AN INVESTIGATION OF THE STREAM INVERTEBRATE FAUNA AT PINEY FORK CREEK

BY

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AN INVESTIGATION OF THE STREAM INVERTEBRATE FAUNA AT PINEY FORK CREEK

A Research Paper

Presented to
the Graduate Council of
Austin Peay State University

In Partial Fulfillment
of the Requirements for the Degree
Master of Science

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by

Robert Paul Zimmerman

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To the Graduate Council:

I am submitting herewith a Research Paper written by Robert Paul Zimmerman entitled "An Investigation of the Stream Invertebrate Fauna at Piney Fork Creek." I recommend that it be accepted in partial fulfillment of the requirements for the degree of Master of Science, with a major in Biology.

Marvin M. Provo
Major Professor

Accepted for the Council:

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INTRODUCTION

Available information regarding factors influencing the distribution of stream invertebrate fauna in Tennessee is limited compared to other states. The only published research of this type in this state is a study by Hunt (1930) on the bottom invertebrate faunal relationships at Otter Creek near Nashville. An inventory of lakes, ponds, reservoirs, and streams of Montgomery County was conducted by the United States Department of Agriculture Soil Conservation Service in 1969, however, extensive research regarding invertebrate fauna and sediment analysis was lacking.

Statement of the Problem

The purpose of this study was: (1) to identify the stream invertebrate fauna at Piney Fork Creek, on the Fort Campbell Military Reservation; (2) to determine substrate-faunal relationships in pool and riffle communities at various locations along the stream; and (3) to ascertain the occurrence of longitudinal zonation of the invertebrate fauna relative to stream order.

Importance of the Study

The study is unprecedented in this geographical area and will aid the researcher by serving as a basis for subsequent investigation and provide a reference to students who wish to pursue a similar study of the local stream invertebrate fauna.

Limitations of the Study

The study was conducted from June through September 1974. The area of investigation was confined to Piney Fork Creek, one of the many tributaries found within the Red River Drainage System.

Summer faunal collections were taken at stations 01 through 04 (Figure 1.). During early fall, the water level at Rendevous Road (station 01) dropped considerably. To compensate for this unforseen circumstance, an alternate site (station 00) was established at Normandy Road. Thus, fall collections were taken from station 00 and 02 through 04.

The summer collections were not analyzed according to community (riffle and pool) makeup or bottom sediment analysis. The purpose of the earlier collections was general identification and familiarization with the invertebrate inhabitants at the given sampling locations. In the fall collections, these two factors were considered during field trips.

Invertebrate fauna collected during the summer included representatives from the neuston, plankton, and benthos, while fall samples consisted primarily of benthic representatives.

Nomenclature

Throughout this manuscript, scientific and common names of species follow Ward and Whipple's, Freshwater Biology, Pennak's, Freshwater Invertebrates of the United

States, and Usinger's, Aquatic Insects of California.

Literature Review

No information relative to stream invertebrate fauna in Piney Fork Creek is available, and the only published research in Tennessee is the previously mentioned study by Hunt (1930). However, numerous publications on other geographical areas are found in the literature, among which are: Carpenter (1927); Crisp and Crisp (1973); Cummins and Lauff (1969); Dodds and Hisaw (1924, 1925); Egglishaw and MacKay (1967); Gersbacher (1937); Harrel and Dorris (1968); Hynes (1971); Macan (1957); Macereth (1957); MacKay and Kalff (1969); Minckley (1963); Moon (1940); Noel (1954); Patrick (1970); Pennak (1971); Pennak and VanGerpen (1947); Percival and Whitehead (1929); Peterka (1969); Stehr and Branson (1938); Waters (1961, 1965); and White (1974).

DESCRIPTION OF THE STUDY AREA

Piney Fork Creek is a part of the Red River watershed within the Fort Campbell Military Reservation. The stream originates in Stewart County and flows in an easterly direction for approximately six miles to a point at where it enters Montgomery County. Within the latter county the stream continues its easterly flow for ten miles and empties into Little West Fork Creek. Mabry Road, Boiling Springs Road, Engineers Road, Palmyra Road, Grant Road, Ghost Corps Trail, Jordon Springs Road, Rendevous Road, and Normandy

Road cross the stream. The width of the stream bed averages approximately 15 feet, varying from four to 30 feet. The mean riffle depth is 1.5 inches, while the average depth of pools is two feet. At minimum flow, water is found only in the pool sections. The stream is dry an estimated three months during the year (USDA-SCS, 1969).

Soil Type

The soil is primarily Dickson-Mountview-Baxter Association; gently sloping to sloping, moderately well drained to well drained silty soils with some moderately steep cherty, clayey soils near drainage ways (Smith, 1974).

Ichthyological Fauna

The primary fish caught in this stream include *Micropterus salmoides* (Largemouth bass), *M. dolomieui* (Smallmouth bass), *Ambloplites rupestris* (Rock bass), *Pomoxis sp.* (Crappie), and *Lepomis macrochirus* (Bluegill) (USDA-SCS, 1969). According to Woodruff (1971) additional species represented in Piney Fork Creek are *Campostoma anomalum* (Stoneroller), *Pimephales notatus* (Bluntnose minnow), *Erimyzon oblongus* (Creek chubsucker), *Lepomis cyanellus* (Green sunfish), *Etheostoma caeruleum* (Rainbow darter), and *E. flabellare* (Fantail darter). Probable inhabitants include *Notropis ardens* (Rosefin shiner), *Semotilus atromaculatus* (Creek chub), *Lepomis megalotis* (Longear sunfish), and *Etheostoma spectabile* (Orange-throat darter).

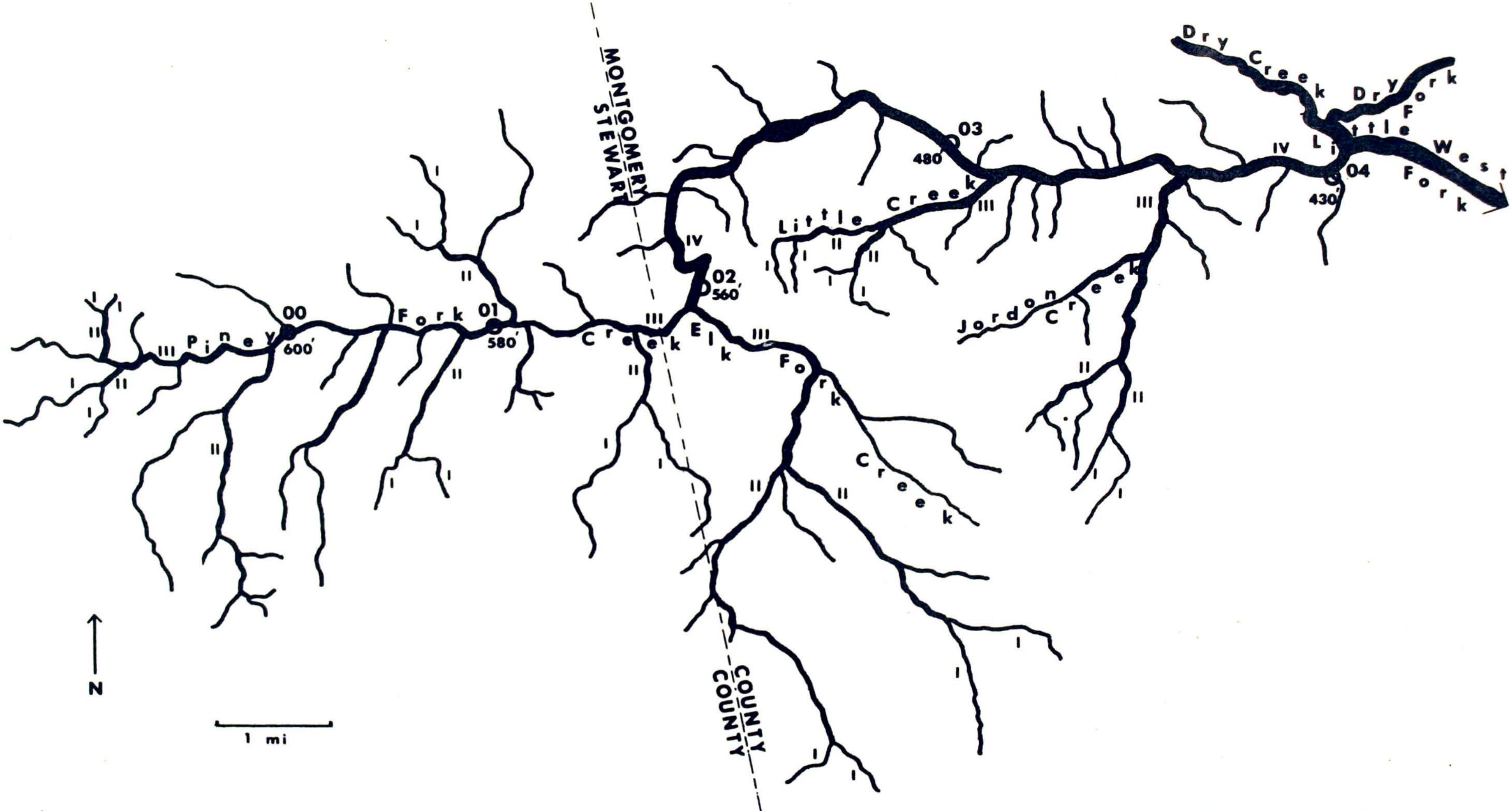

Figure 1. Stream pattern map of Piney Fork Creek, Montgomery and Stewart Counties, Tennessee. Circles and arabic numbers indicate invertebrate collection sites; roman numerals are used to illustrate Horton's method of ranking streams and represent stream order. Thickness of line varies with stream order

Morphometry

Morphometric data were taken from an aerial photographic map of Herndon, Kentucky, Sheet 345711, Series V741, prepared by the Army Map Service (KC), Corps of Engineers, U.S. Army, Washington, D.C. (1964), with a scale of 1:50,000.

Piney Fork Creek (Figure 1) is approximately 16 miles in length from source to mouth. The elevation is 600 feet at the source and 430 feet at the mouth, with an average gradient of 11.6 feet per mile. The stream pattern is dendritic (Reid, 1961).

According to the stream order system developed by Horton, 1945 (in Kuehne, 1962) and based on the comparative branching of stream subsections from source to mouth, Piney Fork Creek is a fourth order stream. The sampling sites established at Normandy Road and Rendevous Road are located on the earlier stretches of the stream and are of the third order. The stream becomes fourth order at its junction with Elk Fork Creek; the latter stream is also classified as third order. Since no other fourth order stream conjoins Piney Fork, the rank is maintained up to its mouth where it enters Little West Fork Creek. Two lower order streams, Little Creek and Jordon Creek, both third order, enter Piney Fork beyond its junction with Elk Fork Creek, but they do not influence the ranking. The three, downstream collection stations, Jordon Springs Road, Palmyra Road, and Boiling Springs Road, are located along the portion which is fourth order.

Description of Sampling Stations

General Characteristics. The five collection sites established along the stream course from source to mouth included Normandy Road (Station 00), Rendevous Road (Station 01), Jordon Springs Road (Station 02), Palmyra Road (Station 03), and Boiling Springs Road (Station 04).

Floral Cover over the respective sampling areas ranged from open, unshaded to densely shaded.

The size of riffle and pool bottom sediment varied from silt covering bedrock to large rock and included coarse sand, gravel, and small rock.

Generally, the riffle sections were narrower than the corresponding, downstream pool, at any given station. The width of the riffle stretches ranged from nine feet to 53 feet, while the pool widths varied from 15 to 50 feet. Riffle depths averaged 3.5 inches, and the mean depth of the pool sections was two feet. These linear measurements appear to contradict the figures presented in the publication by the USDA-SCS, 1969, however extremely high, abnormal precipitation during the study period resulted in greater measurements of width and depth.

Current velocity was negligible at all pools, but varied from 19 to 35 cm. per second at the riffle communities.

Normandy Road. A riffle section was not present at this station. The pool was 15 feet wide with a mean depth of eight inches. The bottom sediment consisted of small rock and gravel covering coarse sand. A large population of floating *Spirogyra sp.* and organic detritus covered the substratum. Vegetative cover over the pool and along the stream banks was negligible.

Rendevous Road. As in the first station, no riffle section was found at this location. The pool was approximately 18 feet wide and 18 inches deep. The bottom sediment included small rock, gravel and sand supporting submergent vegetation and including detritus. The stream and stream banks were virtually unshaded.

Jordon Springs Road. The riffle community was nine feet wide with a mean depth of four inches. The pool was 15 feet wide with an average depth of 15 inches. Current velocity at the riffle was 19 cm. per second. The bottom mineral matter at the riffle included small rock in the middle of the bed with small rock and gravel near either bank. Floral cover along the banks was dense, and both communities were shaded. Pool bottom sediment consisted of small rock and gravel covering coarse sand with a layer of organic detritus.

Palmyra Road. As to bottom mineral matter, the riffle section of this station may be divided, laterally, into two distinct communities. The bottom sediment of one section included large and small rock covering gravel; the adjacent stretch consisted of bedrock with eroded joint plains interrupted by small rock. The latter community contained irregularly scattered islands of rooted, aquatic vegetation. The width of the entire riffle was approximately 55 feet with an average depth of three inches at the stony section and five inches at the other stretch. The pool section was 42 feet wide and had a mean depth of 16 inches. The bottom sediments consisted of small rocks and solid rock fragments were sparsely strewn throughout the community. Both riffle and pool were virtually unshaded. Young Sycamore, Platanus occidentalis, were distributed along the stream banks, and a patch of rooted, aquatic vegetation was located in the anterior littoral of the pool. The current velocity of the riffle was 22 cm. per second.

Boiling Springs Road. The current velocity at the riffle was 35 cm. per second, the highest for the three riffles studied. The width was 20 feet with a mean depth of four inches. The sediment consisted of small rock and gravel. The pool area was approximately 50 feet wide and 12 inches deep. The substrate was composed of solid rock slabs covered with a thin layer of silt, alternating with areas of small rock and gravel that were covered with detritus. Vegetation along the banks was moderate; both communities were sparsely shaded.

METHODS AND MATERIALS

Physical Data

The mean width and depth were calculated at pool and riffle communities from each station. Current velocity was determined by the Surface-Float Method as outlined by Welch (1948) and modified by Robins and Crawford (1954). Since current velocity was negligible within the pool sections, only the riffle was considered.

Sediment analysis was based on the classification used by Hunt (1930). Five different categories were used to describe the mineral material: (1) solid rock; (2) large rock, greater than six inches; (3) small rock, less than six inches but more than 1.5 inches; (4) gravel, less than 1.5 inches but more than one-eighth inch; and (5) coarse sand, 0.5 to two millimeters. Particle size was determined by mere observation and cursory examination. At each stream community a substrate sample was extracted with a conventional shovel and visually analyzed.

Stream order was determined according to the classification by Horton (1945); ultimate headwaters or the smallest unbranched tributaries of a drainage basin are considered to be order one, and the union of two such units form a segment of the next higher order. Rank is not increased by the entrance of lower order units (Kuehne, 1962).

Biological Data

Collecting. The Stratified Random Sample Method was used for all collections. This procedure involves the selection of habitat types such as riffle and pool with the application of random sampling to each community (Cummins, 1962).

The Surber-Bottom-Sampler was used to collect the benthic invertebrate fauna in both riffle and pool communities (Welch, 1948). In the pool sections a plankton dip net and an insect net were also used to secure samples. The latter was improvised as a drag net and provided turbulence and agitation when used in conjunction with the Surber-Bottom-Sampler.

Separation, Preservation, and Identification. During the summer no sophisticated procedure for separation of organisms from mineral matter was attempted. The fall fauna were separated from mineral debris by a floatation method with carbon tetrachloride as outlined by Whitehouse and Lewis (1966).

Unlike the fall samples, summer collections were not preserved in the field. The latter were identified, when possible, in a live state. Occasionally, it was necessary to kill, fix, and preserve organisms to facilitate identification. Larger fauna were immersed in ten percent formalin or 70-80 percent alcohol, while smaller, live invertebrates were mounted on slides. All collection bottles and slides, each with its individual, preserved specimen, were labeled according to major taxon, scientific name, and collection site.

Taxonomic keys used to identify the fauna included Pennak's Freshwater Invertebrates of the United States, Ward and Whipple's Freshwater Biology, and Usinger's Aquatic Insects of California.

RESULTS

Sixty-two different aquatic invertebrate animals representing six phyla were found in Piney Fork Creek. A list of these forms, their distribution, and stage of development is given in Table I. The phyla, Platyhelminthes

Invertebrate Fauna	Stage	Season	
		Summer	Fall
Ephemeroptera			
Stenonema sp.	L	all stns.	all stns.
Heptagenia sp.	L		04
Baetis sp.	L	02,03,04	all stns.
Centroptilum sp.	L	04	02
Choroterpes sp.	L	01,02,03	02,03,04
Brachycercus sp.	L	03	00,03
Habrophlebiodes sp.	L	01,03	02,03
Neocloeon sp.	L		02
Plecoptera			
Claassenia sabulosa......	L	04	02,03
Brachyptera sp.	L		00
Acroneuria sp.	L	04	
Trichoptera			
Cheumatopsyche sp.	L	04	02,04
Polycentropus sp.	L	02,04	
Diptera			
Tabanus sp.	L	03	
Tanypodinae	L,P	01,03,04	all stns.
Chironominae	L,P	01,02,04	all stns.
Mansonia sp.	L	04	
Anopheles sp.	L	01	
Coleoptera			
Hexacylloepus sp.	L	02,03	02,03,04
Optioservus sp.	L	04	04
Psephenus herricki	L	03	03
Chrysomelidae	A	04	
Dytiscidae	A	04	
Elmidae	A	01,04	03,04
Odonata			
Lanthus sp.	L		03
Neoneura sp.	L	01	
Argia/Hyponeura sp.	L		03
Hemiptera			
Gerris remiges	A	all stns.	
Pentacora sp.	A	01	
Veliidae	A		04
Glaenocorisa sp.	A	04	
Trichocorixa reticulata .	A	04	
Megaloptera			
Corydalus cornutus	L	03	

Table I. Total Invertebrate Fauna collected during summer and early fall, 1974, at Piney Fork Creek. A= Adult, L= Larva, I= Immature, and P= Pupa.

Invertebrate Fauna	Stage	Season	
		Summer	Fall
Hydracarina			
Unidentified............	A	all stns.	all stns.
Amphipoda			
Hyalella azteca	A,I	01,03	00,04
Gammarus fasiatus	A,I	04	
Isopoda			
Lirceus sp.	A	04	
Decapoda			
Orconectes propinquus ...	A,I	all stns.	all stns.
Orconectes immunis	A	04	
Gastropoda			
Pleurocera sp.	A	03	03
Goniobasis sp.	A	03	03
Physa gyrina	A	04	
Lymnaea sp.	A	03	
Gyraulus sp.	A	01	
Pelecypoda			
Unidentified	A	03	02,03
Ostracoda			
Limnocythere sp.	A	01	
Copepoda			
Cyclopidae	A	03,04	02
Macrocyclops sp.	A	01	
Macrocyclops albidus	A	02	00,02
Eucyclops agilis	A	02	
Cladocera			
Simocephalus vetulus	A	03,04	
Simocephalus exspinosus..	A		00
Pleuroxus denticulatus...	A	04	
Pleuroxus striatus	A	01,02	
Chydorus sp.	A	01	
Bosmina longirostris	A	01	
Rotatoria			
Euchlanis dilitata	A	03,04	
Lecane sp.	A	04	
Oligochaeta			
Aeolosoma sp.	A	02	02,04
Naididae	A		02
Hirudinea			
Piscicola sp.	A	03	
Platyhelminthes			
Planariidae............	A	02	
Coelenterata			
Chlorohydra viridissima..	A	02	

Table I. Continued

and Coelenterata, were represented by one species each. Other major taxonomic groups, represented by a few individuals, included Aschelminthes, Molluska, and Annelida with 2, 6, and 3 members, respectively. Forty-nine genera of the total fauna collected belong to the Phylum Arthropoda. Of this number, 16 are crustaceans, one belongs to the Class Arachnida, and the remaining 32 fauna are insects representing eight different orders. It is apparent from cursory observation that this phylum, especially the crustaceans and the insects with aquatic, immature stages, comprised the greater part of the stream invertebrate fauna.

Summer Fauna

The summer samples were taken irrespective of community makeup and sediment classification. The most abundant organisms during this season included representatives from the orders, Ephemeroptera, Diptera, Coleoptera, and Decapoda (Table II). The mayfly nymph, *Stenonema sp.*, was found at all stations at high relative densities. *Baetis sp.* and *Choroterpes sp.* were also collected at three of the four collecting sites but less frequently. Only the larvae of one genus of caddisfly, *Cheumatopsyche*, was collected in abundance, and this population was found at station 04. The subfamilies, Tanypodinae and Chironominae, members of the Order Diptera, were abundant at most stations. The former did not occur at station 03, while the latter was absent

Invertebrate Fauna	Station Number			
	01	02	03	04
Ephemeroptera				
Stenonema sp.	A	A	A	A
Baetis sp.		F	F	F
Choroterpes sp.	F	F	F	
Centroptilum sp.				R
Habrophlebiodes sp.	R		R	
Brachycereus sp.			R	
Plecoptera				
Acroneuria sp.				F
Claassenia sabulosa				F
Trichoptera				
Cheumatopsyche sp.				A
Polycentropus sp.		R		R
Diptera				
Tabanus sp.			R	
Tanypodinae	A	A		A
Chironominae	A		A	A
Mansonia sp.				R
Anopheles sp.	F			
Coleoptera				
Hexacylloepus sp.		A	A	A
Psephenus herricki			R	
Chrysomelidae				R
Dytiscidae				R
Odonata				
Neoneura sp.	R			
Hemiptera				
Pentacora sp.	R			
Glaenocorisa sp.				F
Trichocorixa reticulata				F
Gerris remiges	F	F	F	F
Megaloptera				
Corydalus cornutus			R	
Hydracarina				
Unidentified	R	R	R	R
Amphipoda				
Hyalella azteca	R		F	
Gammarus fasciatus				F
Isopoda				
Lirceus sp.				R

Table II. General Distribution and Relative Density of the Invertebrate Fauna collected from summer samples at Piney Fork Creek. Collections were taken from the benthos, plankton and epineuston. A=Abundant, F=Frequent, and R=Rare.

Invertebrate Fauna	Station Number			
	01	02	03	04
Decapoda				
Orconectes propinquus	A	A	A	A
Orconectes immunis				R
Gastropoda				
Gyraulus sp.	R			
Physa gyrina				R
Pleurocera sp.			A	
Goniobasis sp.			A	
Lymnaea sp.			R	
Pelecypoda				
Unidentified			R	
Ostracoda				
Limnocythere sp.	R			
Copepoda				
Macrocyclops sp.	F			
Macrocyclops albidus		F		
Eucyclops agilis		F		
Cladocera				
Simocephalus vetulus			F	F
Pleuroxus denticulatus				R
Pleurosux striatus.................	F	F		
Chydorus sp.	R			
Bosmina longirostris	R			
Rotatoria				
Euchlanis dilitata			F	F
Lecane sp.				R
Oligochaeta				
Aeolosoma sp.		F		
Hirudinea				
Piscicola sp.			R	
Platyhelminthes				
Planariidae		F		
Coelenterata				
Chlorohydra viridissima		R		

Table II. Continued

from station 02. Only one genus from the Order Coleoptera was collected in abundance during the summer. Larvae of the aquatic beetle, Hexacylloepus, were taken at all stations except Rendevous Road, where a riffle section did not exist. This genus belongs to the Family Elmidae (Riffle Beetles). Representatives of the Order Plecoptera appeared only at station 04. The two "species" generally encountered were Acroneuria sp. and Claassenia sabulosa. Aquatic hemiptera, taken from the neuston, included Pentacora sp. (station 01), Glaenocorisa sp. and Trichocorixa reticulata (station 04), and Gerris remiges observed at all stations. Two other groups demonstrating significant representation in the summer samples included the orders, Decapoda and Gastropoda. The former was represented by the crayfish, Orconectes propinquus, while the latter included the genera, Pleurocera and Goniobasis. The decapod was taken, frequently, at all sampling areas, but aquatic snails were restricted in distribution to station 03. Other crustaceans frequently encountered were Hyalella azteca (station 03), Gammarus fasciatus (station 04), Macrocyclops sp. (station 01), M. albidus and Eucyclops agilis (station 02), Simocephalus vetulus (stations 03 and 04), and Pleuroxus striatus (stations 01 and 02). The rotifer, Euchlanis dilitata was collected frequently, at stations 03 and 04, while the annelid, Aeolosoma sp. and members of the Family Planariidae (Platyhelminthes) were found periodically in collections at station 02. Other fauna demonstrating rare occurrence are listed in table II.

Fall Fauna

Riffle Community. Generally, in this study, the most abundant organisms found within the riffle communities at the three stations where riffles were present, belong to three insect orders: Ephemeroptera, Diptera, and Coleoptera (Table III). The mayfly nymphs, Stenonema sp. and Baetis sp., were collected at all riffles. The former genus was abundant at all stations, while the latter was abundantly distbributed at station 04 but only frequently at the other two stations. Choroterpes sp. was periodically collected at all stations but was absent from both the solid rock substrate at station 03 and samples taken near the bank at station 04. The two dipteran subfamilies, Tanypodinae and Chironominae, were, as in the summer, relatively abundant at all stations with the exception of station 03 where they were occasionally found. Aquatic beetle larvae of the genus, Hexacylloepus, were taken in appreciable numbers at station 03 within the stony riffle community and at station 04 near the bank and within the mid-riffle section. The only other members of this order taken in samples were Optioservus, abundant at station 04 and Psephenus herricki, rare at station 03. The only snail population to be found at the sampling stations along this stream occurred at station 03. Both riffle sub-communities, the stony bottom and the solid rock substrate, were well represented by gastropod fauna. Goniobasis sp. was

Benthic Invertebrate Fauna	Stn. 02		Stn. 03		Stn. 04	
	near bank	mid-rif.	stony rif.	solid rock	near bank	mid-rif.
Ephemeroptera						
Stenonema sp.	A	A	A	A	A	A
Baetis sp.	F	F	F	F	A	A
Centroptilum sp.	R					
Choroterpes sp.	F	F	F			F
Neocloeon sp.	R					
Habrophlebiodes sp.		R	R			
Brachycercus sp.			R	R		
Heptagenia sp.					R	
Plecoptera						
Claassenia sabulosa		F	R		F	
Trichoptera						
Cheumatopsyche sp.	F				A	A
Diptera						
Tanypodinae	A	A	A	R	A	A
Chironominae	A	A	A	R	A	A
Coleoptera						
Hexacylloepus sp.	F	F	A		A	A
Optioservus sp.					A	A
Psephenus herricki			R			
Odonata						
Argia/Hyponeura sp.			R			
Hemiptera						
Veliidae					R	
Hydracarina						
Unidentified		R	R	R		R
Amphipoda						
Hyalella azteca						F
Gastrapoda						
Pleurocera sp.			A			
Goniobasis sp			A	A		
Pelecypoda						
Unidentified		R	F			
Copepoda						
Cyclopidae	F					
Macrocyclops albidus		F				
Oligochaeta						
Aeolosoma sp.	F		F		F	
Naididae	R					
Decapoda						
Orconectes propinquus ...	F	F	A	R	F	F

Table III. Distribution and Relative Density of Benthic Macro-invertebrates taken during fall collections in riffle communities at Piney Fork Creek.

prominent in both riffle sections, while *Pleurocera sp.* was collected only from the stony riffle. Caddisfly larvae appeared less frequently in the fall collections. *Cheumatopsyche* was the only form found and appeared in only three of the six riffle sub-communities sampled. These larvae were abundant at station 04 and frequently observed in samples taken near the bank at station 02. The oligochaete, *Aeolosoma sp.*, was collected in small numbers at all stations; near the bank at station 02 and 04 and from the stony riffle at station 03. Other invertebrates with rare occurrence in the fall samples are included in Table III.

Pool Community. The pool communities sampled at stations 02, 03, and 04 (Table IV) were surprisingly similar in faunal types to the corresponding, upstream riffle at each station. The pool at station 00 contained benthic invertebrates which were comparable, taxonomically, to the forms found at the other pool communities, although a few were peculiar to that location. *Stenonema*, *Baetis*, and *Choroterpes* were found in large numbers at stations 02, 03, and 04. *Choroterpes* was absent from samples at station 00, however a few individuals of the genus, *Brachycercus*, were collected. Larvae of the midges (Tanypodinae and Chironominae) were present at all collection sites but in lower numbers. The coleopteran, *Hexacylloepus*, was absent from stations 00 and 04, and *Optioservus* was collected only at station 04. Population densities of these beetle larvae were high at the two locations.

Benthic Invertebrate Fauna	Station Number			
	00	02	03	04
Ephemeroptera				
Stenonema sp.	A	A	A	A
Baetis sp.	F	F	F	F
Choroterpes sp.		F	F	F
Brachycercus sp.	R			
Plecoptera				
Brachyptera sp.	R			
Trichoptera				
Chuematopsyche sp.		F		
Diptera				
Tanypodinae	F	F	F	A
Chironominae	F	F		F
Coleoptera				
Hexacylloepus sp.		A	A	
Optioservus sp.				A
Odonata				
Lanthus sp.			R	
Hemiptera				
Pentacora sp.				R
Hydracarina				
Unidentified	R			
Amphipoda				
Hyalella azteca	R			
Gastrapoda				
Goniobasis sp.			A	
Pleurocera sp.			A	
Pelecypoda				
Unidentified			R	R
Decapoda				
Orconectes propinquus	F	F	F	F
Copepoda				
Macrocyclops albidus	F			
Cladocera				
Simocephalus sp.	F			
Oligochaeta				
Aeolosoma sp.		F		F

Table IV. Distribution and Relative Density of Benthic Macro-invertebrates taken during fall collections in pool communities at Piney Fork Creek.

Three other insect forms were collected, each at one station only; an odonaton, _Lanthus_ sp. at station 03; an hemipteran, _Pentacora sp_. at station 04; and a tricopteran, _Cheumato-psyche sp_. at station 02. The first two genera appeared rarely in samples, and the caddisfly was frequently encountered. The crayfish, _Orconectes propinquus_, was well distributed at all sampling locations within the pool areas. The gastropod fauna at station 03 was considerably less dense in the pool section, but the relative density was significantly high compared to the other invertebrate fauna. Other invertebrates prominent at given locations included the crustaceans, _Macrocyclops albidus_, _Simocephalus sp_., and _Hyalella azteca_, a few unidentified pelecypods, and the oligochaete, _Aeolosoma sp_.

Longitudinal Zonation, Species Diversity, and Stream Order

Table V shows a fairly, steady change in the faunal composition (longitudinal or altitudinal zonation) as the watercourse descends from 600 to 430 feet. This is accomplished by the addition and replacement of species from source to mouth. The number of species collected at each station successively increased from 11 (station 00) to 34 (station 04). Thus, as demonstrated by other authors (Kuehne, 1962; Harrel and Dorris, 1968; MacKay and Kalff, 1969; and Hynes, 1971), species diversity increases longitudinally, in a downstream direction.

Likewise, the number of species increases with

Station Altitude (ft.)		00 600	01 580	02 560	03 480	04 430
Group	"Species"					
Ephemeroptera	*Stenonema*	*	*	*	*	*
Ephemeroptera	*Baetis*	*		*	*	*
Ephemeroptera	*Brachycercus*	-			-	
Plecoptera	*Brachyptera*	-				
Diptera	Tanypodinae	*	*	*	*	*
Diptera	Chironominae	*	*	*	*	*
Hydracarina	Unidentified	-	-	-	-	-
Amphipoda	*Hyalella azteca*	-	-		*	*
Decapoda	*Orconectes propinquus*	*	*	*	*	*
Copepoda	*Macrocyclops Albidus*	*	*	*		
Cladocera	*Simocephalus*	*			*	*
Ephemeroptera	*Choroterpes*		*	*	*	*
Ephemeroptera	*Habrophlebiodes*		-	-	-	
Diptera	*Anopheles*		*			
Odonata	*Neoneura*		-			
Hemiptera	*Pentacora*		-			-
Hemiptera	*Gerris remiges*		*	*	*	*
Gastropoda	*Gyraulus*		-			
Ostracoda	*Limnocythere*		-			
Cladocera	*Pleuroxus*		*	*		-
Cladocera	*Chydorus*		-			
Cladocera	*Bosmina Longirostris*		-			
Ephemeroptera	*Centroptilum*			-		-
Ephemeroptera	*Neocloeon*			-		
Trichoptera	*Cheumatopsyche*			*		*
Trichoptera	*Polycentropus*			-		-
Coleoptera	*Hexacylloepus*			*	*	*
Copepoda	*Eucyclops agilis*			*		
Oligochaeata	*Aeolosoma*			*	*	*
Aligochaeata	Naididae			-		
Tricladida	Planariidae			*		
Coelenterata	*Chlorohydra viridissima*			-		
Pelecypoda	Unidentified			-	-	-
Diptera	Tabanus			-	-	-
Coleoptera	*Psephenus herricki*				-	
Megaloptera	*Corydalus cornutus*				-	
Gastropoda	*Pleurocera*				*	
Gastropoda	*Goniobasis*				*	
Gastropoda	*Lymnaea*				-	

Table V. Longitudinal Zonation of the Invertebrate Fauna at Piney Fork Creek. Stations 00 and 01 represent early fall and summer samples, respectively, while stations 02 through 04 include both summer and early fall collections. A dash (-) denotes the presence of a species, and an asterick (*) represents frequent or abundant distribution.

Station / Altitude (ft.)		00 / 600	01 / 580	02 / 560	03 / 480	04 / 430
Group	"Species"					
Rotatoria	*Euchlanis dilitata*				*	*
Hirudinea	*Piscicola*				-	
Plecoptera	*Claassenia sabulosa*				-	*
Odonata	*Argia/Hyponeura*				-	
Odonata	*Lanthus*				-	
Decapoda	*Orconectes immunis*					-
Gastropoda	*Physa gyrina*					-
Rotatoria	*Lecane*					-
Coleoptera	*Optioservus*					*
Ephemeroptera	*Heptagenia*					-
Coleoptera	*Veliidae*					-
Coleoptera	Chrysomelidae					-
Coleoptera	Dytiscidae					-
Plecoptera	*Acroneuria*					-
Diptera	*Mansonia*					-
Hemiptera	*Glaenocorisa*					*
Hemiptera	*Trichocorixa reticulata*					*
Amphipoda	*Gammarus fasciatus*					*
Isopoda	*Lirceus*					-

Table V. Continued

increasing stream order (Kuehne, 1962 and Harrel and Dorris, 1968). At Piney Fork Creek, samples from stations 00 and 01, stream order three, contained 22 different genera, while collections at stations 02 through 04, stream order four, included 51 "species".

DISCUSSION AND CONCLUSIONS

According to Odum (1953) streams generally exhibit two major habitats, rapids (riffles) and pools. Thus, two general stream community types may be considered. Within these broad categories, the type of bottom, whether sand, pebbles, clay, bedrock or rubble, is a significant factor in determining the nature of the community and population density of its inhabitants. Percival and Whitehead (1929) were the first stream ecologists to investigate the relationship between benthic distribution and the nature of the substrate. They recognized seven basic substrate types and found certain animal species consistently associated with each. Hunt (1930) also recognized the importance of substrate type in determining the distribution of stream benthos. Pennak and VanGerpen (1947) visually recognized four substrate types in a Colorado trout stream and described the benthic fauna associated with each. Cummins and Lauff (1969) related that substrate particle size or food supply exert primary distributional influences for macroinvertebrate fauna. Furthermore, the authors suggested that, in many cases, substrate particle size may serve as a common denominator in benthic stream ecology. Odum (1953) suggested that current is a major, limiting factor in rapids, but the hard bottom, especially if composed of stones, may offer favorable surfaces for attachment. The soft, continually shifting bottom of pool areas generally limits smaller benthic organisms to burrowing forms, but the deeper, slower water is more favorable for nekton, neuston, and plankton. The number of species able to live in any one habitat is proportional to the number of potential microhabitats in that environment (MacKay and Kalff, 1969). Generally, sand is the least favorable sediment type and supports the smallest number of species and individuals of benthic organisms. Clay bottom is more favorable than sand; flat or rubble rocks produce the largest variety and highest density of bottom organisms. However, MacKay and Kalff, 1969, state that leaf habitats are the most diversified relative to numbers of species. Usually, benthic invertebrates have a higher density in riffle communities, whereas stream nekton and burrowing forms, i.e. clams, burrowing Odonata and Ephemeroptera are more abundant in pool communities.

Benton and Werner (1958) state that midge larvae (Chironomidae) and the water penny (Psephenidae) are common in swift water. Certain snails and crayfish are among the larger invertebrates of the fast-water community, and flatworms (Turbellaria) and larvae of such insect groups as the Ephemeroptera, Plecoptera, and Odonata make the stony habitat of the bottom their home. Animals of the slow stream are more varied than in swift water and include greater numbers of large species. Yet, the bottom fauna may not be more numerous; for without stones, suitable dwelling places, except for burrowing forms, are lacking. Snails, clams, bryozoans, amphipods, leeches, crayfish, and aquatic earthworms may be present, as well as many insects, both larvae and adult.

Distribution of Piney Fork Fauna by Groups

Ephemeroptera. Pennak and VanGerpen (1947) suggested that this order is adapted to a wide range of current speeds and exposure in stream habitats. According to Reid (1961) mayfly nymphs are common inhabitants of most streams that contain sufficient oxygen. Smith (1966) related that the non-burrowing forms are peculiar to swift water (greater than 50 cm/sec), however current velocities did not exceed 35 cm/sec at Piney Fork Creek. The Ephemeroptera was the most diversified group represented in samples and appeared in all riffle and pool communities. Densities were higher in the former. Minckley (1963) related that this order is more characteristic of riffle sections.

Stenonema. Hynes (1970) stated that this genus, due to its flat morphology, lives in stony streams but on unexposed surfaces. According to Reid (1961), Stenonema is usually found wherever there is some water movement. Crisp and Crisp (1973) found it more numerous in riffles than in pools. In a study by Pennak and VanGerpen (1947), Stenonema was rare on rubble and coarse sand riffles. At Piney Fork Creek, Stenonema was abundant in pool and riffle communities, on all substrates. Highest densities appeared on gravel and small rock riffles.

Baetis. Pennak and VanGerpen (1947) found this form in abundance on rubble and gravel, and bedrock. According to Reid (1961) and Hynes (1970), Baetis is a widespread stream inhabitant, especially on stony substrates. According to Macan (1963), Baetis has been found in streams with current velocities of ten to 182 cm/sec, and specimens have been collected within a range of 15 to 60 cm/sec. During the present study, Baetis was collected, frequently, at all stations, both pool and riffle areas. Since this form is common in stream drift (Peterka, 1969 and Waters, 1961, 1965), its presence in pool communities is anticipated.

Choroterpes. This genus was the only other significant member of the Ephemeroptera collected at Piney Fork Creek. This form was frequently taken in collections at riffle and pool areas.

Other Ephemeroptera. Several additional genera including Brachycercus, Centroptilum, Habrophlebiodes, Heptagenia, and Neocloeon were collected in rare numbers. Centroptilum was found on the riffle edge at station 02. According to Hynes (1970), this form is numerous on stony substratum.

One individual of Heptagenia was taken from the edge of the small rock and gravel riffle at station 04. Hunt (1930) found Heptagenia abundant, on large rock riffles and solid rock bottom pools. Heptagenia has been found in current velocities no greater than 28 cm/sec (Macan, 1963).

Plecoptera. Reid (1961) and Smith (1966) relate that stoneflies are characteristic of swift water communities. Hunt (1930) found this order in riffle areas with free, rock bottoms, especially large rock. According to Pennak and VanGerpen (1947), plecopteran nymphs are confined to the undersurfaces and lateral aspects of rubble and gravel. The authors contend that exposed bedrock, coarse gravel, and coarse sand in a Colorado trout stream were not suitable for representatives of this order. During the present investigation, plecopteran nymphs were found, frequently, in the riffle at station 04, but were virtually absent from other sample sites.

Acroneuria. Crisp and Crisp (1973) found this form, typically, in riffle communities, although a few individuals were collected from pools. In Piney Fork Creek, Acroneuria was found at station 04 in a small rock and gravel riffle. White (1974) observed this genus throughout the year in riffles of Brashear's Creek, Kentucky.

Brachyptera. The stonefly nymph was taken at one station, the pool community at Normandy Road. Brachyptera fasciata was collected by White (1974) from the riffles of Brashear's Creek where the water was deep and relatively slow.

Claassenia sabulosa. This species was the most prominent representative of the Plecoptera collected at Piney Fork Creek. This insect larva was found in the riffles at stations 02 through 04 and was absent from all pool communities.

Trichoptera. According to Dodds and Hisaw (1925), caddisfly larvae have successfully invaded waters of all swiftness from stagnant pools to mountain torrents. Absence of portable cases must be considered an adaptation to swift waters. Minckley (1963) discovered that trichopterans were negligible in silty to sandy pools but were present in significant numbers in riffles and plant beds. Smith (1966) reported that caddisfly larvae are characteristic of bedrock and swift water. Pennak and VanGerpen (1947) while investigating a trout stream in Colorado, found this order surprisingly low; coarse sand and gravel had only negligible populations. Hunt (1930) found Hydropsychidae characteristic of the rapids community, especially at shallow depths. He found this family far more abundant on solid rock bottoms than any other type.

During the present study, *Cheumatopsyche* was taken primarily from riffle sections, while *Polycentropus* was collected rarely in this habitat. During a study of the Susaa River (Macan, 1963), *Polycentropus* was found in stretches with gravel, sand, and occasionally, stone bottoms, and in current of slight to moderate velocity (10-50 cm/sec).

Diptera. Two subfamilies, Chironominae and Tanypodinae, of the Family Chironomidae, were highly represented at all stations along Piney Fork Creek. Minckley (1963) reported that dipteran larvae may be found in significant numbers at riffles, pools, and in plant beds. According to this author, percentage composition increases downstream. Smith (1966) suggested that the optimum substrata for larvae of this order are bedrock and gravel. Hunt (1930) found chironomids more abundant on solid rock riffles. They were also abundant on large rock bottoms and slightly distributed in small rock riffles. In the pool communities of Otter Creek, this family was prevalent on solid rock bottoms but relatively scarce on other sediment types. Densities were higher in shallow water. Stehr and Branson (1938), during their investigation of an intermittent stream in Ohio, reported that the larvae of true midges were far more abundant in riffle sections than in pools. The Chironomidae collected by Crisp and Crisp (1973) were peculiar to the riffle areas with small rubble and a few large rocks.

Chironominae. At Piney Fork Creek this group was collected in significant numbers from all substrata except solid rock. Pennak and VanGerpen (1947) found these forms to be highly concentrated on coarse sand, abundant on coarse gravel and rare on rubble and bedrock. During a study of West Creek in Quebec, MacKay and Kalff (1969) reported that this group was numerically important in the detritus at all seasons of the year. Pennak (1953) related that the majority of the Chironominae occur in sluggish streams, ponds, and lakes.

Tanypodinae. In Piney Fork Creek, the distribution of this group was similar to that of the Chironominae. In a stream near Madison, Wisconsin, Cook (1965) found this group most frequently in shallow, mud bottoms. Pennak (1953) stated that representatives of this subfamily occur in a variety of habitats.

Other Diptera. Less important representatives of this order included the larva of the horsefly, *Tabanus*, and *Anopheles* and *Mansonia*, both members of the mosquito family (Culicidae). A single larva of *Tabanus* was collected at station 03 during the summer. Gersbacher (1937) reported a few larval tabanids from a lower, sandy bottom stretch and muddy bottoms in Illinois streams. Only a few species of this genus occur in swift water (Pennak, 1953). *Anopheles* was collected frequently from the pool section at station 01. This genus was absent at all other sites. According to Stehr and Branson (1938), the culicids are characteristic of upstream habitats and are more frequent in sandy bottom pools (Reid, 1961). Pennak (1953) noted that *Anopheles* is usually found in all types of nonstagnant water, from small puddles to streams. One specimen of *Mansonia* was taken from samples at station 04.

Coleoptera. Of the 13 families found in freshwater habitats, only four were collected at Piney Fork Creek;

Elmidae, Psephenidae, Dytiscidae, and Chrysomelidae.

Elmidae. Larvae of the riffle beetle were the most abundant organisms from this order taken during the present study.

Hexacylloepus and *Optioservus* were collected from small rock and gravel sediments. The former appeared frequently, if not abundantly, in most riffles and was collected at two of the five pools sampled. As reported by Hynes (1971), this form was prevalent at the middle and lower stretches of the stream.

Optioservus was peculiar to station 04, occurring in both stream communities. Hunt (1930) considered the riffle beetle characteristic of riffle bottoms covered with free rock, especially the large rock type. He found pool areas to be virtually devoid of this form. In a Colorado trout stream, adult and larval elmid beetles were found to be most densely populated on rubble with only a few individuals taken from gravel bottoms; they were negligible on bedrock and absent on sand (Pennak and VanGerpen, 1947). In Lander Springbrook, New Mexico, Noel (1954) found large populations in a section with rubble sediment and swift current.

Psephenidae. These organisms commonly occur on rocky or gravel bottoms along wave-swept shores and in streams where the water is shallow and swift (Pennak, 1953). A few individuals of *Psephenus herricki* were collected at station 03 in the riffle section. According to Smith (1974), this species is characteristic of swift streams (current velocity greater than 50 cm/sec). In a study of a West Indian stream, Hynes (1971) reported this species from the middle and lower reaches. Crisp and Crisp (1973) found Psephenus abundant in riffle areas and rare in pools. Individuals appeared to be peculiar to rubble riffles.

Chrysomelidae and Dytiscidae. One adult specimen belonging to the Family Chrysomelidae (leaf beetles) was collected during the summer at station 04. However, Pennak (1953) contends that there are no true aquatic adults and only a few semiaquatic species in this family. A solitary adult diving beetle (Dytiscidae) was taken in a summer sample at station 04. This family occurs in the shallow bays and small inlets of lakes and requires a clean substrate and aquatic vegetation. Few species inhabit muddy bottoms, rapid water, or springs (Pennak, 1953). During the summer, this family becomes more abundant (Hunt, 1930). Stehr and Branson (1938) found this family to be characteristic of sandy pools and rocky riffles during the summer and fall.

Odonata. This order was virtually absent from most stations at Piney Fork Creek. During early fall, Argia/Hyponeura was collected from the riffle and Lanthus from the pool at station 03. A single specimen of Neoneura was taken from the pool at station 01. Adult representatives of the Family Coenagrionidae and Calopteryx maculata, the black-winged damselfly, were observed in abundance during the summer at station 03. Smith (1966) considers this order characteristic of the pool community. Hunt (1930) collected one individual of Argia from a large rock bottom in a shallow pool of Otter Creek. Crisp and Crisp (1973) found one specimen of this order at an upstream station in a rubble riffle. During a study of a West Indian stream, Hynes (1971) found Argia present at all stations along the stream course but more dense in the middle stretches. Wright (1943) reported several nymphs of this genus from solid rock slabs in creeks near Nashville.

Hemiptera. Representatives of four families from this order were found at Piney Fork Creek; Gerridae (water striders), Corixidae (water boatmen), Veliidae (ripple bugs), and Saldidae (shore bugs). All families, except a single member of the Saldidae, were collected from station 04. Hunt (1930) reported that in a creek near Nashville the density of these families increase during the summer. Stehr and Branson (1938) found corixids and water striders characteristically in pools but suggested their probable occurrence in rocky riffles. These forms were taken from the middle and lower sections of an intermittent stream in Ohio. According to Smith (1966), water boatmen and water striders are peculiar to slow streams. Pennak (1953) related that corixids occur everywhere along the bottom in the shallows of ponds, lakes and streams, while ripple bugs occur chiefly in or near the ripples and rapids of small streams. Pentacora, a saldid, was collected during the summer from the pool at station 01. Borror and White (1970) state that shore bugs are common along grassy shores and banks.

Amphipoda. Minckley (1963) found members of this group abundant in plant beds and bare riffles, and low in rubble riffles and silty to sandy pools. Stehr and Branson (1938) considered the Gammaridae as fauna peculiar to the middle and lower reaches in rock bottom pools. During the present study, *Hyalella azteca* was collected from four of the five sampling stations in both riffle and pool sections but was more dense at the lower segments. Reid (1961) related that *H. azteca* is a common inhabitant of southern lakes and streams in North America. Noel (1954) in a study of a New Mexico springbrook found *Gammarus fasciatus* at all sampling sites even though there was great variation in substrate type and current velocity. This species occurred only at station 04 during the summer at Piney Fork Creek. Waters (1961, 1965) states that *Gammarus* is a principal stream drift organism and is common on all bottom types, especially sandy pools. According to Hynes (1970), in small streams and larger ones with slow current, *Gammarus* is fairly evenly distributed in areas where the amphipod can shelter under stones. In swift current, they are found more frequently along the edges rather than in mid-riffle areas. Pennak (1953) states that both species are common in unpolluted, clear waters including springs, springbrooks, streams, pools, ponds, and lakes.

Decapoda. Two crayfish species were encountered at Piney Fork Creek. *Orconectes propinquus* was collected frequently in pools and riffles. Reid (1961) found this form, typically, in stream habitats, while Pennak (1953) states that it is a common inhabitant of stony bottoms. During an eight-year study on the Vermillion River, in Illinois, *O. propinquus* was found to be most abundant on riffle substrates but also appeared frequently on sandy and muddy pool bottoms (Kendeigh, 1961). One specimen of *O. immunis* was collected from under a large rock in slow current at station 04. This species is characteristic of sluggish streams and ponds (Pennak, 1953).

Gastropoda. Pennak (1953) relates that the great majority of species and individuals occurs in shallow water, especially at depths less than three meters. According to Hynes (1970), the broad foot of gastropods is an adaptation to stony substrata. Minckley (1963) found gastropods rare on riffle bottoms but abundant in plant beds and silty to sandy pools. The riffle and pool at station 03 contained large populations of *Goniobasis* and *Pleurocera*. Both genera were absent from all other stations. Hynes (1970) observed that the former is able to maintain its position in fast water only if upon a solid substrate. Shelford (1937) stated that in swift streams this form occurs on the upper surfaces of stones. In the Vermillion River, in Illinois, Kendeigh (1961) related that *Goniobasis* and *Pleurocera* were almost exclusively collected from riffle stretches. Pennak (1953) suggests that the latter is usually taken from rocky substrata. Other members of this order found at Piney Fork Creek include *Gyraulus*, *Physa gyrina*, and *Lymnaea*. Only one specimen of each form was collected. According to Hynes (1970), *Physa* and *Lymnaea* inhabit swift water. Stehr and Branson (1938) collected *Physa* from rocky and sandy pool bottoms and from rocky riffles. *Physa*, according to Pennak (1953), occurs in greatest density where there is a moderate amount of aquatic vegetation and organic debris, and it is rare among dense mats of vegetation.

Less Significant Fauna. One individual of *Corydalus cornutus* (Megaloptera) was collected from the pool at station 03 during the summer. This species was absent from all other stations. *C. cornutus* is peculiar to the riffle community in swift water (Kendeigh, 1961). Hunt (1930) found *Corydalus* in gravel-bottomed pools and large rock-bottomed riffles but suggested that its usual habitat was the latter.

Only one isopod, *Lirceus*, was found in Piney Fork Creek; a few individuals were collected during the summer at station 04. Hunt (1930) encountered similar forms (Asellidae) from both large and small rock riffles. Minckley (1963) observed isopods in large numbers in the upper reaches of a springbrook at Doe Run, Kentucky. Specimens were significant on bare, riffle bottoms and in plant beds. In silty to sandy pools, this order (Isopoda) demonstrated low density with percentage composition decreasing downstream.

The water mites (Hydracarina) were sparsely represented at all sampling locations. Few distinct species were collected and population densities were low. As related by Pennak (1953), this group is most abundant, in species and individuals, among heavy growths of rooted aquatics in shallow water. Some forms are restricted to stream habitats and are conspicuously modified for withstanding the force of swift current.

During the summer a few planarians and leeches (Piscicola) were collected at stations 02 and 03, respectively. According to Pennak (1953), Planariidae are characteristic of brooks and streams. The specimens taken during this investigation probably belong to the genus, Curtisia, and occur in small creeks and lakes in states east of the Mississippi River. Leeches normally abound in warm, protected shallows where there is little wave action, and plants, stones, and debris offer concealment. The great majority of specimens are collected between the waters edge and depths of two meters and require solid substrates for adherence (Pennak, 1953).

One specimen of Chlorohydra viridissima was identified from samples taken at station 02 during the summer. Hydroids are typical of littoral and shallow stream associations. This species is common and generally distributed (Pennak, 1953).

Several animal plankters were collected in the pool and sidewater communities at Piney Fork Creek. The cyclopoid copepods included *Macrocyclops albidus* and *Eucyclops agilis*. They were found at stations 00 and 02 but probably occur in most of the lentic habitats along the stream course. According to Pennak (1953), many Cyclopoida have become adapted to benthic habitats, but few copepods are characteristic of rapid streams. *M. albidus* is usually found in the shallows among vegetation or on the bottom, while *E. agilis* is common everywhere on the bottom in many different habitats.

The Order Cladocera was represented by six different species. At least one form was found at all stations with three distinct species collected at station 01. Cladocerans are abundant everywhere in freshwater except in rapid streams, brooks, and grossly polluted water. The greatest number of species may be collected at the littoral, vegetative margins of lakes and rivers (Pennak, 1953). During the present study, most forms were taken from littoral regions filled with rooted, aquatic vegetation.

The Order Ostracoda was poorly represented during this study. Only two specimens were collected and belong to the genus, *Limnocythere*. Pennak (1953) relates that the nature of the substrate seems to have little influence on distribution of this order. This form is common in a variety of habitats.

Euchlanis dilitata and *Lecane* (Rotatoria) were taken from the littoral regions at stations 03 and 04. Rotifers occur in an extreme variety of habitats but are poorly represented in swift-flowing streams (Pennak, 1953). More intensive investigation in the vegetative littoral of this stream would probably uncover other species.

The aquatic oligochaete, Aeolosoma, was a frequent inhabitant of the riffles in Piney Fork Creek. Specimens were also taken in moderate numbers from some of the pool substrates. A single member of the Family Niadidae was collected from the riffle at station 02. Minckley (1963) related that this group (Oligochaeta) has been found rare on riffle substrates but abundant in silty to sandy pools and in certain plant beds. The families, Aeolosomatidae and Niadidae, are strictly aquatic (Pennak, 1953) with greatest density on organically rich substrates (Reid, 1961).

Longitudinal Zonation

According to Odum (1953), there exists, in streams, a general zonation of animals from source to mouth. Factors influencing this phenomenon include gradient, temperature, and water volume.

In the general sequence of stream succession, headwaters move upstream eroding the hills, and more and more of the swift-water communities are replaced by slow-water biocoenoses. Along the length of the stream, a gradual change in the biota occurs as the shift from slow to swift water takes place. There are irregularities in transition; the rapids are interrupted by pools, and the latter may possess some species peculiar to the slow-water community. Furthermore, the current is not uniform across a stream nor from the surface to the bottom, and these variations will produce deviations in the community (Benton and Werner, 1958).

Longitudinal zonation (addition and replacement of species) is not a matter of a uniform, continuous change; specific conditions and populations may reappear at intervals, as is indicated by the discontinuous distribution of some species (Odum, 1953).

Regarding most of the animal groups, longitudinal zonation in Piney Fork Creek, at the generic level, was a function of addition rather than replacement of species. Possible replacement at the generic level was found in the following orders: Ephemeroptera (Baetidae), *Brachycercus* was replaced at station 02 by *Centroptilum* and *Neocloeon*; Diptera (Culicidae), *Anopheles* was replaced by *Mansonia* at station 04; Odonata (Coenagrionidae), *Neoneuria* was replaced by *Argia*/*Hyponeura* at station 03. At the specific level, replacement was demonstrated by the Order Cladocera. *Simocephalus vetulus*, collected from two downstream locations replaced *S. exspinosus* from an upstream station. *Pleuroxus striatus*, collected from two, upstream sites was replaced by *P. denticulatus* at station 04. As reported by Hynes (1971), this concept (replacement) is prominent at all taxonomic levels and in streams over long distances. More intensive identification to the specific level of stream invertebrates at Piney Fork Creek would probably corroborate the findings of Hynes and other authors.

SUMMARY

A study of the invertebrate fauna of Piney Fork Creek, located on the Fort Campbell Military Reservation, was conducted during the summer and early fall of 1974.

Five collecting stations were established at substantial intervals from source to mouth. Collections were made, generally, in the early afternoon with a Surber-Bottom-Sampler, insect net, and dip net.

Physical parameters were measured at each station and included width, depth, current velocity, and bottom sediment type. Morphometric data were taken from an aerial, photographic map and included total stream length, stream pattern, total gradient, and stream order.

Subsequently, biological data were correlated with physical and morphometric information to determine tendencies or patterns of animal distribution.

Sixty-two different aquatic invertebrate specimens representing six phyla were collected from this stream, with the immature insects comprising the majority of organisms.

Piney Fork Creek, according to Horton's (1945) system of stream classification, is a fourth order stream. Collections at successive stations from source to mouth indicate a definite longitudinal (or altitudinal) zonation of invertebrate fauna. Species diversity increased from source to mouth and with increasing stream order; third order stations contained 22 different forms, while fourth order collections included 51 "species".

LITERATURE CITED

Benton, H.A. and W.E. Werner. 1958. Principles of Field Biology and Ecology. McGraw-Hill. New York, Toronto, London. 341 p.

Borror, D.J. and R.E. White. 1970. A Field Guide to the Insects of America North of Mexico. Houghton Mifflin Co. Boston. 404 p.

Carpenter, K.E. 1927. Faunistic Ecology of some Cardiganshire Streams. J. Ecol. 15: 33-54.

Cook, H.G. 1965. The Immature Tendipedids of Subfamily Tanypodinae in the Vicinity of Madison, Wisconsin. J. Elisha Mitchell Scientific Society. 8(1): 124-36.

Crisp, N.H. and C.B. Crisp. 1973. Some Physical, Chemical, and Benthic Characteristics of War Fork, an Interrupted Stream in Jackson County, Kentucky. Trans. Ken. Acad. Sci. 34: 33-43.

Cummins, K.W. 1962. An Evaluation of some Techniques for the Collection and Analysis of Benthic Samples with Special Emphasis on Lotic Waters. Amer. Midl. Nat. 67: 477-504.

_______ and G.H. Lauff. 1969. The Influence of Substrate Particle Size on the Microdistribution of Stream Macrobenthos. Hydrobiologia. 34: 145-181.

Dodds, G.S. and F.G. Hisaw. 1924. Ecological Studies of Aquatic Insects. I. Adaptations of Mayfly Nymphs to Swift Streams. Ecology. 5: 137-148.

_______. 1925. Ecological Studies of Aquatic Insects. III. Adaptations of Caddisfly Larvae to Swift Streams. Ecology. 6: 123-137.

Egglishaw, H.J. and R. MacKay. 1967. A Survey of Bottom Fauna of Streams in Scottish Highlands. Part III. Hydrobiologia. 30: 305-344.

Gersbacher, W.M. 1937. Development of Stream Communities in Illinois. Ecology. 18: 359-390.

Harrel, R.C. and T.C. Dorris. 1968. Stream Order, Morphometry, Physico-Chemical Conditions, and Community Structure of Benthic Macroinvertebrates in an Intermittent Stream System. Amer. Midl. Nat. 80(1): 220-251.

Horton, R.E. 1945. Erosional Development of Streams and their Drainage Basins; hydrophysical approach to quantitative morphology. Bull. Geol. Soc. Amer. 56: 275-370.

Hunt, J.S. 1930. Bottom as a Factor in Animal Distribution in Small Streams. Tenn. Acad. Sci. 5(1): 11-18.

Hynes, H.B.N. 1970. The Ecology of Running Waters. University of Toronto Press. 555 p.

______. 1971. Zonation of the Invertebrate Fauna in a West Indian Stream. Hydrobiologia. 38: 1-8.

Kendeigh, S.C. 1961. Animal Ecology. Prentice Hall, Inc. Englewood Cliffs, N.J.

Kuehne, R.A. 1962. A Classification of Streams, Illustrated by Fish Distribution in an Eastern Kentucky Creek. Ecology. 43: 608-614.

Macan, T.T. 1957. The Ephemeroptera of a Stony Stream. J. Anim. Ecol. 26: 317-342.

______. 1963. Freshwater Biology. Camelot Press Ltd. London and Southampton. 339 p.

Macereth, J.C. 1957. Notes on the Plecoptera from a Stony Stream. J. Anim. Ecol. 26: 343-351.

MacKay, R. and J. Kalff. 1969. Seasonal Variation in Standing Crop and Species Diversity of Insect Communities in a Small Quebec Stream. Ecology. 50: 101-109.

Minckley, W.L. 1963. The Ecology of a Spring Stream Doe Run, Meade County, Kentucky. Wildl. Monogr. Chestertown. 11: 124 p.

Moon, H.P. 1940. An Investigation of the Movements of Freshwater Invertebrate Fauna. J. Anim. Ecol. 9: 76-83.

Noel, M.S. 1954. Animal Ecology of a New Mexico Springbrook. Hydrobiologia. 6: 120-135.

Odum, E.P. 1953. Fundamentals of Ecology. W.B. Saunders Co. Philadelphia and London. 384 p.

Patrick, R. 1970. Benthic Stream Communities. Am. Sci. 58: 546-549.

Pennak, R.W. 1953. Freshwater Invertebrates of the United States. Ronald Press Co. New York. 769 p.

_______. 1971. Toward a Classification of Lotic Habitats. Hydrobiologia. 38: 321-334.

_______ and E.D. Van Gerpen. 1947. Bottom Fauna Production and Physical Nature of the Substrate in a Northern Colorado Trout Stream. Ecology. 28: 42-48.

Percival, E. and H. Whitehead. 1929 A Quantitative Study of the Fauna of Some Types of Stream-beds. J. Ecol. 17: 282-314.

Peterka, J.J. 1969. Distribution, Standing Crops, and Drift of Benthic Invertebrates in a Small Wisconsin Stream. Trans. Wis. Sci. Arts. Lett. 57: 155-161.

Reid, G.K. 1961. Ecology of Inland Waters and Estuaries. Reinhold Publishing Corp. New York. 375 p.

Robins, C.R. and R.W. Crawford. 1954. A Short Accurate Method for Estimating the Volume of Stream Flow. J. Wildl. Mgmt. 18: 366-369.

Shelford, V.E. 1937. Animal Communities in Temperate America. Univ. of Chicago Press. Chicago, Illinois. 368 p.

Smith, B. 1974. Director, Montgomery County Soil Conservation Service. Personal Communication.

Smith, R.L. 1966. Ecology and Field Biology. Harper and Row. New York and London. 686 p.

Stehr, W.C. and J.W. Branson. 1938. An Ecological Study of an Intermittent Stream. Ecology. 19: 294-310.

United States Department of Agriculture Soil Conservation Service, et al. 1969. An Appraisal of Potentials for Outdoor, Recreational Developments in Montgomery County, Tennessee. U.S.D.A. - S.C.S. No. 4-29327 5-70. Fort Worth, Texas. 21 p.

Usinger, R.I. 1956. Aquatic Insects of California. Univ. of California Press. Berkeley.

Ward, H.B. and G.C. Whipple. 1959. Freshwater Biology. John Whiley and Sons, Inc. New York. 1248 p.

Waters, T.F. 1961. Standing Crop and Drift of Stream Bottom Organisms. Ecology. 42: 532-537.

______. 1965. Interpretation of Invertebrate Drift in Streams. Ecology. 46: 327-334.

Welch, P.S. 1948. Limnological Methods. McGraw-Hill. New York. 381 p.

White, D.S. 1974. The Distribution of Stoneflies (Insect: Plecoptera) of the Salt River, Kentucky. Trans. Ken. Acad. Sci. 35(1-2): 17-23.

Whitehouse, J.W. and B.G. Lewis. 1966. The Separation of Benthos from Stream Samples by Flotation with Carbon Tetrachloride Limnol. Oceanogr. 11(1): 124-126.

Woodruff, B.L. 1971. A Survey of the Fishes of the Northwestern Highland Rim with Emphasis on Montgomery County, Tennessee. Unpublished Master's Thesis. Austin Peay State University, Clarksville, Tenn. 61 p.

Wright, M. 1943. The Effect of Certain Ecological Factors on Dragonfly Nymphs. J. Tenn. Acad. Sci. 18: 172-196.