Benthic Macroinvertebrates of Cane Creek, North Carolina, and Comparisons with Other Southeastern Streams

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ABSTRACT.— The macrobenthos of Cane Creek, in the Piedmont Plateau of North Carolina, have been sampled by several investigators. This information was combined to generate a list of 272 invertebrate taxa. Cane Creek is compared to other unstressed Piedmont streams to define characteristics of a "normal" stream in this geographic area. If used cautiously, this data set can provide control information for biological monitoring. Average taxa richness appears to be the best tool for environmental assessment work. It shows little variability across a wide range of North Carolina streams, even outside the Piedmont. Such a pattern suggests a constant number of niches in stream ecosystems.

INTRODUCTION

The study of pollution in freshwater ecosystems is a complex problem. Water quality degradation may be caused by an immense number of pollutants, many of which have an alarming degree of temporal and/or spatial variability. To deal with this variability, water quality monitoring often includes some biological sampling.

The North Carolina Division of Environmental Management (DEM) has used biological monitoring to analyze a wide variety of water quality problems (Penrose et al. 1980). Specifically, the Division's biologists use the structure of the benthic macroinvertebrate community to detect stress in aquatic systems. There are many ways to examine such data (Lenat et al. 1980), but all are based on comparisons of actual data with some expected pattern. The expected pattern is often derived from a control area, but in many situations it may be difficult to locate good control stations. This difficulty can often be overcome by using control data sets. The Division's Biological Monitoring Group has attempted to generate control data sets by compiling information from many unpolluted North Carolina streams and rivers. An earlier contribution examined the benthos of a Mountain river system (Penrose et al. 1982). This paper describes the benthic macroinvertebrates of a typical Piedmont stream.

Dick - ID of E. interna is tentative, based on shell shape. These specimens could E. complanata

STUDY SITE

Cane Creek is a third-order stream located in Orange County, North Carolina (Fig. 1). The total watershed is about 90 km^2 and average discharge is roughly 0.7 m^3/s (N.C. Division Environmental Management 1975). Cane Creek is classified as A-II water, i.e. suitable for drinking (after treatment), body contact, recreation, and "fish and wildlife propagation".

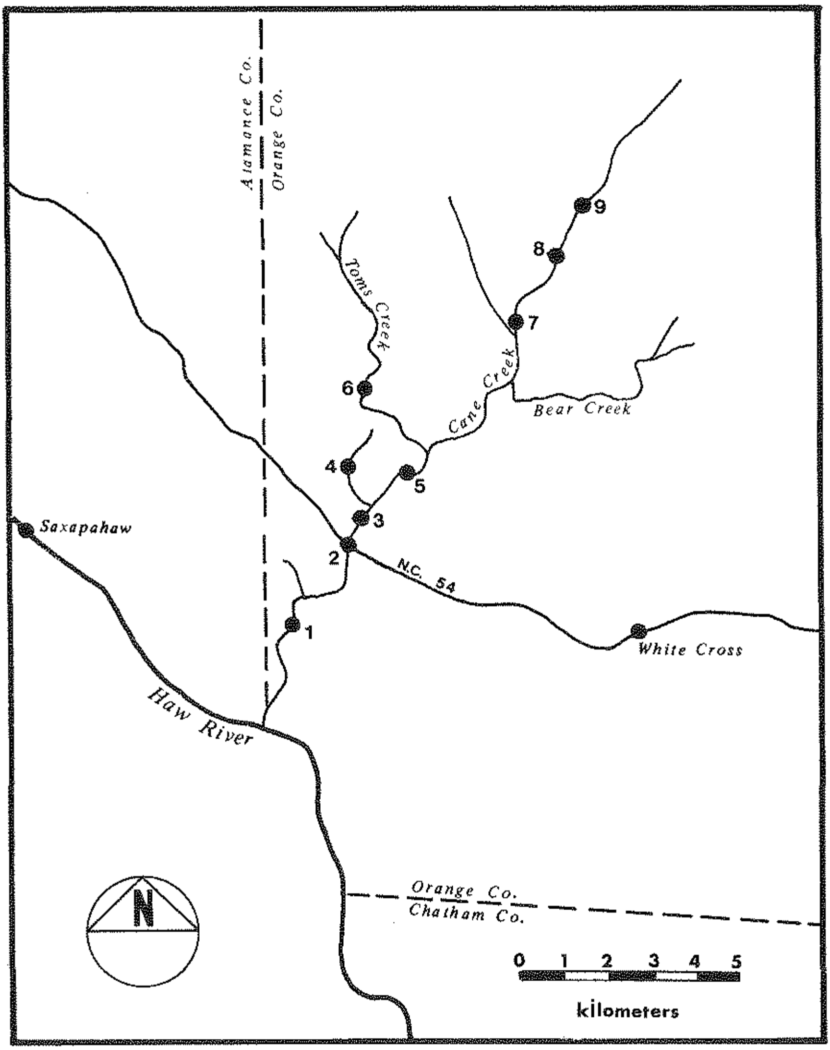

Fig. 1. Sampling Stations, Cane Creek, North Carolina.

Fish collections from Cane Creek (unpublished data on file with N.C. Wildlife Resources Commission) include 25 species. The list appears typical of Piedmont streams in North Carolina.

The watershed contains both forest and agriculture, principally dairy farming and row crops. According to the water basin plan (N.C. Division Environmental Management 1975), there are no point source discharges in this area, but runoff often causes high turbidity in Cane Creek. In 1978 the Soil Conservation Service (unpublished) cited Cane Creek as a high priority area for land treatment to reduce erosion rates. However, little accumulation of coarse bedload sediment was noted in biological surveys, which may be due to local geology. Cane Creek is located in the "slate belt" of North Carolina, a zone of metamorphosed volcanic rock (Simmons and Heath 1979). DEM surveys within this land type (unpublished data) suggests that little "sandy" stream sediment is produced through erosion.

METHODS

Several investigators have collected benthic macroinvertebrates from Cane Creek (Smock and Hughes 1975; Mozley 1978; Penrose et al. 1980). Extensive collections have also been made by the author and by a limnology class at North Carolina State University. Collection methods included Hester-Dendy multiple plate samplers (Fullner 1971), "kicks" (Frost et al. 1971), and various qualitative techniques. The most intensive collections have been at Station 1 (Lower Cane Creek), but all areas of the Cane Creek watershed have been sampled (see Fig. 1). Areas sampled included temporary streams and stream orders 1 through 3. All records were vertified by the author.

RESULTS AND DISCUSSION

Taxa List

Table 1 lists 272 taxa collected from Cane Creek. A list of taxonomic references used for identification of these organisms is available from the author. This table also contains data on frequency (rare, common, or abundant), a classification that is somewhat subjective since most collections were qualitative. The list contains few species not collected in other Piedmont streams (DEM, unpubl. surveys). The most unusual record was *Mystacides alafimbriata* Hill-Griffin, a common edge species found at several stations in July 1979. This caddisfly had not been collected east of the Mississippi River. Identification was based on young larvae and should be confirmed by collection of adults. Another unusual caddisfly record was *Dibusa angata* Ross, a species strongly associated with red algae (Wiggins 1977).

The turbellarian *Hydrolimax grisea* Haldeman was collected several times in Cane Creek. Pennak (1978) listed this species as rare and

Table 1. List of benthic macroinvertebrates from Cane Creek. Under frequency, A = abundant, C = common, R = rare.

Taxon	Frequency
EPHEMEROPTERA	
Baetis amplus	A
B. flavistriga	A
B. intercalaris	A
B. pluto	C
B. propinquus	R
Callibaetis sp.	R
Centroptilum sp.	R
Cloeon alamance	R
Pseudocloeon spp.	C
Caenis cf. *diminuta*	C
Ameletus lineatus	C
Isonychia spp.[1]	C
Siphloplectron basale	R
Leptophlebia sp.	C
Paraleptophlebia sp.	A
Hexagenia munda	C
Ephemerella (E.) catawba[2]	R
E. *(Attenella) attenuata*	R
E. (Danella) simplex	R
E. (Seratella) deficiens	C
E. (Eurylophella) bicolor	C
E. (E.) temporalis	C
E. (E.) funeralis	R
Heptagenia aphrodite	C
Stenonema modestum[3]	A
S. smithae	C
S. vicarium	C
S. *(femoratum)*	R
Stenacron interpunctatum	A
S. pallidum	C
PLECOPTERA	
Allocapnia spp.	C
Leuctra sp.	R
Acroneuria abnormis	C
A. evoluta	R
Eccoptura xanthenes	R
Perlesta placida	C
Taeniopteryx metaqui	A
T. burksi	A
Strophoteryx fasciata	A
Amphinemura sp.	R
Isoperla clio	C
Isoperla namata	R
Hastaperla brevis	R

HEMIPTERA	
Belastoma fluminea	R
Sigara spp.	A
Gerris remigis	C
Limnogonus sp.	R
Trepobates sp.	R
Metrobates hesperius	R
Rheumatobates palosi	R
Mesovelia mulsanti	R
Rhagovelia obesa	C
Microvelia americana	C
NEUROPTERA	
Climacia sp.	R
MEGALOPTERA	
Corydalus cornutus	C
Nigronia serricornis	C
Chauliodes pectinicornis	R
Sialis	A
ODONATA	
Argia spp.	C
A. sedula	-
A. translata	-
A. moesta	-
A. tibialis	-
Enallagma spp.[4]	C
Ischnura spp.	C
Calopteryx sp.	C
Baesiaeschna janata	R
Boyeria vinosa	C
Cordulegaster sayi	R
Helocordulia selysii	R
Neurocordulia obsoleta	R
Epitheca cynosura	R
Libellula sp.	R
Perithemis tenera	R
Macromia allegheniensis	C
Didymops transversa	R
Gomphus spp	C
Lanthus parvulus	R
Stylogomphus albistylus	R
Hagenius brevistylus	R
Dromogomphus spinosus	C
TRICHOPTERA	
Diplectrona modesta	C
Cheumatopsyche spp.	A
Hydropsyche betteni	A
Macronema carolina	C
Nectopsyche sp.	R

Ceraclea ancylus	C
C. tarsipunctata	R
Oecetis spp.[5]	C
Triaenodes injustus	R
Triaenodes tardus	R
T. cf. sp. b	C
Mystacides alafimbriata	C
Dibusa angata	R
Stactobiella sp.	R
Pycnopsyche guttifer	R
P. gentilis	R
Hydatophylax argus	R
Neophylax cf. *oligius*	R
Ptilostomis sp.	R
Brachycentrus sp.	R
Polycentropus spp.[6]	C
Phylocentropus sp.	C
Lype diversa	R
Molanna blenda	R
Chimarra cf. *aterrima*	C
Wormaldia sp.	R
Psilotreta sp.	R
Lepidostoma sp.	R
Rhyacophila carolina	R
R. acutiloba	R
R. ledra	R
COLEOPTERA	
Helichus fastigiatus	C
Ancyronyx variegata	C
Macronychus glabratus	C
Stenelmis spp.	C
Oulimnius latiusculus	R
Optioservus ovalis	R
Dubiraphia quadrinotata	C
Ectopria nervosa	R
Psephenus herricki	C
Anchytarsus bicolor	R
Hydroporus spp.	C
Hydrovatus sp.	R
Rhantus sp.	R
Tropisternus sp.	R
Helophorus sp.	R
Laccophilus sp.	R
Copelatus glyphicus	R
Dineutes sp.	C
Gyrinus sp.	R

DIPTERA (Miscellaneous)	
Palpomyia (complex)	C
Anopheles punctipennis	C
Culex restuans	R
Chaoborus punctipennis	R
Dolichopodidae	R
Empididae	R
Simulium vittatum	A
Prosimulium mixtum	A
P. rhizophorum	C
Chrysops sp.	C
Tabanus sp.	R
Antocha sp.	C
Dicranota sp.	R
Hexatoma sp.	R
Limonia sp.	R
Pseudolimnophila sp.	R
Tipula sp.	R
T. abdominalis	C
Dixa sp.	R
DIPTERA: CHIRONOMIDAE	
Chironomus sp.	R
Cryptochironomus blarina	R
C. fulvus gr.	R
Demicryptochironomus sp.	R
Dicrotendipes nervosus	R
D. neomodestus	A
Glyptotendipes sp.	R
Kiefferulus dux	R
Microtendipes pedellus	A
M. nr. *rydalensis*	R
Paratendipes albimanus	C
Phaenopsectra sp.	R
P. flavipes	C
Polypedilum aviceps	R
P. convictum	C
P. fallax	R
P. illinoense	C
P. scalaenum	R
Stenochironomus sp.	C
Stictochironomus sp.	R
Tribelos jucundus	C
Xenochironomus xenolabis	R
Cladotanytarsus spp.	R
Constempellina sp.	R
Micropsectra sp.	R

Paratanytarsus sp.	R
Rheotanytarsus spp.	A
Tanytarsus spp.	A
T. guerlus gr.	C
T. nr.*glabrescens*	C
T. glabrescens	R
Zavrelia sp.	R
Ablabesmyia mallochi	R
A. ornata	C
A. parajanta	R
Clinotanypus pinguis	C
Conchapelopia group	C
Labrundinia neopilosella	R
L. nr. *virescens*	C
Larsia sp.	R
Natarsia sp.	R
Nilotanypus sp.	R
Procladius bellus	R
P. sublettei	R
Psectrotanypus dyari	R
Zavrelimyia sp.	R
Sympotthastia sp.	R
Brillia spp.	R
Xylotopus par	C
Corynoneura spp.	C
Cardiocladius sp.	R
Cricotopus/Orthocladius gr.	
Cricotopus (*C.*) *bicinctus*	C
C. (*C.*) *tremulus* gr. sp. 1 (=*C. infuscatus*)	R
C. (*C.*) *tremulus* gr. sp. 2	R
C. (*C.*) cf. *cylindraceus*	C
Orthocladius (*O.*) *robacki*	R
O. (*O.*) nr. *dorenus*	C
O. (*O.*) cf. *obumbratus*	C
O. (*O.*) cf. *nigritus*	R
O. (*O.*) nr. *clarkei*	R
O. (*Euorthocladius*) sp. 1	R
O. (*E.*) sp. 2	C
Diplocladius cultriger	C
Eukiefferiella claripenis gr.	R
Tretenia bavarica gr.	R
T. discoloripes gr.	R
Heterotrissocladius marcidus	R
Hydrobaenus spp.	R
Nanocladius spp.	C
Genus nr. *Nanocladius*	R

Parakiefferiella sp. 1	C
P. sp. 3	R
P. nr. *triquetra*	C
Paraphaenocladius sp. 1[7]	C
Paracricotopus sp.	R
Parachaetocladius sp.[8]	R
Pseudosmittia sp.	R
Psectrocladius sp.	R
Rheocricotopus cf. *robacki*	C
Synorthocladius sp.	R
Thienemaniella sp.	C
MOLLUSCA	
Somatogyrus sp.	R
Ferrissia rivularis	C
Physella sp.	C
Stagnicola sp.	R
Gyraulus sp.	R
Heliosoma anceps	C
Elimia sp.	C
Campeloma decisum	C
Eupera cubensis	R
Pisidium spp.	C
Sphaerium simile	C
Elliptio camplanata	R
E. icterina	R
Strophitus undulatus	R
CRUSTACEA	
Cambarus acuminatus	C
Procambarus acutus	R
Palaemonetes paludosus	R
Lirceus sp.	C
Crangonyx spp.	C
Hyallela azteca	
OLIGOCHAETA	
Aulodrilus pigueti	R
A. pluriseta	R
Limnodrilus hoffmeisteri	C
Ilyodrilus templetoni	R
Peloscolex variegatus	C
Branchiura sowerbyi	R
Nais bretscheri	R
N. variabilis	A
Slavinia appendiculata	R
Stylaria lacustris	R
HIRUDINEA	
Helobdella elongata	R
Placobdella multilineata	R

P. papillifera	R
Mooreobdella tetragon	R
TURBELLARI	
Cura foremanii	C
Dugesia tigrina	C
Hydrolimax grisea	R
BRYOZOA	
Plumatella repens	C
Fredericella sultana	R
MISCELLANEOUS	
Porifera: *Eunapius* sp.	C
Nemertea: *Prostoma graecens*	R
Hydracarina	C
Nematoda	C

[1] Includes *Isonychia bicolor*.
[2] Subgenera listed for *Ephemerella* are considered as genera by some authors.
[3] Old identifications of Lewis (1974) have been revised in accordance with Bednarik and McCafferty (1979).
[4] Includes *Enallagma divergens*.
[5] Includes *Oecetis* cf. *cinerascens*.
[6] Probably includes *Cernotina* sp.
[7] This species listed as *Parametriocnemus* in many other surveys.
[8] Near *Pseudorthocladius*; identified by Len Ferrington.

"reported from New Jersey and east Pennsylvania". This interpretation of range probably results from taxonomic difficulties rather than rarity. I have found this species to be widespread in Piedmont and Coastal Plain streams, especially in the latter.

Several common Piedmont macroinvertebrates were rare or absent in Cane Creek. *Ephemerella catawba* Traver, which I have found to be a highly abundant organism in most Piedmont streams, was collected only once. This mayfly prefers sand-gravel areas, a rare habitat in Cane Creek. The lack of sand substrates probably also accounts for the absence of *Baetisca carolina* Traver, *Progomphus obscurus* Rambur, and *Robackia demeijerei* (Kruseman).

Taxa collected in first-order tributaries were markedly different from the fauna at lower stream stations. Many of these first-order stream taxa were more typical of small mountain streams: *Diplectrona modesta* Banks, *Ephemerella funeralis* McDonnough, *Amphinemura* sp., *Micropsectra* sp., and *Heterotrissocladius* sp. This may reflect the colder water temperature normally found in headwater areas (Vannote and Sweeney 1980). Other taxa collected only in first-order tributaries included *Paraleptophlebia* sp., *Eccoptura xanthenes* (Newman), *Pycnopsyche gentilis* (McLachlan), and *Molanna blenda* Sibley.

Total Taxa Richness

Table 2 presents Cane Creek taxa richness by group, and includes data from several other southeastern Piedmont stream investigations. These data show a remarkable degree of consistency if allowances are made for geographic area, collection methods, and special interest of the investigators. Some differences, as seen in South Carolina and Georgia samples, are attributable to collections of nonaquatic adult insects. This usually increases estimates of species richness, as greater taxonomic precision may be attained with adult specimens.

Collections in semiaquatic areas also may increase the number of species collected, especially for Coleoptera. Holeski and Graves (1978) found that 30+ species of "shore beetles" were usually found at most stations, but that this type of data was not useful in assessing environmental stress. Eighty chironomid taxa were identified from Cane Creek, about 30% of the total fauna. Use of adults or pupal exuviae might have doubled this figure. Coffman (1973), using pupal exuviae, identified 143 chironomid taxa from Linesville Creek, while larval sampling from the same area produced only 77 taxa.

Table 2. Total taxa richness at Cane Creek, with selected data from other intensive stream investigations. Numbers in parentheses omit data based only on nonaquatic adults. NI = Not Identified.

Stream: State:	Cane[1] NC	Wildcat[2] SC	Little Garvin[3] SC	Upper Three Runs[4] GA	Linesville[5] PA
EPHEMEROPTERA	30	54	20(19)	32(27)	13
ODONATA	22	29	30(16)	24	?
PLECOPTERA	13	44	6	28(17)	5
HEMIPTERA	10	4	8	27	5
MEGALOPTERA	4	2	5	6(4)	2
LEPIDOPTERA	1	0	0	9(1)	0
NEUROPTERA	1	0	0	2	0
COLEOPTERA	16	20	15	86[6]	15
TRICHOPTERA	31	48	10	108(46)	25
DIPTERA/(MISCELLANEOUS)	19	17	12	NI	14
DIPTERA: CHIRONOMIDAE	80	50	61	NI	77
OLIGOCHAETA	13	NI	NI	NI	?
HIRUDINEA	4	NI	NI	NI	?
MOLLUSCA	14	NI	NI	NI	?
OTHER	8	NI	NI	NI	?
TOTAL	272	266	167	321	192

[1] This study.
[2] White and Fox (1980), based largely on the collections of Paul Carlson.
[3] White and Fox (1980).
[4] Morse et al. (1980).
[5] Coffman et al. (1971).
[6] Includes many semiaquatic species.

Table 3. Average taxa richness by group for North Carolina Piedmont streams. Ranges are rounded to integer values.

Stream: # Collections: County:	Cane 3 Orange	Bolin 3 Orange	Cates 3 Orange	UT Lanes Creek 3 Union	Long Branch 4 Gaston	4-Mile 4 Davidson	
Group							Range
EPHEMEROPTERA	8.3	8.7	8.7	7.7	8.0	9.4	8-9
PLECOPTERA	1.7	3.7	3.7	2.0	3.0	5.0	2-5
ODONATA	0.7	0.7	3.7	0.7	1.0	1.6	1-4
TRICHOPTERA	5.0	4.0	5.6	2.0	7.3	3.4	2-7
COLEOPTERA	5.0	4.7	5.7	5.3	3.7	3.0	3-6
MEGALOPTERA	2.0	2.0	1.3	2.7	1.0	1.8	1-3
DIPTERA	21.0	13.7	19.7	16.0	17.3	14.6	14-21
MOLLUSCA	3.3	2.3	1.7	2.3	1.3	1.4	1-3
OLIGOCHAETA	3.7	1.0	2.7	2.3	1.7	1.8	1-4
CRUSTACEA	1.7	3.0	2.7	1.7	2.0	1.7	2-3
OTHER	2.7	2.0	0.3	0.6	-	-	0-3
TOTAL	55.1	45.8	55.8	43.3	46.3	44.0	43-56

Average Taxa Richness/Percent Density

Environmental assessment is often based on quantitative data from a single collection or on data averaged over several collections. It may be difficult to relate these data to water quality if good control information is lacking. Tables 3 and 5 present average taxa richness and density values from Cane Creek and make comparisons with five other relatively unstressed Piedmont streams. All samples were taken during DEM investigations. Collection methods (kicks) and identification techniques were identical for all streams. From this data set, one may attempt to define the normal characteristics of Piedmont stream macroinvertebrate communities.

Table 3 gives average taxa richness values in the range of 43 to 56 ($\bar{x}$ = 48.5). There was often a remarkable constancy at the group level. For example, Ephemeroptera varied only from 8.3 to 9.4. Plecoptera values were generally in the range of 2 to 4, except at 4-Mile Creek. The greater number of Plecoptera in this stream, which is at a higher elevation, may reflect colder water temperatures. The expected number of Odonata is close to the average (1.4), except at Cates Creek. This is a very narrow, slow stream and might be expected to show a high proportion of bank associated (edge) species in quantitative samples. Odonata are most frequently collected in bank areas. Variations in Coleoptera and Trichoptera, especially the latter, are not easily explained. Various regional differences in water chemistry, temperature, and gradient may be responsible. The number of Diptera, especially chironomids, had a wide range (14-21), but was always high. Even stressed areas may have a diverse chironomid fauna (Penrose et al. 1980) although tolerant species will become dominant. The "other" category includes miscellaneous Insecta (Neuroptera, Lepidoptera), Turbellaria, Hirudinea, Nemertea, Porifera, and Nematoda. Variation in this category is very unpredictable.

Table 4 presents average taxa richness values for streams in three broad geographic areas in North Carolin: Mountains (data expanded from Penrose et al. 1982); Piedmont (as in Table 5); and Coastal Plain. These three physiographic regions have differing physical characteristics. Going from the mountains to the coast one would expect increasing water temperature, lower gradient, and increasing amonts of sand and silt. The Coastal Plain data set is based on collections in Craven, Hertford, and Northampton counties. These coastal streams are not entirely unstressed, but the data are adequate to illustrate geographic trends.

The overall trend suggests a relatively constant number of species in stream environments. Average taxa richness for Coastal Plain and Mountain streams is well within the range expected for Piedmont streams (Table 3). From this pattern one might advance the hypothesis that unpolluted streams have a relatively constant number of niches. Furthermore, these data imply that taxa richness is an excellent monitoring tool across a wide range of stream types. A similar hypothesis was advanced by Patrick (1975:448). She examined species richness in nine different rivers and concluded that "similar-sized areas of different streams support similar numbers of species." This constancy of "α - diversity" prevailed even when the number of species shared between streams was low.

Table 4. Average taxa richness by group for Coastal Plain, Piedmont and Mountain streams in North Carolina. See text for data sources. Number of streams shown in parentheses.

Group	Coastal Plain (7)	Piedmont (6)	Mountains (9)
EPHEMEROPTERA	2.9	8.5	9.7
PLECOPTERA	0.8	3.2	6.5
ODONATA	2.5	1.4	0.8
TRICHOPTERA	3.9	4.6	7.8
COLEOPTERA	2.8	4.6	2.5
MEGALOPTERA	0.7	1.8	0.2
DIPTERA	23.0	17.1	14.5
MOLLUSCA	3.7	2.1	0.5
OLIGOCHAETA	3.6	2.2	0.9
CRUSTACEA	2.5	2.1	0.9
OTHER	2.0	0.9	0.2
TOTALS	48.4	48.9	44.5

At the group level, taxa richness varies considerably across the three types of streams. Each stream type has a different assemblage of invertebrate predators. Plecoptera and Trichoptera are most diverse in Mountain streams, Megaloptera in Piedmont streams, and Odonata in Coastal Plain streams. The "other" category, also most important in Coastal Plain streams, includes many other predators: Hirudinea, Turbellaria, and *Prostoma graecens* (Bohmig). Shifts may also be observed in the collector-gatherer groups. Going from the mountains toward the coast, Ephemeroptera-Trichoptera decline and are replaced by Coleoptera (Piedmont only), Oligochaeta, Crustacea, and Mollusca.

Table 5 shows density (expressed as a percentage of total density) for Cane Creek and five other North Carolina Piedmont streams. The density values show much greater between-stream variability than does average taxa richness. These data may serve as controls only if used with extreme caution. Variability is imposed by such factors as stream size, substrate, and geographic locality. The data are further biased by the selection of riffle areas and by the mesh size used in sample processing. A smaller mesh size will increase the importance of Diptera and Oligochaeta.

Table 5. Density by group (as percent of total density) for Cane Creek and other unstressed North Carolina Piedmont streams. Data are the average of 3-4 collections, rounded to integer value.

Stream:	Cane	Bolin	Cates	UT Lanes	Long Br.	4-Mile
Group						
EPHEMEROPTERA	13	12	16	6	27	38
PLECOPTERA	3	5	9	3	4	14
ODONATA	-	-	1	-	1	1
TRICHOPTERA	50	70	3	14	25	10
COLEOPTERA	5	3	4	29	2	9
MEGALOPTERA	2	1	1	-	-	-
DIPTERA	20	8	61	45	39	27
MOLLUSCA	3	-	-	2	-	-
OLIGOCHAETA	2	-	2	1	1	-
CRUSTACEA	-	1	2	-	-	1
OTHER	2	-	1	-	-	-

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