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AQUATIC INSECTS OF UPPER THREE RUNS CREEK, SAVANNAH RIVER PLANT, SOUTH CAROLINA. PART I: ORDERS OTHER THAN DIPTERA

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ABSTRACT

The aquatic insect fauna of Upper Three Runs Creek and its tributaries on the Savannah River Plant near Aiken, S.C., was documented to support ecological investigations by the Savannah River Laboratory. Aquatic insects were

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collected biweekly over a one-year period with light traps and benthic sampling techniques. At least 321 species of aquatic insects other than Diptera were identified from 28,178 specimens. Several rare and unusual species found in the stream are discussed.

INTRODUCTION

Upper Three Runs Creek and its tributary sources, located mostly on property of the Savannah River Plant near Aiken, South Carolina (Fig. 1), is well-known as an unpolluted, blackwater drainage system which is probably typical of smaller, Sandhills waterways of primeval southeastern North America. Probably no other stream on Savannah River Plant property now has such characteristics. To some extent, the rich species composition of the main stream at the Plant's Flowing Stream Laboratory (or Thermal Effects Laboratory) has been documented by a research team from the Academy of Natural Sciences of Philadelphia (A.N.S.P.).

It became advisable that the insect species composition in the creek above this laboratory be documented by intensive collections and expert identifications because (1) several unusual and possibly endangered insect species

Fig. 1. – Map of the Savannah River Plant, South Carolina, showing collection sites A - F on Upper Three Runs Creek and its tributaries.

were encountered in the creek by the A.N.S.P. and related studies, (2) the aquatic insect fauna of the Plant's Flowing Stream Laboratory's artificial channels was developed by migration and colonization from the creek, (3) there is always the pobbibility of future environmental changes, and thus faunistic modifications, in the drainage system caused by activities of man or events of nature, and (4) since it is a U.S.G.S. National Hydrologic Benchmark Stream in a National Environmental Research Park, this creek and its fauna may be used as a standard of reference for other streams in the surrounding area.

MATERIALS AND METHODS

Upper Three Runs Creek and its tributaries are spring-fed and drain an area of about 492 km^2. The headwaters are north and east of the Savannah River Plant, arising on the Aiken Plateau. Geologic formations exposed by the stream include the Barnwell, McBean, and Congaree, all deposited in the Eocene Epoch. Barnwell, the more recent and uppermost formation, extends to 61 m above sea-level and consists of red, brown, yellow, and buff, fine to coarse sand and sandy clay. The McBean formation extends to 37 m above sea-level and the Congaree to sea-level. These consist of yellow-brown to green, fine to coarse, glauconite quartz sand, intercalated with green, red, yellow, and tan clay, sandy marl, and lenses of siliceous limestone (Langley and Marter 1973; Liverman 1977).

The mean annual temperature of Upper Three Runs Creek, measured biweekly at SRP route 8-1 (site "A"), was 15.3 C (range 6.0 C in Jan. to 21.0 C in July). This stream system has never received heated discharges of cooling water from the production reactors. Discharge measurements taken at S.C. route 125, approximately 12 km downstream from the study area, ranged between 5.32 and 14.56 m^3/sec and averaged 7.42 m^3/sec (Langley and Marter 1973; Liverman 1977). Water quality data collected at the Flowing Stream Laboratory in 1977 are summarized in Table I.

The stream bottom is mostly shifting sand with almost no rocks, occasional fallen limbs and logs, and where the forest canopy is open (sites "A" and "F"), rooted vegetation such as *Vallisneria americana* Michaux and *Potamogeton epihydrus* Rafinesque. Small flood plains at two collection sites (sites "A" and "F") are dominated by *Orontium aquaticum* L., *Sagittaria latifolia* Willdenow, *Ludwigia* sp., and *Polygonum* sp. Surrounding forests are mixed stands of pines and hardwoods. Trees adjacent to the stream include tulip poplar, beech, sweet gum, willow oak, swamp chestnut oak, water oak, loblolly pine, ash, dogwood, *Viburnum*, holly, and red buckeye.

The task of characterizing the aquatic insect fauna of this stream was accomplished by making periodic stream bottom and light trap collections from September 1976 through August 1977, identifying the captured, nondipterous specimens to the lowest taxonomic level possible through cooperation among nine taxonomic experts, and tabulating the species and genera with relative abundance figures and information on captured adults.

Samples were taken from Upper Three Runs Creek, Tinker Creek, Mill Creek, and Boggy Cut Creek above the Savannah River Plant Flowing Stream

Table 1. Chemical characteristics of Upper Three Runs Creek, Savannah River Plant, Flowing Stream Laboratory, January - December 1977

Parameter	Number of Samples	Mean	Range
pH	217	6.0	4.9 - 6.7
SO_4 (mg/l)	42	1.94	0.83 - 4.00
Alkalinity (mg/l - $CaCO_3$)	35	2.0	0.2 - 3.5
Conductivity (μmhos/cm)	32	23.5	20 - 28
Ca (mg/l)	32	1.37	1.17 - 1.80
NO_3 (mg/l - N)	21	0.279	<0.001 - 0.957
ortho PO_4 (mg/l)	21	0.012	<0.001 - 0.034
Si (mg/l)	19	3.08	2.15 - 3.81
Cl (mg/l)	9	2.38	2.03 - 2.62
Mg (mg/l)	9	0.332	0.287 - 0.370
Mn (mg/l)	5	<0.019	<0.019 - <0.02
Na (mg/l)	4	2.29	1.81 - 2.63

Laboratory from the following six sites (Fig. 1):

Site "A" – Upper Three Runs Creek at SRP route 8-1

Site "B" – Tinker Creek at SRP route 8-1

Site "C" – Mill Creek at SRP route E-2

Site "D" – Boggy Gut Creek at U.S. Forest Service Route 781-4

Site "E" – Mill Creek at unnamed fork 2.75 km upstream from SRP route E-2 (Site "C")

Site "F" – Upper Three Runs Creek at SRP route F.

The collecting techniques used were semi-quantitative in order to capture as many species as possible and, at the same time, to gain a measure of relative species abundance. Ten bottom samples (one pooled net sample and one debris sample for each of five sites) and three night-long light trap collections were taken at approximate two-week intervals during the course of one year.

Two benthic net collections were taken and pooled to constitute a single sample at the time of each visit to sites "A", "B", "C", "D", and "E": one collection from the organically rich margin of the stream and one from the sandy channel of the stream. These samples were taken with a standard "D"-frame benthic net ("Turtox Indestructible Dip Net", with an opening of approximately 20 cm high X 30 cm across the straight bottom and with mesh openings approx. 1 mm), dragging the net quickly against the current through the substrate at a depth of about six cm for a distance of about 0.5 m. In an effort to standardize the procedure as much as possible, one person took all of these samples during the course of the project. Specimens were separated from these benthic samples by standard sugar flotation procedures from solutions having hygrometer readings greater than 1.12 s.g.

Benthic insects were also collected from natural, solid substrates lying or suspended in the stream, including sticks, roots, rooted vegetation and occasional rocks. Ordinarily, such debris was collected at the time of each visit to sites "A", "B", "C", "D", and "E" in a quantity sufficient to displace one

liter of ethanol in an appropriately marked plastic bucket. These materials were brought back into the laboratory in the alcohol where they were carefully inspected for attached and dislodged insects. Again, to standardize the procedure, one person took all of these samples during the course of the project.

Night-long trap collections were made for flying insects using a two-mantle Coleman® lantern and three different ultraviolet fluorescent lights: two 8-watt (Sylvania® F8T5/BL) and one 15-watt (GE® F15T8/BL). These light traps were operated at stations "A", "B", "C", and "F" according to the schedule shown in Table II. All aquatic insects (or insects with some portion of their life cycle known to be aquatic) were removed from these samples for subsequent identification. Some of the collections in the late spring and summer contained so many aquatic Diptera and Trichoptera specimens that these orders were merely subsampled, setting the remainder aside for later examination if necessary. Subsamples of these two orders consisted of specimens which could be sorted from the collections in a two-hour period, with a conscientious attempt to maximize the number of aquatic species.

Identifications, along with their appropriate collection data, are stored on cards from which they may be accessed by SAS sort procedures (Barr *et al.* 1976). By this means one may ascertain taxa found at any particular site, on any particular date(s), and by any particular collection method.

Table II. Schedule of light-trap collections

Date	Site "A"	"B"	"C"	"F"
4 Sep 76	k	e	s	
18 Sep 76	e	k		c
1 Oct 76		e	k	
16 Oct 76	k	c		
19 Nov 76	l	l	l	
11 Feb 77	k			
25 Feb 77	e	k	c	
11 Mar 77	e	k		c
29 Mar 77	k	c		e
15 Apr 77	c	k	e	
3 May 77	k	e		c
17 May 77	e	c	k	
1 Jun 77	c	k		
14 Jun 77	k	e	c	
28 Jun 77	e	k		c
8 Jul 77	c	k	e	
22 Jul 77	k	e		c
8 Aug 77	e	c	k	
22 Aug 77	k	c		e

(k = Survival Corp. trap kit with 8-watt bulb
e = Ellisco® trap with 15-watt bulb
c = Coleman® lantern
s = Safari® light with 8-watt bulb
l = type of light not recorded)

RESULTS

A total of at least 321 species of aquatic insects other than Diptera were identified from 28,178 specimens examined in the study. Based on an average, for all benthic samples, of ranked numerical abundance and ranked frequency of collection for each species (except Diptera and Coleoptera other than Dryopoidea), the 25 most commonly collected species are indicated in Table III.

On the average, debris samples contained 60% more organisms and 26% more species than bottom net samples. In considering the significance of this result, it is necessary to bear in mind that very different sampling methods were employed, involving differences in manner of substrate selection, unit surface area of substrate, sampling effort, techniques for sorting specimens from substrate, and relative size of specimens. Clearly however, such sampling of debris, which would not be accomplished by most conventional sampling methods (Merritt and Cummins 1978), is necessary to adequately describe the fauna in a qualitative (species richness) or quantitative (biomass turnover, energy flow) sense.

A Kruskal-Wallis test (Conover 1971) was used to analyse between-station differences in species richness and relative organism abundance on a seasonal basis. Significant ($P<.05$) differences in species richness were detected during all seasons but fall. During the other three seasons, station "A" had the greatest species richness based on benthic samples (pooled debris and bottom net) while station "E" had the lowest. Differences ($P<.05$) in relative abundance existed during spring and summer with station "A" having the greatest abundance. During winter the established level of significance was approached ($P<.06$) with "A" again having the highest value. The lack of differences in species richness and relative numerical abundance during fall was likely due to a loss of some samples through improper labeling. The greater faunal richness and abundance of aquatic insects at station "A" is attributed to the large macrophyte beds at this site.

A significant difference ($P<.05$) existed between the number of species and organisms taken by the three most frequently used types of light trap, with the Ellisco® model being most efficient and the Coleman lantern least efficient. Friedman's two-way classification test (Steel and Torrie 1960) was used to block out the effects of collection date.

The periods of adult flight activity as indicated by light trap collections, the different life-history stages captured, and overall abundance ranking are indicated in Tables IV-XI for each species identified from the drainage system. These findings are summarized below by the nine cooperating taxonomic specialists.

Table III. The 25 Most Commonly Collected Species

Rank[1]	Taxon	Number of specimens/ Number of times collected[2]	Habit(s)[3]	Trophic relationship(s)[3]
1.0	Cheumatopsyche spp. (Trichoptera)	665/88	Clingers	Filterers
2.0	Macronychus glabratus Say (Coleoptera, adults & larvae)	315/65	Clingers	Gatherers ?, scrapers ?
3.0	Gonielmis dietrichi (Musgrave) (Coleoptera, adults & larvae)	336/55	Clingers, climbers	Gatherers ?, scrapers ?
4.0	Lepidostoma spp. (Trichoptera)	293/61	Climbers, sprawlers, clingers	Shredders
5.0	Phylocentropus spp. (Trichoptera)	454/49	Burrowers	Filterers
6.0	Baetis spp. (Ephemeroptera)	313/58	Swimmers, climbers, clingers	Gatherers, scrapers
7.0	Hydropsyche elissoma Ross (Trichoptera)	327/41	Clingers	Filterers
8.0	Brachycentrus nigrosoma (Banks) (Trichoptera)	223/44	Clingers	Filterers, scrapers
9.5	Perlesta placida (Hagen) (Plecoptera)	187/52	Clingers	Predators
9.5	Stenonema sp. nr. smithae (Ephemeroptera)	153/59	Clingers	Gatherers, scrapers
11.0	Stenelmis markeli Motschulsky (Coleoptera, adults)	259/40	Clingers	Scrapers, gatherers
12.0	Gomphus (Gomphus) spp. (Odonata)	136/49	Burrowers	Predators
13.0	Hexagenia sp. (Ephemeroptera)	223/31	Burrowers	Gatherers
14.0	Caenis sp. (Ephemeroptera)	182/33	Sprawlers	Gatherers
15.0	Ancyronyx variegata (Germar) (Coleoptera, adults & larvae)	84/42	Clingers, sprawlers	Gatherers ?, scrapers ?

16.0	Triaenodes spp. (Trichoptera)	96/36	Swimmers, climbers	Shredders
17.0	Stenelmis spp. (Coleoptera, larvae)	89/37	Clingers	Scrapers, gatherers
18.0	Microcylloepus pusillus lodingi Musgrave (Coleoptera, adults)	155/26	Clingers, climbers, burrowers	Gatherers ?, scrapers ?
19.0	Ephemerella inconstans Traver (Ephemeroptera)	198/21	Clingers, sprawlers, swimmers	Gatherers, scrapers, shredders, predator
20.0	Gomphus (Stylurus) sp. (Odonata)	82/34	Burrowers	Predators
21.0	Microcylloepus pusillus subsp. (Coleoptera, larvae)	104/25	Clingers, climbers, burrowers	Gatherers ?, scrapers ?
22.5	Brachycentrus chelatus Ross (Trichoptera)	601/14	Clingers	Filterers, scrapers
22.5	Lype diversa (Banks) (Trichoptera)	62/34	Clingers ?	Gatherers ?
24.0	Sialis sp. (Megaloptera)	75/28	Burrowers, climbers, clingers	Predators
25.0	Micrasema rusticum (Trichoptera)	197/18	Clingers, sprawlers	Shredders, gatherers

[1]Based on an average, for all benthic samples, of ranked numerical abundance and ranked frequency of collection for all species (except Diptera and Coleoptera other than Dryopoidea)

[2]Out of a total of 125 benthic samples

[3]Merritt & Cummins, 1978

EPHEMEROPTERA

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At least 32 species of mayflies were identified from 3319 nymphs, subimagoes, and adults (Table IV). Of the species listed, five are known in South Carolina only from the Sandhills region, or along the Fall Line. *Baetis ephippiatus* Traver, *Ephoron leukon* Williamson, *Leptophlebia cupida* (Say), *Pseudocloeon bimaculatus* Berner and an apparently new species of *Pseudocloeon*, occur as part of a relict fauna which includes many other groups of aquatic and semiaquatic macroinvertebrates.

Eighteen of the 19 genera of mayflies collected in this study are known to be statewide in distribution in South Carolina, with *Ephoron* being known only from the Sandhills region. It is expected that this genus will eventually be reported from outside the Sandhills in South Carolina.

The sampling techniques used in this study were designed to obtain the greatest number of species while still providing some information on relative abundance of those species encountered. Various species of mayflies, which are known to occur either in the Sandhills region of South Carolina or in the Upper Three Runs Creek drainage basin, were not collected by these sampling techniques. The apparent absence of species such as *Dolania americana* Edmunds and Traver, *Leptohyphes dolani* Allen, *L. robacki* Allen, *Acanthametropus* sp., *Homoeoneuria* sp., and possibly *Pseudiron* sp. is a result of both the elusive habits of the nymphs and the difficulty of sampling certain types of aquatic habitats. Very often, many hours of specialized sampling are needed to obtain even a small number of the nymphs mentioned. Clean, shifting-sand habitats, particularly in the Sandhills region of South Carolina, seldom have been studied. Much concentrated collecting effort in this type of habitat is needed.

The absence of any known collection records of *Siphlonurus* spp. from the Sandhills region is probably due to the peculiar habit of nymphs behaviorly drifting downstream, probably early in their development, to mature in a lake or pond farther downstream. Other interesting behavioral phenomena, yet unknown for certain of these rarer species, will probably help in understanding why they are so difficult to collect.

ODONATA

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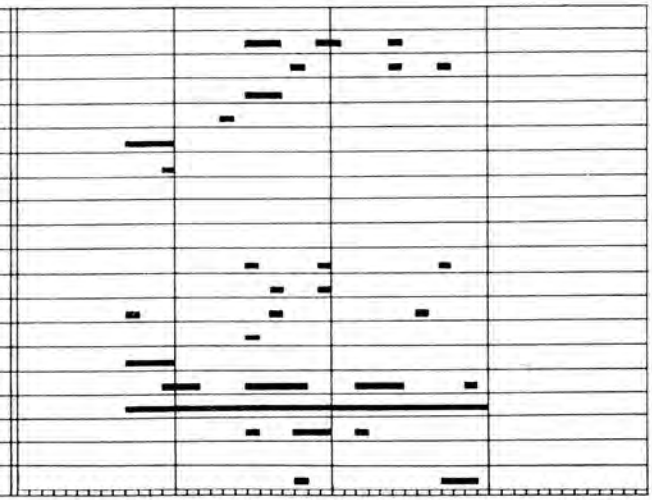
At least 15 species of Anisoptera and nine species of Zygoptera were identified from 748 nymphs (Table V). Species of particular interest include *Ophiogomphus* (?) sp., *Gomphus (Hylogomphus)* sp., and *Lestes inaequalis*. Collections of adults are necessary to resolve the dubiety concerning these

Table IV. Ephemeroptera

	Form(s)[1]	Rank[2]	Adults & Subimagoes taken in Light Traps Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
Baetis ephippiatus Traver	A		
Baetis sp.	A,L,S	6.0	
Baetis sp. A	A		
Baetis spinosus McDunnough	A		
Baetisca obesa (Say)	L	161.5	
Baetisca rogersi Berner	L	161.5	
Brachycercus sp.	L	64.5	
Caenis amica Hagen	A		
Caenis sp.	A,L,S	14.0	
Centroptilum sp.	S		
Ephemerella attenuata McDunnough	A,L	161.5	
Ephemerella deficiens Morgan	L	119.0	
Ephemerella doris Traver	L	142.5	
Ephemerella inconstans Traver	L	19.0	
Ephemerella prudentalis McDunnough	A		
Ephemerella simplex McDunnough	L	134.0	
Ephemerella sp.	A,L	37.0	
Ephemerella sp. A	A		
Ephoron leukon Williamson	S		
Habrophlebiodes americana (Banks)	A		
Habrophlebiodes sp.	L	51.0	
Heptagenia flavescens (Walsh)	A,S		
Hexagenia munda elegans Traver	A,S		

Hexagenia sp.	L	13.0	
Isonychia pictipes Traver	A		
Isonychia sp.	L,S	103.5	
Isonychia sp. A	A		
Isonychia sp. B	A		
Leptophlebia cupida (Say)	A		
Leptophlebia sp.	A,L	69.0	
Neoephemera youngi Berner	L	42.0	
Paraleptophlebia sp.	L	47.0	
Paraleptophlebia sp. A	L	134.0	
Paraleptophlebia volitans (McDunnough)	A,L,S	105.0	
Pseudocloeon bimaculatus Berner	L,S	46.0	
Pseudocloeon sp.	A,L,S	82.5	
Pseudocloeon sp. nov.	A		
Siphloplecton sp.	A,L	77.5	
Stenacron interpunctatum (Say)	A,L,S	142.5	
Stenonema smithae Traver	A,L,S	48.0	
Stenonema sp.	A,L,S	107.0	
Stenonema sp. nr. smithae	L	9.5	
Tricorythodes sp.	A,L,S	27.5	

[1]A = adult, L = nymph, S = subimago

[2]Based on an average, for all benthic samples, of ranked numerical abundance and ranked frequency of collection for each species (except Diptera and Coleoptera other than Dryopoidea)

Table V. Odonata

	Form[1]	Rank[2]
ANISOPTERA:		
Aeshnidae gen. sp.	L	126.5
Basiaeschna janata (Say)	L	134.0
Boyeria vinosa (Say)	L	32.5
Cordulegaster maculata Selys	L	161.5
Cordulegaster sp.	L	36.0
Corduliidae gen. sp.	L	142.5
Dromogomphus armatus (Selys)	L	65.0
Erythemis simplicicollis (Say)	L	161.5
Gomphidae gen. sp.	L	66.0
Gomphus (Gomphus) lividus Selys	L	134.0
Gomphus (Gomphus) sp.	L	12.0
Gomphus (Gomphus) sp. 2	L	161.5
Gomphus (Hylogomphus) sp.	L	99.5
Gomphus (Stylurus) ivae Williamson	L	79.0
Gomphus (Stylurus) sp.	L	20.0
Hagenius brevistylus Selys	L	110.0
Helocordulia selysii Hagen	L	110.0
Macromia sp.	L	92.0
Neurocordulia alabamensis Hodges	L	38.0
Neurocordulia sp.	L	119.0
Ophiogomphus ? sp.	L	161.5
ZYGOPTERA:		
Argia fumipennis (Burmeister)	L	73.0
Argia sp.	L	113.5
Argia tibialis (Rambur)	L	54.5
Calopterygidae gen. sp.	L	134.0
Calopteryx dimidiata Burmeister	L	49.0
Calopteryx maculata (Beauvois)	L	50.0
Calopteryx sp.	L	35.0
Coenagrionidae gen. sp.	L	161.5
Enallagma divagans Selys	L	161.5
Enallagma sp.	L	29.5
Enallagma weewa Byers	L	85.0
Hetaerina americana (Fabricius)	L	134.0
Ischnura prognatha (Hagen)	L	134.0
Lestes inaequalis Walsh	L	161.5

[1] L = nymph

[2] Based on an average, for all benthic samples, of ranked numerical abundance and ranked frequency of collection for each species (except Diptera and Coleoptera other than Dryopoidea)

species. The genus *Ophiogomphus* is distributed mainly in northern North America, where it typically inhabits cool, swift streams. *Ophiogomphus mainensis*, however, occurs as far south as Alabama, and has recently been reported to occur in South Carolina (Bisker and Ingram 1976). Nymphs of *Ophiogomphus* are difficult to distinguish from those of *Erpetogomphus*, especially in the early instars. Therefore the identification of the single, small nymph from Mill Creek ("Site E") is not certain. The subgenus *Hylogomphus* is in need of revision, with several species to be described. *Lestes inaequalis* has not been reported previously to occur in South Carolina, and its presence should be verified by collection of adults. Nymphs inhabit ponds and slow reaches of woodland streams.

Other southeastern species reported here that are uncommonly collected in the nymph stage are *Dromogomphus armatus, Gomphus (Stylurus) ivae, Gomphus (Stylurus)* sp. (probably *laurae*), and *Helocordulia selysii.* In general, the odonate fauna of Upper Three Runs Creek and its tributaries is quite typical of small, sandy, unpolluted southeastern streams.

PLECOPTERA

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Twenty-eight species of stoneflies were identified from 6817 nymphs and adults (Table VI). Species of particular interest include *Alloperla leonarda* complex sp., *Leuctra moha* Ricker (previously known from GA and questionably from LA), and 8 additional species not previously reported in published literature from South Carolina. These latter species include *Leuctra ferruginea, Taeniopteryx lita, Acroneuria carolinensis, Perlinella fumipennis, Perlinella drymo, Isoperla cotta, Isoperla marlynia,* and *Isoperla orata.*

HEMIPTERA

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At least 27 species of aquatic bugs were identified from 339 nymphs and adults (Table VII). Species reported were typical southeastern U.S. fauna and no range extensions were found.

MEGALOPTERA AND AQUATIC NEUROPTERA

by J. W. Chapin[2]

At least six species of megalopterans and two species of spongillaflies were identified from 174 larvae and adults (Table VIII).

Neuroptera

Two of the three species of aquatic Neuroptera known from the Carolinas (Brigham 1978) were collected: *Climacia areolaris* (Hagen) and *Sisyra vicaria*

Table VI. Plecoptera

	Form(s)[1]	Rank[2]	Adults taken in Light Traps Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
Acroneuria abnormis (Newman)	A,L	58.0	
Acroneuria arenosa (Pictet)	A,L	99.5	
Acroneuria carolinensis (Banks)	A		
Alloperla leonarda complex sp.	A		
Amphinemura nigritta (Provancher)	L	161.5	
Eccoptura xanthenes (Newman)	A		
Hastaperla brevis (Banks)	A,L	161.5	
Helopicus subvarians (Banks)	L	126.5	
Isoperla clio (Newman)	A,L	86.0	
Isoperla cotta Ricker	A		
Isoperla dicala Frison	A,L	43.5	
Isoperla marlynia (Needham & Claassen)	A		
Isoperla orata Frison	A		
Leuctra ferruginea (Walker)	A,L	45.0	
Leuctra moha Ricker	A,L	93.0	
Leuctra triloba Claassen	A		
Neoperla carlsoni Stark & Baumann	A,L	119.0	
Paragnetina fumosa (Banks)	A,L	41.0	
Paragnetina kansensis (Banks)	A,L	57.0	
Peltoperla maria Needham & Smith	L	161.5	
Perlesta frisoni Banks	A		
Perlesta placida (Hagen)	A,L	9.5	
Perlinella drymo (Newman)	A,L	161.5	
Perlinella ephyre (Newman)	A		
Perlinella fumipennis (Walsh)	A		
Phasganophora capitata (Pictet)	A		
Pteronarcys dorsata (Say)	A,L	90.0	
Taeniopteryx lita Frison	L	43.5	

[1]A = adult, L = nymph

[2]Based on an average, for all benthic samples, of ranked numerical abundance and ranked frequency of collection for each species (except Diptera and Coleoptera other than Dryopoidea)

Table VII. Hemiptera

	Form(s)[1]	Rank[2]	Adults taken in Light Traps Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
Belostoma sp.	L	161.5	
Buenoa confusa Truxal	A	161.5	
Buenoa scimitra Bare	A		
Corisella edulis (Champion)	A		▬
Corixidae gen. sp.	L	123.0	
Gerris canaliculatus Say	A	161.5	
Hesperocorixa brimleyi (Kirkaldy)	A	142.5	
Hesperocorixa lucida (Abbott)	A		
Hesperocorixa minor (Abbott)	A		
Hydrometra martini Kirkaldy	A	134.0	
Mesovelia mulsanti White	A	134.0	
Metrobates sp.	L	106.0	
Microvelia sp.	A,L	87.5	
Palmacorixa buenoi Abbott	A,L	161.5	
Pelocoris femoratus (Palisot de Beauvois)	A	115.5	
Ramphocorixa acuminata (Uhler)	A		▬
Ranatra buenoi Hungerford	A	161.5	
Rhagovelia obesa Uhler	A,L	53.0	
Rhagovelia sp.	L	77.5	
Sigara alternata (Say)	A	115.5	▬ ▬ ▬
Sigara bradleyi (Abbott)	A	102.0	▬
Sigara modesta (Abbott)	A	161.5	
Sigara sigmoidea (Abbott)	A	94.0	▬
Sigara sp.	A		▬
Sigara zimmermanni (Fieber)	A	113.5	▬ ▬ ▬
Trichocorixa calva (Say)	A	67.0	▬ ▬ ▬ ▬
Trichocorixa kanza Sailer	A		
Trichocorixa macroceps (Kirkaldy)	A	134.0	
Trichocorixa minima (Abbott)	A		
Trichocorixa sexcincta (Champion)	A	96.5	▬ ▬ ▬

[1]A = adult, L = nymph

[2]Based on an average, for all benthic samples, of ranked numerical abundance and ranked frequency of collection for each species (except Diptera and Coleoptera other than Dryopoidea)

Table VIII. Megaloptera and Neuroptera

	Form(s)[1]	Rank[2]	Adults taken in Light Traps Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
MEGALOPTERA:			
Chauliodes pectinicornis (L.)	A		
Chauliodes rastricornis Rambur	A		
Corydalus cornutus (L.)	A,L	161.5	
Nigronia fasciatus (Walker)	L	161.5	
Nigronia serricornis (Say)	L	32.5	
Sialis sp.	L	24.0	
Sialis vagans Ross	A		
NEUROPTERA:			
Climacia areolaris (Hagen)	A		
Sisyra vicaria (Walker) ?	A		

[1] A = adult, L = larva

[2] Based on an average, for all benthic samples, of ranked numerical abundance and ranked frequency of collection for each species (except Diptera and Coleoptera other than Dryopoide)

(Walker). The latter, a state record for the genus, was represented by a single adult male taken by ultraviolet light. Sponge was rarely collected in the benthic samples and none of the sponge feeding immatures of this family (Sisyridae) were collected.

Megaloptera

The Upper Three Runs Creek drainage contains five of the seven species of Corydalidae known from the Carolinas and a member of the Sialidae not previously known from the Southeast.

Only adults of *Chauliodes pectinicornis* (Linneaus) and *C. rastricornis* Rambur were collected. Significantly, although Cuyler (1958) reported that larvae are most common in lentic waters, all the collection sites of this study were lotic. In the genus *Nigronia*, only larvae were collected, with all but one specimen being *N. serricornis* (Say). The specimen of *N. fasciatus* (Walker) was collected at site "D" on Boggy Gut Creek. The stream is approximately 1 m wide at this point and Neunzig (1966) stated that *N. fasciatus* prefers smaller woodland streams than *N. serricornis* which was found at all sites.

Sialis larvae were taken at all benthic sites. *Sialis vagans* Ross, which was the only adult collected, has not previously been recorded from the Southeast. This brings to five the number of species known from the two Carolinas.

Keys, life histories, distribution information, and literature references for the Megaloptera and aquatic Neuroptera can be found in Brigham *et al.* (in press).

TRICHOPTERA

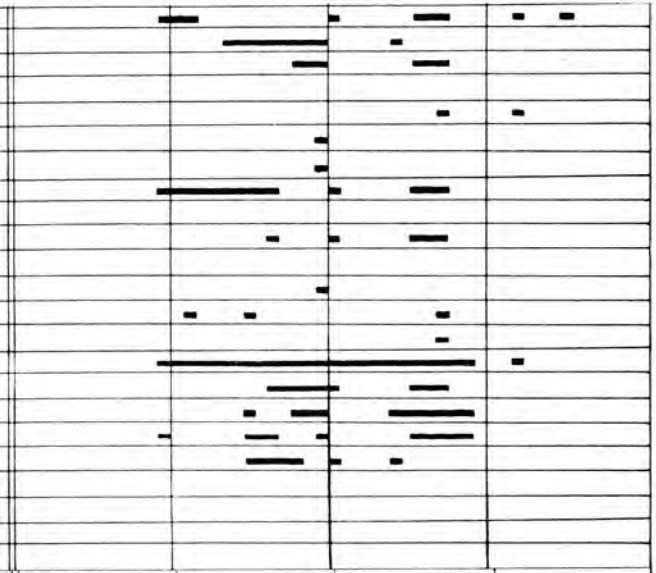
by J. C. Morse[1] and J. W. Chapin[2]

A total of at least 108 species of caddisflies were identified from 13,225 larvae, pupae, and adults (Table IX). Larvae and pupae were identified from all sites, but adults were identified almost exclusively from site "A". Most of the adults collected from the other three light-trap collection sites have not been identified yet. Species of particular interest include eight species new to science (to be described in other publications) and 17 additional species not reported previously as occurring in South Carolina. Especially significant range extensions are documented here for *Orthotrichia dentata* (previously known only from the type locality, Temple Terrace, FL), *Neotrichia falca* (previously known only from ME and NJ), and *Oxyethira azteca* (previously known only from Mexico and the southwestern U.S. to central TX). Some very rare caddisflies were also captured in this study. Among these are *Cheumatopsyche edista* and *Cheumatopsyche richardsoni*. In Upper Three Runs Creek, the latter is the most abundant species of this ubiquitous genus, yet the species is known from nowhere else in the world. Similarly, *Hydropsyche elissoma* is almost unknown outside the Upper Three Runs Creek drainage, yet it is certainly the most common species of *Hydropsyche* in that stream. *Agarodes wallacei* is known only from Upper Three Runs Creek and Holly Creek, a spring-fed Sandhills stream just north of the Savannah River Plant. *Triaenodes ochraceus*, described from a specimen captured in neighboring Burke Co., GA, sometime in the 1790's by the famous naturalist-illustrator John Abbott, had not been sighted since then. This *Triaenodes* species,

Table IX. Trichoptera

	Form(s)[1]	Rank[2]	Adults taken in Light Traps Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
Agarodes crassicornis (Walker)	A		
Agarodes libalis Ross & Scott	A		
Agarodes sp.	L	161.5	
Agarodes sp. A	L,P	110.0	
Agarodes sp. B	L,P	123.0	
Agarodes wallacei Ross & Scott	A		
Agrypnia vestita (Walker)	A		
Anisocentropus pyraloides (Walker)	A,L	63.0	
Banksiola concatenata (Walker)	A		
Brachycentrus chelatus Ross	A,L,P	22.5	
Brachycentrus nigrosoma (Banks)	A,L,P	8.0	
Brachycentrus numerosus (Say)	A,L,P	27.5	
Ceraclea cancellata (Betten)	A		
Ceraclea diluta (Hagen)	A		
Ceraclea flava (Banks)	A		
Ceraclea maculata (Banks)	A		
Ceraclea protonepha Morse & Ross	A		
Ceraclea resurgens (Walker)	A		
Ceraclea sp. A	L	70.0	
Ceraclea tarsipunctata (Vorhies)	A		
Ceraclea tarsipunctata group spp.	A		
Ceraclea transversa (Hagen)	A		
Cernotina spicata Ross	A		
Cheumatopsyche edista Gordon	A		
Cheumatopsyche gyra Ross	A		
Cheumatopsyche pasella Ross	A		
Cheumatopsyche pettiti (Banks)	A		
Cheumatopsyche pinaca Ross	A		
Cheumatopsyche richardsoni Gordon	A		
Cheumatopsyche spp.	L	1.0	
Cheumatopsyche virginica Denning	A		
Chimarra aterrima Hagen	A		
Chimarra florida Ross	A		

Chimarra sp.	L	161.5	
Chimarra sp. A	L	68.0	
Chimarra sp. B	L	56.0	
Cyrnellus fraternus (Banks)	A		
Diplectrona modesta Banks	A,L	84.0	
Glossosoma sp.	P	161.5	
Heteroplectron americanum (Walker)	A,L	161.5	
Hydropsyche betteni Ross	A		
Hydropsyche decalda Ross	A		
Hydropsyche elissoma Ross	A,L,P	7.0	
Hydropsyche nr. bidens	A		
Hydropsyche nr. incommoda	A		
Hydropsyche nr. orris	A		
Hydropsyche nr. scalaris	A		
Hydropsyche sp.	L	52.0	
Hydropsyche sparna Ross	A		
Hydroptila angusta group sp.	A		
Hydroptila nr. consimilis	A		
Hydroptila quinola Ross ?	A		
Hydroptila remita Blickle & Morse	A		
Hydroptila sp.	L	119.0	
Hydroptila sp. 2	A		
Hydroptila sp. 3	A		
Hydroptila strepha Ross	A		
Hydroptila waubesiana Betten	A		
Lepidostoma carolina (Banks)	A		
Lepidostoma carrolli Flint	A		
Lepidostoma latipenne (Banks)	A		
Lepidostoma sp.	L,P	4.0	
Leptocerus americanus (Banks)	A		
Lype diversa (Banks)	A,L,P	22.5	
Macronema carolina (Banks)	A,L	80.0	
Mayatrichia ayama Mosely	A		
Micrasema rusticum (Hagen)	A,L,P	25.0	
Micrasema sp.	L	134.0	
Micrasema wataga Ross	A,L,P	60.0	
Molanna blenda Sibley	L	54.5	

Molanna tryphena Betten	A,L	71.0	
Nectopsyche candida (Hagen)	A		
Nectopsyche pavida (Hagen)	A		
Nectopsyche sp.	L	98.0	
Neotrichia falca Ross	A		
Neotrichia minutissimella (Chambers)	A		
Neureclipsis crepuscularis (Walker)	A		
Neureclipsis melco Ross	A		
Neureclipsis sp.	A	59.0	
Nyctiophylax affinis (Banks)	A		
Nyctiophylax moestus Banks ?	L	95.0	
Nyctiophylax sp.	A		
Oecetis cinerascens (Hagen)	A		
Oecetis ditissa Ross	A		
Oecetis inconspicua (Walker)	A		
Oecetis nr. persimilis	A		
Oecetis nr. sphyra	A		
Oecetis osteni Milne	A		
Oecetis persimilis (Banks)	A		
Oecetis sp.	L,P	90.0	
Oecetis sp. A	L	74.0	
Oecetis sp. B	L	76.0	
Oecetis sp. C	L	90.0	
Oecetis sp. D	L,P	61.0	
Orthotrichia aegerfasciella (Chambers)	A		
Orthotrichia dentata Kingsolver & Ross	A		
Orthotrichia nr. baldufi	A		
Oxyethira azteca (Mosely)	A		
Oxyethira lumosa Ross	A		
Oxyethira pallida (Banks)	A		
Oxyethira sp. 2	A		
Oxyethira sp. 3	A		
Oxyethira sp. 6	A		
Oxyethira sp. 7	A		
Oxyethira sp. 8	A		
Oxyethira sp. 9	A		
Oxyethira sp. 10	A		

Oxyethira sp. 11	A		
Phylocentropus carolinus Carpenter	A		
Phylocentropus lucidus (Hagen)	A		
Phylocentropus placidus (Banks)	A		
Phylocentropus sp.	L,P	5.0	
Polycentropus blicklei Ross & Yamamoto	A		
Polycentropus cinereus Hagen	A		
Polycentropus nascotius Ross	A		
Polycentropus sp.	L	87.5	
Protoptila sp. 1	A		
Psilotreta hansoni Denning ?	A		
Psilotreta sp.	L	123.0	
Ptilostomis ocellifera (Walker)	A		
Ptilostomis sp.	L	161.5	
Pycnopsyche divergens (Walker) ?	L	161.5	
Pycnopsyche guttifer (Walker) ?	L	75.0	
Pycnopsyche indiana (Ross)	A		
Pycnopsyche lepida group sp.	L	101.0	
Pycnopsyche luculenta (Betten)	A		
Pycnopsyche luculenta or sonso	L	40.0	
Pycnopsyche scabripennis (Rambur)	A,L	72.0	
Pycnopsyche sp.	L,P	31.0	
Rhyacophila carolina Banks ?	L	119.0	
Triaenodes abus Milne	A		
Triaenodes ignitus (Walker)	A		
Triaenodes inflexus Morse	A		
Triaenodes marginatus group sp.	A		
Triaenodes nr. ignitus	A		
Triaenodes ochraceus Betten & Mosely	A		
Triaenodes pernus Ross	A		
Triaenodes sp.	L,P	16.0	
Triaenodes sp. A	L	161.5	
Triaenodes sp. B	L	62.0	

[1]A = adult, L = larva, P = pupa

[2]Based on an average, for all benthic samples, of ranked numerical abundance and ranked frequency of collection for each species (except Diptera and Coleoptera other than Dryopoidea)

Hydroptila strepha and *Polycentropus blicklei* are rare "Species of Special Concern" on the lists of the Endangered Species Section of the South Carolina Department of Wildlife and Marine Resources.

Thus, Upper Three Runs Creek is the only known locality for at least nine species of caddisflies. It lies at the known limits of ranges, or harbors an isolated population, of several others. In short, with regard to Trichoptera, this stream is a truly significant landmark.

LEPIDOPTERA

by D. D. Herlong[3]

Nine species of aquatic moths were identified from 128 larvae and adults (Table X). Three species, *Parapoynx obscuralis, Munroessa icciusalis*, and *Eoparargyractis irroratalis* were frequently collected at the lights. Sporadic adult occurrence and the lack of larval collections of the other six species makes it difficult to determine whether they are endemic to Upper Three Runs Creek and its tributaries or are merely occasional immigrants from other, nearby waterways.

COLEOPTERA (DRYOPOIDEA)

by D. S. White
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Sixteen species of riffle beetles were identified from 1739 larvae and adults (Table XI). The dryopoid families discussed here are Dryopidae, Eubriidae, and Elmidae; other families such as Chelonariidae and Ptilodactylidae (e.g., *Anchytarsus*) are mentioned in the following section. Distributions of eastern dryopoids, particularly the Elmidae, recently have been reviewed by Brown and White (1978) and Brigham *et al.* (in press). Therefore, it is most unusual to find the species assemblage and diversity exhibited in Upper Three Runs Creek. Certain genera such as *Helichus, Ectopria, Macronychus, Ancyronyx* and *Stenelmis* were to be expected and many of these rank highly among the common taxa collected (Table III). Of particular interest are a new form of *Stenelmis* (to be described elsewhere), four species not known previously from South Carolina, and the combination of Appalachian and Gulf Coast types.

Gonielmis dietrichi, falling second among the Elmidae and third among the most commonly collected of all species ranked (Table III), was known previously from only the lowland, sandy Gulf Coast stremas of western Florida to Louisiana. This represents a significant range extension, although the physical nature of Upper Three Runs Creek would seem an ideal habitat. Similar range extensions were noted for *Stenelmis antennalis, Stenelmis convexula*, and *Microcylloepus pusillus lodingi*, all of which primarily had been recorded from the Gulf Coast (wee Brown 1972, for notes on general distributions). *Oulimnius latiusculus*, though long known from South Carolina, rarely is found outside the fast-flowing Appalachian streams. Its presence

Table X. Lepidoptera

	Form(s)[1]	Rank[2]	Adults taken in Light Traps Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
Chrysendeton kimballi Lange	A		
Chrysendeton medicinalis (Grote)	A		
Eoparargyractis irroratalis (Dyar)	A		
Munroessa gyralis (Hulst)	A		
Munroessa icciusalis (Walker)	A		
Neocataclysta magnificalis (Hubner)	A		
Parapoynx allionealis Walker	A		
Parapoynx obscuralis (Grote)	A,L	39.0	
Parapoynx seminealis (Walker)	A		

[1]A = adult, L = larva

[2]Based on an average, for all benthic samples, of ranked numerical abundance and ranked frequency of collection for each species (except Diptera and Coleoptera other than Dryopoidea)

Table XI. Coleoptera

	Form(s)[1]	Rank[2]	Adults taken in Light Traps: Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
Agabetes acuductus (Harris)	A		
Agabus gagates Aube	A		
Anchytarsus bicolor (Melsheimer)	L	126.5	
Ancyronyx variegata (Germar)	A,L	15.0	
Berosus aculeatus LeConte	A		
Berosus exiguus (Say)	A		
Berosus infuscatus LeConte	A		
Berosus pantherinus LeConte	A		
Berosus perigrinus Herbst	A		
Berosus pugnax	A		
Berosus striatus (Say)	A		
Celina angustata Aube	A		
Celina grossula LeConte	A		
Celina slossoni Mutchler	A		
Cercyon sp.	A		
Chelonarium lecontei Thomson	A		
Copelatus chevrolati chevrolati Aube	A		
Copelatus glyphicus (Say)	A		
Coptomus obscurus Sharp	A		
Cybister fimbriolatus (Say)	A		
Cymbiodyta blanchardi Horn	A		
Cymbiodyta chamberlaini Smetana	A		
Cymbiodyta vidicata Fall	A		
Cyphon cf. obscurus (Guerin-Meneville)	A		
Desmopachria sp. nov.	A		
Donacia spp.	L	81.0	
Dubiraphia quadrinotata (Say)	A	110.0	
Dubiraphia spp.	L	34.0	
Dubiraphia vittata (Melsheimer)	A	103.5	
Ectopria nervosa Melsheimer	L	29.5	

Enochrus blatchleyi (Fall)	A		
Enochrus cinctus (Say)	A		
Enochrus consors (LeConte)	A		
Enochrus consortus Green	A		
Enochrus horni Leech	A		
Enochrus interruptus Gunderson	A		
Enochrus ochraceus (Melsheimer)	A		
Enochrus pygmaeus nebulosus (Say)	A		
Gonielmis dietrichi (Musgrave)	A,L	3.0	
Graphoderus liberus (Say)	A		
Haliplus punctatus Aube	A		
Helichus basalis LeConte	A	96.5	
Helichus fastigiatus (Say)	A	140.0	
Helichus lithophilus (Germar)	A		
Helochares maculicollis Mulsant	A		
Helocombus bifidus (LeConte)	A		
Hydaticus bimarginatus (Say)	A		
Hydaticus modestus Sharp	A		
Hydrobius fuscipes (L.)	A		
Hydrocanthus iricolor Say	A		
Hydrocanthus oblongus Sharp	A		
Hydrochara obtusata (Say)	A		
Hydrochus subcupreus Randall	A		
Hydroporus americanus Aube	A		
Hydroporus cimicoides Sharp	A		
Hydroporus clypialis Sharp	A		
Hydroporus lobatus Sharp	A		
Hydroporus pilatei Fall	A		
Hydrovatus p. pustulatus Melsheimer	A		
Hygrotus farctus (LeConte)	A		
Liodessus affinis	A		
Liodessus fuscatus (Crotch)	A		
Macronychus glabratus Say	A,L	2.0	

Microcylloepus pusillus subsp.	L	21.0	
Microcylloepus pusillus lodingi Musgrave	A	18.0	
Microcylloepus sp.	L	126.5	
Omophron americanum Dejean	A		
Oulimnius latiusculus (LeConte)	A	161.5	
Paracymus dispersus Wooldridge	A		
Paracymus subcupreus (Say)	A		
Peltodytes muticus (LeConte)	A		
Peltodytes oppositus Roberts	A		
Peltodytes sexmaculatus Roberts	A		
Prionocyphon limbatum LeConte	A		
Scirtes cf. ovalis Blatchley	A		
Stenelmis antennalis Sanderson	A		
Stenelmis convexula Sanderson	A	110.0	
Stenelmis lateralis Sanderson	A	161.5	
Stenelmis markeli Motschulsky	A	11.0	
Stenelmis sinuata LeConte	A	26.0	
Stenelmis sp. A	A		
Stenelmis spp.	L	17.0	
Suphisellus puncticollis (Crotch)	A		
Thermonectes ornaticollis basilaris (Harr.)	A		
Tropisternus b. blatchleyi D'Orchymont	A		
Tropisternus collaris striolatus (LeC.)	A		
Tropisternus lateralis nimbatus (Say)	A		
Tropisternus mixtus (LeConte)	A		
Uvarus lacustris (Say)	A		

[1]A = adult, L = larva

[2]Based on an average, for all benthic samples, of ranked numerical abundance and ranked frequency of collection for each species (except Diptera and Coleoptera other than Dryopoidea)

most likely can be attributed to the relatively cool temperatures of the study area. Finding three species of *Helichus* within a small stream system also must be regarded as exceptional. Other than very large drainages, rarely do streams contain the diversity of riffle beetles as does Upper Three Runs Creek.

COLEOPTERA (OTHER THAN DRYOPOIDEA)

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At least 69 species of aquatic beetles other than riffle beetles were identified from 1,689 larvae and adults (Table XI). Hydrophilidae and Dytiscidae were most diverse, with 28 and 24 species, respectively. The remaining species came from nine other families. The most abundant genera, both Hydrophilidae, were *Berosus* (seven species) and *Enochrus* (eight species). The dytiscid genus *Celina* also was notable for its diversity, with three species being taken.

Thirty-five specimens of the dytiscid genus *Desmopachria* were collected. Frank N. Young (pers. comm.) has informed me that an undescribed species occurs throughout the Southeast. It is likely that these specimens are referable to the new species and they have been forwarded to Dr. Young for study.

Nine specimens of the rare beetle *Chelonarium lecontei* were taken during the course of the study, with five coming from a single light trap collection. Larvae of this family are unknown from the United States. It is likely that they are, at best, only semiaquatic.

DISCUSSION

Table III shows that 21 of the 25 most common species (other than Diptera and non-dryopoid Coleoptera) collected in benthic samples are either climbers, clingers, or sprawlers (Merritt and Cummins 1978) which require solid substrate habitats or various types. Of these most common species, only *Phylocentropus* spp., *Gomphus (Gomphus)* spp., *Hexagenia* sp., and *Gomphus (Stylurus)* sp. are burrowers in the sandy stream bottom. Insects with other habits, such as diving or skating, were collected infrequently. This result undoubtedly was influenced by the benthic sampling techniques used since it appears closely correlated with the fact that "debris" samples of solid substrate materials usually yielded the greater number of specimens and the larger number of species as compared with "bottom net" samples. Similarly, this result correlates with the fact that site "A" usually yielded the greatest number of specimens and largest number of species as compared with the other sites from which benthic samples were taken ("B", "C", "D", and "E"), bearing in mind that site "A" has much more solid substrate habitat in the form of rooted vegetation.

Table III also lists the known feeding strategies (Merritt and Cummins 1978) for the 25 most common species. From this perspective the com-

munity appears to have a broad range of functional components, with organisms in the stream feeding on drifting detritus, periphyton, allochthonous materials, and other macroinvertebrates. Vascular plant herbivores are relatively rare. Trichoptera are the principle filterers and shredders. Species of elmid beetles and mayfiles apparently constitute the most significant gatherers (or sediment feeders) and grazing scrapers of periphyton. A stonefly species, an alderfly species, and certain gomphid dragonflies are the primary predators.

It is clear that the aquatic insect fauna of the Upper Three Runs Creek drainage basin is unusual. It not only includes many rare species, but also, because of its special combination of ecological characteristics, contains species not often found living together in the same freshwater system. This spring-fed stream is colder and generally clearer than most surface waters at its low elevation, reminiscent of unpolluted streams in northern North America or high in the Appalachian Mountains. On the other hand, its shifting sandy bottom and somewhat tea-colored water are visibly indistinguishable from those of other lowland southeastern streams. As a result, many typically northern and mountain species co-exist here with southern lowland species. For example, the species of the dragonfly genus *Ophiogomphus* are distributed mainly in northern North America; the beetle *Oulimnius latiusculus* is rarely found away from fast-flowing Appalachian streams; the caddisfly *Lepidostoma carollia* was previously known only from ME, NJ, and TN; the caddisfly *Hydroptila strepha* only from NH, PA, ME, a mountain stream in Pickens County, SC; and the caddisfly *Triaenodes inflexus* only from the mountains of SC and TN. On the other hand, the caddisflies *Chimarra florida*, *Neureclipsis melco*, and *Agarodes libalis* are known only from a few similarly spring-fed, lowland, southeastern streams. Four species of Elmidae (*Gonielmis dietrichi, Stenelmis antennalis, S. convexula*, and *Microcylloepus pusillus lodingi*) are characteristically found only in the Gulf region.

In consideration of the many rare insect species in the Upper Three Runs Creek drainage and of the several "typically northern" species coexisting here with an endemic southeastern fauna, it is probably safe to say that this stream has persisted for a very long time without appreciable alteration. It is therefore appropriate to regard the system as an outstanding example of an unpolluted, spring-fed, Sandhills waterway.

This study has established a frame of reference for the insect species diversity and relative abundance in Upper Three Runs Creek and its tributaries. The insect fauna of few other stream systems is as well known.

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