne* (22), *Micropterus dolomieu* (1), *Etheostoma vitreum* (16), *Percina nevisense* (7), *Ameiurus melas* (1), and *A. platycephalus* (2) (Table 3).

Most abundant throughout rkm 261-253 were four cyprinids: *Lythrurus ardens* (888 specimens; mean catch 80.73), *Luxilus cerasinus* (586; 53.27), *Nocomis leptocephalus* (490; 44.54), and *Notropis chiliticus* (435; 39.54) (Table 3, 4). *Etheostoma flabellare* (267 specimens; 24.27) and *Noturus insignis* (206; 18.73) were also abundant.

Section rkm 249-199: Inner Piedmont, Lower

Seven species were added between rkm 249 and 199: *Micropterus salmoides* (3 specimens taken), *Moxostoma erythrurum* (31), *Scartomyzon ariommus* (32), *M. pappillosum* (43), *Ameiurus brunneus* (50), *Notropis amoenus* (1), and *Cyprinus carpio* (1) (Table 3). Seven species present upstream from rkm 261 to 253 were absent here.

Most abundant in this section were *Percina roanoka* (1238 specimens; mean catch 58.95), *Nocomis leptocephalus* (1024; 48.76), *Noturus insignis* (995; 47.38), *Notropis chiliticus* (832; 39.62), *Lythrurus ardens* (616; 29.33), and *Etheostoma podostemone* (396; 18.86) (Table 3, 4).

Rkm 193: Fault Basin, Upper Site

Fourteen species were first recorded at rkm 193: six centrarchids [*Lepomis cyanellus* (3 specimens), *L. gibbosus* (1), *L. macrochirus* (3), *L. microlophus* (1), *Pomoxis annularis* (3), *P. nigromaculatus* (1)], three ictalurids [*Ameiurus catus* (1), *A. nebulosus* (5), and *Ictalurus punctatus* (9)], and five others, namely *Esox americanus* (1), *Carassius auratus* (2), *Cyprinella lutrensis* (2), *Carpiodes cyprinus* (1), and *Moxostoma collapsum* (27) (Table 3). All 14 species are typical of slower waters and of sand/silt/mud substrates.

Most abundant here were *Cyprinella analostana* (354 specimens), *Lepomis auritus* (110), and *Notropis chiliticus* (102) (Table 3).

Section rkm 183-170: Fault Basin

Three species were first collected in this section: *Gambusia holbrooki* (2 specimens) at rkm 183, *Notemigonus crysoleucas* (2) at rkm 174, and *Ameiurus natalis* (1) at rkm 170 (Table 3).

Most abundant in this section were *Lepomis auritus* (165 specimens) and *Moxostoma erythrurum* (135) (Table 3).

Section rkm 156-135: Fault Basin

Five species were first collected here: *Notropis hudsonius* (1 specimen) at rkm 156, *Lepomis gulosus* (3) at rkm 139, *Moxostoma macrolepidotum* (5) and *Ambloplites rupestris* (2) at rkm 138, and *Dorosoma cepedianum* (38) at rkm 135 (Table 3). The only other records of *Ambloplites cavifrons* (4 specimens) from outside the Upper Gorge were taken from rkm 139 to 135. Seven species recorded upstream in the Fault Basin were not taken below this section.

Most abundant in this section were *Lepomis auritus* (1936 specimens), *Cyprinella analostana* (1056), *Moxostoma erythrurum* (916), *Luxilus albeolus* (665), *Lepomis macrochirus* (576), and *Ameiurus brunneus* (363)(Table 3).

Rkm 120: Fault Basin

Thirty-six of the 59 species collected at, or upstream of, rkm 120 in the Fault Basin were not collected farther downriver (Table 3). This is probably an artifact of sampling, since fishes downstream of rkm 120 were collected only with a boat electroshocker. No species was taken only at rkm 120. Most abundant at rkm 120 were *Lepomis auritus* (210 specimens) and *Ameiurus brunneus* (180 specimens) (Table 3).

Rkm 84 and 23: Fault Basin

Stizostedion vitreum (1 specimen) was taken only at rkm 84 (Table 3). Most abundant at rkm 84 were *Dorosoma cepedianum* (66 specimens) and *Ameiurus brunneus* (22). Most abundant at rkm 23 were *Lepomis macrochirus* (18 specimens) and *L. auritus* (10).

Rkm 193-23: Fault Basin, All Sites Summarized

Lepomis auritus (2832 specimens; 21.29 mean catch) and *Cyprinella analostana* (2248; 16.90) were the most abundant species taken throughout the Fault Basin (Table 3, 4). Other important Fault Basin species included *Moxostoma erythrurum* (1376; 10.34), *Luxilus albeolus* (906; 6.81), *Lepomis macrochirus* (873; 6.56), *Nocomis raneyi* (762; 5.73), *Ameiurus brunneus* (638; 4.80), and *Lythrurus ardens* (620; 4.66). All these species were also abundant in other sections of the river.

Of the 24 species found only in the Fault Basin (15 sites, 133 collections) (Table 3, 4), seven species, *Dorosoma cepedianum, Notropis hudsonius, Moxostoma collapsum, Ictalurus punctatus, Lepomis cyanellus, L. macrochirus,* and *L. microlophus,* were represented by more than 100 specimens each. Of the remaining 17 species that first occurred from rkm 193 (start of the Dan River-Danville Basin) and downstream, taken were three species (*Lepisosteus osseus, Esox americanus, Stizostedion vitreum*) that were represented by only one or two specimens of each, and four species (*Carassius auratus, Gambusia holbrooki, Ameiurus natalis, Ambloplites rupestris*) that were represented by a total of only 11 specimens and that were taken at only two sites each (Table 3). The remaining 10 species occurred intermittently throughout the 170 rkm reach from rkm 193 to rkm 23 of the Triassic Basin section of the river (Table 3).

Faunal Groupings

Based on our analysis, we identified three distinct faunal breaks, thus four fish groupings (Fig. 4). The first faunal break, with a similarity index value of 0.30, occurred between rkm 286 and 283 and was located between sites 5 and 6 in the narrow Upper Gorge (Fig. 5). The river at this point changed from a coldwater to a coolwater stream. This thermal change may explain this break. No reproducing trout have been found, by us and by pertinent state fisheries biologists, in the river below rkm 283. The second faunal break, with a similarity index value of 0.23, occurred between rkm 270 and 261, just below the gorge. The third faunal break, with a similarity index value of <0.10, occurred between rkm 199 and 193. This corresponded to the break between that section of river over the Upper Precambrian-Paleozoic rocks at rkm 199 and that section over the rocks of the Upper Triassic found at rkm 193 and downstream.

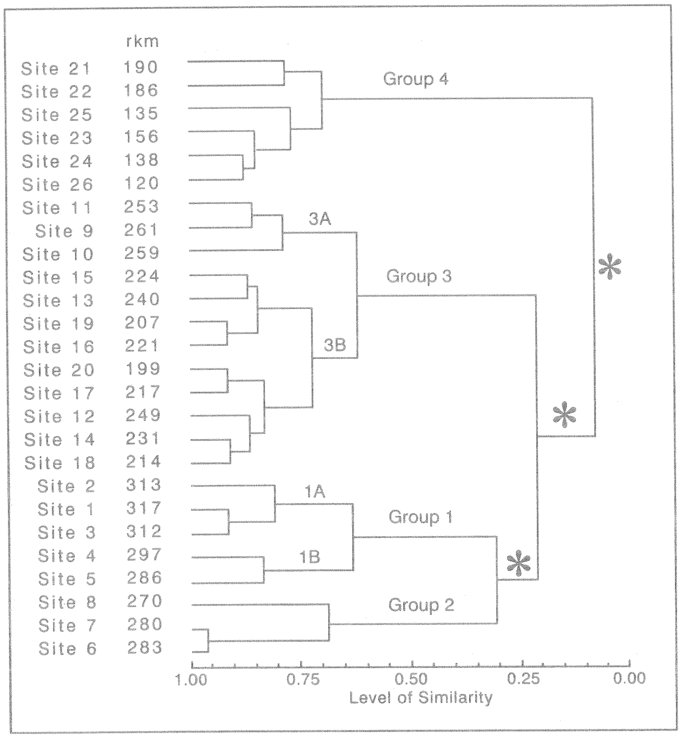

Figure 4. Dendrogram of groupings of fishes in the Dan River by sampling sites as based on Horn's modification of Morisita's Index. Faunal breaks are indicated by an asterisk.

The fishes in Group 1, which consists of 19 species, were found at sites 1 to 5 (Fig. 4, Table 3). This group comprised the assemblage found on the Uplands above the Escarpment crest at sites 1 to 3 (at rkm 317 to 312), and in the constricted portion of the Upper Gorge at sites 4 and 5 (at rkm 297 and 286).

Two subgroups, with a similarity index value of 0.63 to each other, were evident in Group 1. These corresponded well to the two conspicuous geomorphic units sampled: subgroup 1A, with 17 species, occurred above the gorge at three sites; and subgroup 1B, with 18 species, occurred in the Upper Gorge at two sites.

The fish assemblage in Group 2, of 25 species, was found at sites 6 to 8 in the Lower Gorge from immediately downstream of the Pinnacles Power Plant, from rkm 283 to rkm 270. Replacement of species was evident between those found in Group 1 and those found in the next section of river, in Group 2. Of the 19 species in Group 1, two dropped out (temporarily) and were replaced by eight additional species in Group 2 (Table 3).

Group 3, of 38 species, occurred from below the gorge and downstream for the next 62 rkm, at sites 9 to 20 (from rkm 261 to 199). Notable when moving from Group 2 to Group 3 was the loss of three species (*Rhinichthys atratulus, Thoburnia hamiltoni, Salvelinus fontinalis*) and an addition of 15 species (including two from Group 1), primarily of openwater cyprinids, catostomids, ictalurids, and piscivorous centrarchids.

Identified in Group 3 were two subgroups, with a similarity index value of 0.60 (Fig. 4). Subgroup 3A consisted of 30 species that were found at three sites, from rkm 261 to 253. Subgroup 3B consisted of 32 species that were found at nine sites in 50 kilometers of river from rkm 249 to 199. The primary physical differences which may account for the separation here were river width (wider in the lower reach), slower current, and substrate (more bedrock/boulders in the lower reach).

Group 4, of 56 species, occurred in the lowermost portion of the study area, from rkm 190 to 120 (Fig. 5). Over five times as many species (21) were added here, particularly of ictalurids and centrarchids, than were lost (4).

A dendrogram based on species similarities rather than on site similarities shows two clusters (I, II) and their contained groupings (Fig. 6). Cluster I contains three groups of species (Ia, Ib, Ic) related by distribution and abundance and are dominant in the upper reach of the river, and these are discussed here. The distributions of *Cottus caeruleomentum* and *Exoglossum maxillingua* (0.53 similarity) were previously mentioned as being highly restricted. The taxa in group Ib (*Clinostomus funduloides - Phoxinus oreas - Semotilus atromaculatus - Catostomus commersoni - Rhinichthys atratulus*) represent those species that are the most common in the headwaters (0.48). Two salmonids (*Salmo trutta - Oncorhynchus mykiss*) comprise group Ic (0.73), and these were most abundant in the Upper Gorge.

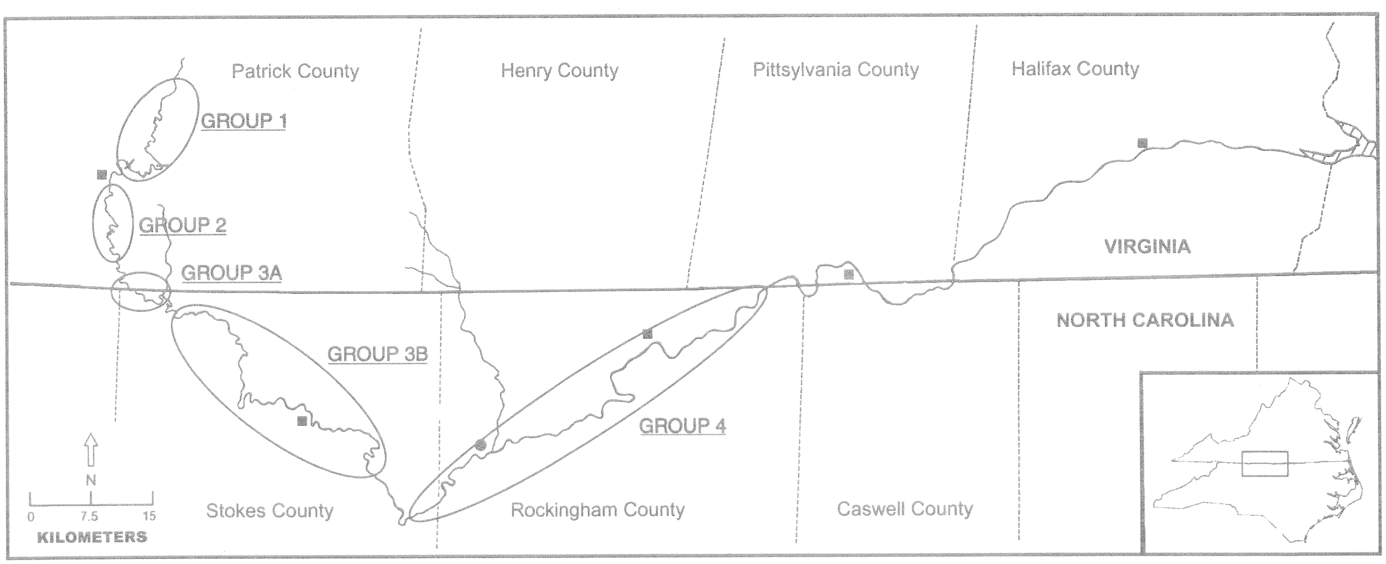

Figure 5. Fish groupings in the Dan River as based on Horn's modification of Morisita's Index.

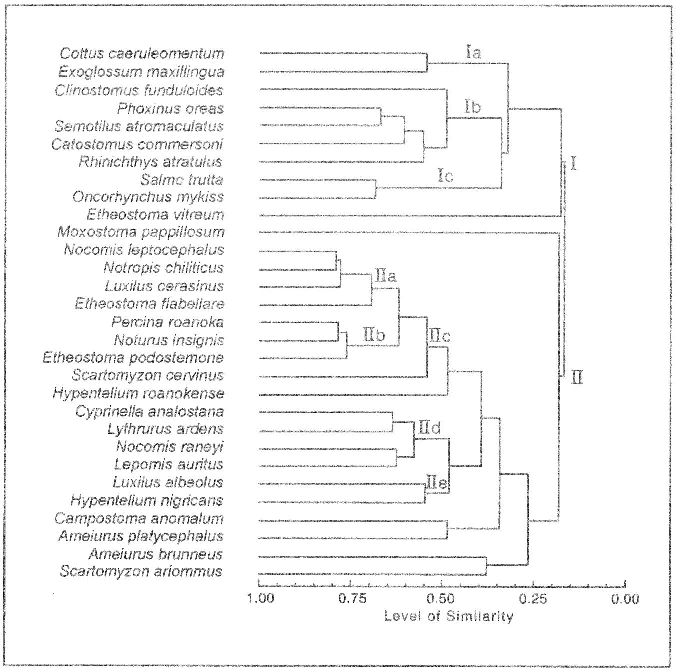

Figure 6. Dendrogram of selected fishes groupings in the Dan River as based on Horns' modification of Morisita's Index.

Cluster II contains five species groups, IIa to IIe (similarity index >0.5). Highly similar were fishes that were abundant and widespread in the river below the gorge downstream to the Triassic Basin. This includes two highly related groups: IIa) *Nocomis leptocephalus - Notropis chiliticus - Luxilus cerasinus - Etheostoma flabellare* (0.72 similarity) and IIb) *Percina roanoka - Noturus insignis - Etheostoma podostemone* (0.75). These two groups are strongly related to each other (0.60). Group IIc includes these two groups (a,b) and also includes *Scartomyzon cervinus* (0.55 similarity). Also similar (0.56) is group IId (*Cyprinella analostana - Lythrurus ardens - Nocomis raneyi - Lepomis auritus*) which is abundant in the deeper waters of the runs. This latter group is also related (0.47) to the *Luxilus albeolus - Hypentelium nigricans* group IIe (0.53) (Fig. 6) found in the more shallow portions of runs.

CONCLUSIONS

The Dan River supports a diverse and abundant fish fauna, and 80 species are known to occur or potentially could occur. This diversity is due, in part, to the high water quality present in the upper part of the river, consistent stream flow, and extensive habitat diversity throughout. Initially, at its origin on the Blue Ridge Uplands, the river is narrow and shallow, with a slow current. In the gorge, due to an increase in gradient, the current speed increases. Below the gorge, the gradient decreases but fast-current areas are frequent as the river traverses constrictions in the crystalline rocks of the Inner Piedmont; the river substrate there is composed primarily of rubble and gravel. The lowermost reach of river passes through the Fault Basin where river width and depth increase, the current slows slightly, and the substrate consists primarily of sand with gravel. All of these factors, and a general increase in water temperature, are possible major determinants of Dan River fish distribution. Local habitat heterogeneity may explain some of the disjunct fish distributions noted in the Dan River.

From the headwaters, where 17 species were taken, fish diversity increased steadily downstream to just below the VA-NC border (at rkm 261) where a group of five species was first taken, to comprise a total of 35 species collected in that reach of river approximately upstream of the VA-NC border. The reason for this pronounced increase of five species may be that the upstream-most deep run (>1 m depth) of the river is located here and that species often found in such habitat, e.g., *Nocomis raneyi, Notropis procne,* and *Micropterus dolomieu*, were first found here.

Species were added gradually, and others dropped out, as the river ran through the rest of the Upper Precambrian/Lower Paleozoic rocks area, for a total of 39 species that occurred in this mid-river reach (from rkm 259 to 199).

A major faunal break then occurred in the river as it entered the Dan River-Danville (Triassic) Basin. Fourteen species first occurred here, we presume primarily because of a change in substrate from gravel-rubble to primarily sand, from a faster to a slower current, and possibly because of an increase in water depth and a tolerance to increased turbidity.

Nine species that were found upstream in the Upper Precambrian/Lower Paleozoic region (from rkm 317 to 199) were absent from downstream in the Triassic Basin (from rkm 193 to 23) (Table 3). Eight other species were present in very low numbers and were taken at only one or two sites, mostly below a dam located at rkm 135 where, according to David Coughlan (DPC, 2001, pers. comm.), the "swift current had created an oasis of gravel, rock, and cobble habitat" in an area of otherwise sand substrate.

Most (47) of the 68 species that we recorded in this survey were widely distributed in the river (some conspicuous examples are *Luxilus cerasinus, Nocomis leptocephalus, Catostomus commersoni,* and *Noturus insignis*), or widely distributed throughout a particular geologic section (particularly *Cyprinella analostana, Moxostoma erythrurum, Lepomis auritus* throughout the Fault Basin, and *Percina roanoka* throughout the Inner Piedmont).

The distribution of *Exoglossum maxillingua, Thoburnia hamiltoni,* and *Cottus caeruleomentum* was limited, and each was restricted to 56 rkm or less of the upper river. Their occurrence there ranged from abundant (*C. caeruleomentum*) to rare (*T. hamiltoni*), and all were apparently restricted to some specific and as yet unidentified bottom type, water temperature, and/or flow regime. These restrictors likely are suitable spawning substrate for the sculpin and very high water quality for the sucker. The distributions of some fishes (e.g., *Notropis procne, Scartomyzon ariommus, S. cervinus, Ambloplites cavifrons, Micropterus dolomieu, Etheostoma nigrum,* and *E. vitreum*) are less easily characterized since each has a major gap in occurrence in the Dan River. Some of the more rarely-captured species, such as *Lepisosteus osseus, Esox americanus, Carassius auratus, Ameiurus melas, A. natalis, Gambusia holbrooki,* and *Stizostedion vitreum*, were found at only one to three widely-spaced sites. Their low rates of occurrence and localized distributions presumably are a result of a lack of habitat. Our analysis of the distribution of fishes in the Dan River support the hypothesis of Matthews (1986) that differences in microhabitats, rather than of stream order, influence and complicate longitudinal succession.

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