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Biology Section

Winter Bat Survey In The Caves of Monroe County, West Virginia

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Abstract

Nineteen caves in Monroe County, West Virginia were surveyed between 15 January and 14 March, 1982 to ascertain species diversity and abundance of bats and to measure temperature and relative humidity of sites containing hibernating bats. A total of four species was observed. No cave was observed to house all species, and five caves were observed to contain no bats. The following percentages of occurrence were determined: *Pipistrellus subflavus* (94.29), *Eptesicus fuscus* (4.65), *Myotis lucifugus* (0.85), and *Myotis leibii* (0.21). The relative abundances of these species varied from cave to cave. The species were hibernating at localities characterized at about the following average temperature and relative humidity: *P. subflavus* (9°C.; 97%), *E. fuscus* (4°C.; 98%), *M. lucifugus* (11°C.; 98%), and *M. leibii* (8°C.; 100%). Calculation of the coefficients of skewness and kurtosis was made for only the distribution of the dry and wet-bulb temperatures and relative humidity values for the sites housing *P. subflavus* and *E. fuscus.* Temperature and relative humidity are given for those caves observed to contain no bats.

Introduction

Monroe County is located in the southeastern portion of the state along the West Virginia-Virginia border. A total of 207 caves and pits has been recorded and published for this area (Hempel, 1975), and to date others have been discovered (Boyce et al. pers. comm., a). Since very little chiropteran work is presently occurring in this county, the accumulation of available data for its species diversity and relative abundance of bats is extremely diminutive. In analyzing the possible reasons for the apparent lack of consideration for Monroe County caves, difficulty has been experienced in that much of the evidence is intangible, obscure, and highly inferential and circumstantial.

General survey-type bat studies have been conducted for only a pittance of caves (Frum, 1947; Dotson, 1977; Delfino, 1983; Tipton pers. comm.) known to exist in the state (Davies, 1958; Hempel, 1975; Medville and Medville, 1976; Garton and Garton, 1976; Boyce et al. pers. comm., b). Clearly, a knowledge and understanding of the biogeography of bats in West Virginia is in its infancy. Additionally, very few of our caves have had hibernation sites monitored for air temperature and relative humidity, both of which have been shown to be important factors influencing site selection by wintering bats (Barbour and Davis, 1969).

This work represents a continual effort to update species diversity and abundance of bats in West Virginia caves and to provide temperature and relative humidity values for sites housing hibernating bats. Hopefully, it will channel an interest in the natural history component of bat biology for the caves of Monroe County at a time when few individuals are truly concerned.

Methods

Selection of Caves

Nineteen caves were surveyed between 15 January and 14 March, 1982 (Figure 1). They were chosen because previous scouting trips for cave entrances by Boyce et al. (pers. comm., c), using Davies (1958) and Hempel (1975) for guidance, yielded either exact locations or very close approximations. The size and current accessibility of each cave did not influence the selection.

Sampling technique

A detailed description of the procedure has been given in Delfino (1983) with two exceptions made for this study. First, a golfball retriever was not used to dislodge bats from the cave ceiling or walls for observation, since all were in identifiable range. Second, dry and wet-bulb temperatures were taken, respectively, with a Tele-Thermometer and Bacharach sling psychrometer for given hibernation sites housing bats. Rooms, domes, main and side passages, areas of extensive breakdown, and above pools and streams were monitored. Readings were carried to the nearest degree and were converted into percent of relative humidity using Psychrometric Tables of the United States Weather Bureau (Blair et al., 1965).

Statistical analysis

The coefficients of skewness and kurtosis were determined for the distribution of the temperature and relative humidity data for *Pipistrellus subflavus* and *Eptesicus fuscus* to indicate the measure of departure of these data from normality (Table 1); the sample sizes of the data for *Myotis lucifugus* and *Myotis leibii* were too small to obtain these values. Utilizing the coefficient of kurtosis to obtain a corrected

Survey Date			Survey Time (hrs.)	Cave
15	January	1982	2.5	Haynes
16	January	1982	0.7	Bob Canterbury
16	January	1982	2.3	McClung Zenith
17	January	1982	1.0	Cold Hole #2
22	January	1982	2.3	Walker Farm
23	January	1982	4.3	Wickline #1
24	January	1982	0.8	Hinkle
06	February	1982	1.0	Cold Hole
06	February	1982	1.0	Crowder
27	February	1982	0.5	Broad Run
27	February	1982	1.1	Kidd Bone
27	February	1982	1.0	Wickline Stream
27	February	1982	0.3	Wolf Creek #1
27	February	1982	0.3	Wolf Creek #3
28	February	1982	3.0	Atkins
13	March	1982	2.8	Ellison
13	March	1982	1.0	Neel
13	March	1982	1.0	Neel Insurgence
14	March	1982	2.5	Scott

FIGURE 1. List of the caves in Monroe County, West Virginia visited January-March, 1982, along with the survey date and time.

standard deviation (S) in those non-normal samples (Snedecor and Cochran, 1969) allowed for a corrected calculation of the values of the standard error (SE) about the means ($\overline{X}$). To standardize the methodologies employed here, all calculations of the standard error (SE) incorporated the kurtic factor independent of its level of significance (Pearson and Hartley, 1970).

The relative humidity values given here represent conservative estimates since the 100% and +100% measurements were pooled to incorporate into calculation those readings exceeding one-hundred percent. This procedure was considered acceptable since in the troposphere relative humidity rarely surpasses one-hundred percent by more than a few tenths (Neiburger et al., 1973). Increasing the value of those +100% readings by as much as 0.5 would not alter the averages ($\overline{X}$).

Results

Observations in 19 caves produced a total of four species of bats (Table 2). No cave was observed to contain all species and five caves, namely, Hinkle, Cold Hole, Kidd Bone, and Wolf Creek #1 and #3, were observed to house no bats. Wickline #1 and Crowder Caves displayed dissimilar diversity, both containing 3 species. Bob Canterbury, Cold Hole #2, Neel, and Neel Insurgence Caves showed identical species diversity with 2 species, while Scott Cave also housed 2 species but of unlike diversity. Haynes, McClung Zenith, Walker Farm, Broad Run,

Table 1. Calculation of the Coefficients of Skewness (Sk) and Kurtosis (Ks) for the Distribution of Dry and Wet-Bulb Temperatures (°C.) and Relative Humidity (%RH) for Sites Housing *Pipistrellus subflavus* and *Eptesicus fuscus* in the Caves of Monroe County, West Virginia

Species of Bat	*Temperature*	*Coefficients*	*N*	*Probability*
Pipistrellus subflavus	Dry	$S_k = -1.005$ $K_s = +0.233$	43	* NS
	Wet	$S_k = -1.152$ $K_s = +0.283$	43	* NS
	−%RH	$S_k = -2.511$ $K_s = +6.501$	43	* *
Eptesicus fuscus	Dry	$S_k = +0.087$ $K_s = -1.762$	11	ANS *
	Wet	$S_k = -0.318$ $K_s = -1.579$	11	ANS *
	−%RH	$S_k = -1.651$ $K_s = +0.722$	11	AS NS

−The 100% and +100% relative humidity values were pooled (Neiburger et al., 1973) for analysis. For *P. subflavus* 14 of 43 values exceeded one-hundred percent, for *E. fuscus* 3 of 11 values.

* : significant at the 0.05 level.

AS : appears significant at the 0.05 level since this value is > the SE obtained from a normally distributed sample.

NS : non-significant at the 0.05 level.

ANS: appears non-significant at the 0.05 level since this value is < the SE obtained from a normally distributed sample.

Wickline Stream, Atkins, and Ellison Caves displayed identical species diversity, all containing only 1 species.

The percentages of the bat species observed in each cave are presented in Table 3. The most abundant species observed during the survey was *Pipistrellus subflavus,* representing 94.29% of the individuals and appearing in all 14 of those caves containing bats. *Eptesicus fuscus* was the next most common species observed, totalling 4.65% of the bats and occurring in six caves. *Myotis lucifugus* represented 0.85% of the individuals encountered and inhabited two caves, followed by *Myotis leibii* with 0.21% of the bat occurrence in one cave.

Table 4 indicates the number and percentage of caves in which a particular species was most abundant (relative abundance of 1) to least abundant (theoretical relative abundance of 4, since 4 species were observed; a realized minimum relative abundance of 3 occurred, since no cave was found that housed more than 3 species). Table 4 demonstrates that the relative abundance of a particular species varied from cave to cave.

Table 5 displays the average temperature (°C.) and relative humidity (% RH) for given hibernation sites containing bats. *M. lucifugus* hiber-

Table 2. Species Diversity of Bat Observed in Nineteen Caves of Monroe County, West Virginia

	Species of Bats			
Cave	*Pipistrellus subflavus*	*Eptesicus fuscus*	*Myotis lucifugus*	*Myotis leibii*
Haynes	x			
Bob Canterbury	x	x		
McClung Zenith	x			
Cold Hole #2	x	x		
Walker Farm	x			
Wickline #1	x	x	x	
Hinkle				
Cold Hole				
Crowder	x	x		x
Broad Run	x			
Kidd Bone				
Wickline Stream	x			
Wolf Creek #1				
Wolf Creek #3				
Atkins	x			
Ellison	x			
Neel	x	x		
Neel Insurgence	x	x		
Scott	x		x	

nated at sites characterized by a temperature of about 11°C. and 98%RH, followed by *P. subflavus* at localities of about 9°C. and 97%RH, and *M. leibii* at one location of about 8°C. and 100%RH. *E. fuscus* generally inhabited the cooler regions of the caves of about 4°C. with 98%RH. *P. subflavus* hibernated over the greatest range of temperature and relative humidity, followed by *E. fuscus* and *M. lucifugus*; *M. leibii* exhibited no range.

The temperature and relative humidity for those caves observed to contain no bats are offered in Table 6. These caves exhibited a temperature range of about 0°-10°C. with relative humidity equaling or exceeding 100 percent.

Discussion

The asymmetry of the temperature and relative humidity data for *P. subflavus* and *E. fuscus* (Table 1) was probably the result of the heterogeneity in the samples and not a characteristic of the temperature distribution in animals essentially similar in all respects but temperature. The sampling technique employed here would not allow an adequate or reasonable approach to a clear and useful insight concerning the variability of the variate being measured. Rather, it did yield relatively unified

Table 3. Percentages of Bat Occurrence Observed in Nineteen Caves of Monroe County, West Virginia

Cave	*Pipistrellus subflavus*	*Eptesicus fuscus*	*Myotis lucifugus*	*Myotis leibii*	*Bat Total*
Haynes	100.00	0.00	0.00	0.00	100.00
Bob Canterbury	43.75	56.25	0.00	0.00	100.00
McClung Zenith	100.00	0.00	0.00	0.00	100.00
Cold Hole #2	50.00	50.00	0.00	0.00	100.00
Walker Farm	100.00	0.00	0.00	0.00	100.00
Wickline #1	95.97	1.61	2.42	0.00	100.00
Hinkle	0.00	0.00	0.00	0.00	0.00
Cold Hole	0.00	0.00	0.00	0.00	0.00
Crowder	66.67	16.67	0.00	16.67	100.01
Broad Run	100.00	0.00	0.00	0.00	100.00
Kidd Bone	0.00	0.00	0.00	0.00	0.00
Wickline Stream	100.00	0.00	0.00	0.00	100.00
Wolf Creek #1	0.00	0.00	0.00	0.00	0.00
Wolf Creek #3	0.00	0.00	0.00	0.00	0.00
Atkins	100.00	0.00	0.00	0.00	100.00
Ellison	100.00	0.00	0.00	0.00	100.00
Neel	99.00	1.00	0.00	0.00	100.00
Neel Insurgence	77.78	22.22	0.00	0.00	100.00
Scott	96.88	0.00	3.13	0.00	100.01
Bat Total	94.29	4.65	0.85	0.21	100.00

Table 4. Numbers and Percentages ( ) of Caves in Which a Bat Species Was Most Abundant (relative abundance level 1) to Least Abundant (minimum possible relative abundance level 4). Since No Cave Was Observed to Contain More Than Three Species, the Minimum Relative Abundance Level Actually Observed Was 3

	Species of Bat			
Relative Abundance Level (1-max.—4-min.)	*Pipistrellus subflavus*	*Eptesicus fuscus*	*Myotis lucifugus*	*Myotis leibii*
1	12	1	0	0
	(85.71)	(7.14)	(0.00)	(0.00)
2	1	3	2	1
	(7.14)	(21.43)	(14.29)	(7.14)
3	0	1	0	0
	(0.00)	(7.14)	(0.00	(0.00)
4	0	0	0	0
	(0.00)	(0.00)	(0.00)	(0.00)

Table 5. Temperature (°C.) and Relative Humidity (%RH) Presented As $\overline{X}$±SE and (Range) for Hibernation Sites (N) of the Species Of Bat Occurring in Fourteen Caves of Monroe County, West Virginia. All Temperatures Were Carried To the Nearest Degree

Hibernation Site (N)		*Temperature* $\overline{X}$ *± SE (Range)*	*Species of Bat*
	Dry	9.0 ± 0.5 (0-13)	
43	Wet	9.0 ± 0.5 (0-13)	*Pipistrellus subflavus*
	%RH	*97.0 ± 2.8 (72-+100)	
	Dry	4.0 ± 0.5 (0-7)	
11	Wet	4.0 ± 0.6 (0-7)	*Eptesicus fuscus*
	%RH	*98.0 ± 2.1 (91-+100)	
	Dry	**11.0 ± − (11-12)	
3	Wet	**11.0 ± − (11-12)	*Myotis lucifugus*
	%RH	*98.0 ± − (94-+100)	
	Dry	8.0 ± 0.0 (0)	
1	Wet	8.0 ± 0.0 (0)	*Myotis leibii*
	%RH	100.0 ± 0.0 (0)	

*This value is a conservative estimate since the 100% and +100% relative humidity measurements were pooled (Neiburger et al., 1973). For *P. subflavus* 14 of 43 values exceeded one-hundred percent, for *E. fuscus* 3 of 11, and for *M. lucifugus* 1 of 3.

**Sample size (N) was too small to determine the kurtic factor for the corrected calculation of SE.

samples. Specifically, the sexes and age groups were not separated, and there may have been a remote possibility of a difference in a race of bat.

The distribution of the temperature and relative humidity data for *P. subflavus* (Table 1) was of a significantly negatively skewed nature which indicated that the most frequent measures were those above the mean ($\overline{X}$) values (Table 5). For *E. fuscus* only the distribution of the relative humidity data appeared significantly left-skewed, suggesting that the large variants were more common within this sample representing the population.

The influence of kurtosis on the distribution of the temperature and relative humidity data for *P. subflavus* and *E. fuscus* may be seen in Table 1. A significantly positive coefficient for the relative humidity data for *P. subflavus* suggested a dampering of the amount of heterogeneity in these data as displayed by its significant skew. While the significantly negative values of kurtosis for the dry and wet-bulb temperature data for *E. fuscus* reflected some heterogeneity in these samples not shown by their coefficients of skewness.

These caves have apparently afforded more suitable wintering micro-

Table 6. Temperature (°C.) and Relative Humidity (%RH) Presented As $\overline{X} \pm SE$ and (Range) for the Caves of Monroe County, West Virginia Containing No Bats. All Temperatures Were Carried To the Nearest Degree

Cave	*Temperature Reading (N)*		*Temperature $\overline{X} \pm SE$ (Range)*
		Dry	10.0 ± 0.0 (0)
Hinkle	2	Wet	11.0 ± 0.0 (0)
		%RH	+100.0 ± 0.0 (0)
		Dry	0.0 ± 0.0 (0)
Cold Hole	2	Wet	0.0 ± 0.0 (0)
		%RH	100.0 ± 0.0 (0)
		Dry	8.0 ± – (0)
Kidd Bone	3*	Wet	8.0 ± – (0)
		%RH	100.0 ± – (0)
		Dry	4.0 ± 0.0 (0)
Wolf Creek #1	2	Wet	5.0 ± 0.0 (0)
		%RH	+100.0 ± 0.0 (0)
		Dry	6.0 ± 0.0 (0)
Wolf Creek #3	2	Wet	7.0 ± 0.0 (0)
		%RH	+100.0 ± 0.0 (0)

*Sample size (N) was too small to ascertain the kurtic factor for the corrected calculation of SE.

habitat to *P. subflavus* than the other species of bat, as demonstrated by the total abundance column in Table 3. *P. subflavus* is known to inhabit more caves in eastern North America than any other species of bat (Barbour and Davis, 1969). It would be interesting to determine the status of the winter geographical distribution of bats in Monroe County, since various area spelunkers (Boyce et al. pers. comm., a) have indicated that a few caves in this county house many hibernating bats, while there exists far more caves which contain few if any.

The observed range for any given variate is dependent on the sample size, and generally as the number of observations is increased, the more encompassing will be the observed range (Simpson et al., 1960). This relationship is problematical and dependent largely on chance. Keeping in mind that the observed range is an estimate of the continuously changing and surely never available population range (Simpson et al., 1960), the observed ranges calculated in Tables 5 and 6 represent reliable yet definitely restrictive limits. To suggest that these values were the only ones possible and did not vary in nature would be erroneous and absurd. As more observations are made, possibly and probably the larger will be the observed range over which these bats hibenate (Table 5).

The caves housing no bats (Table 6), except Cold Hole Cave, need further investigation. Cold Hole Cave is very shallow and short in length, and with such a large entrance attainment of a stable internal temperature during the winter season is anticipated to be very low. Sustained hibernation here would be foreseen as lethal for bats.

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The Results of Ohio River Macroinvertebrate Sampling for 1975-1981

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Abstract

The results of macroinvertebrate sampling from nine stations along the Ohio River are presented. Comparisons of Brillouin diversity, numbers of individuals, and taxa present for each site indicated significant improvements in the biological communities for two sites, Weirton and Hannibal. Only one site, Keyger Creek, was significantly poorer over time. Most other stations appeared to have made some improvement or remained unchanged, with the notable exceptions, however, of Willow Island and Belleville. These stations appeared to have been adversely impacted by some factor or combination of factors. The Belleville site had shown continued improvement from 1975 through 1980. However, the 1981 sample revealed a significant drop in diversity.

Introduction

The Ohio River is a valuable and unique stream system utilized by millions of people along its course. The future can only hold increased competition from the various user groups for its limited resources. If all user conflicts are to be resolved and the stream managed optimally, more must be known about the system. The mainstem is of particular importance to West Virginia when one considers that it comprises approximately one-half of the State's surface water.

The River is a large and complex system that is difficult to study for a variety of reasons. A great deal of chemical data have been collected in the past; yet little emphasis had been placed on biological information. This is somewhat unfortunate when one considers that the primary thrust of Federal and State legislation (i.e., P.L. 92-500 and P.L. 95-217, and Articles 5, 5A, 5B, and 5E of Chapter 20 of the West Virginia Code) is the protection of the biota.

The West Virginia Department of Natural Resources, Division of Water Resources, uses a multiplate system to complement water chemistry data, to help evaluate long-term water quality improvements, and to serve as a screening tool for discharger impacts over the short term. A statewide network composed of 42 stations is maintained. Data from only the Ohio Mainstem are presented in this paper.

Area Description

The study area was confined to that section of the Ohio River which extends from the Ohio-Pennsylvania-West Virginia State line southwestward to the Ohio-Kentucky-West Virginia common corner. As measured downstream from Pittsburgh, this portion has a length of 277 miles. It extends from Ohio River Mile (ORM) 40.1 to 317.1.

This segment of the Ohio River Basin lies approximately in the center of the Appalachian Plateau Physiographic Province. The main valley is broad, and much of the immediately adjacent area is gently rolling lowlands. The climate of the area is temperate with marked seasons. Principal industries are steel, aluminum, and nickel production; chemicals; coal mining; and glass, ceramic, textile, and tobacco products.

The Ohio River is the receiving stream for all domestic, industrial, and natural wastes produced on its parent streams, its tributaries, and its own channel. Practically every type of pollutant that can occur on inland waters contributes to the present condition to some degree. Problems are primarily associated with excessive mineral content and oxygen deficiency caused by water temperature increases from electric power generation and industrial cooling, mine drainage, and sediment-laden runoff (West Virginia Department of Natural Resources, 1976).

Methods and Materials

Macroinvertebrate sampling by the Division of Water Resources, in cooperation with the Ohio River Valley Water Sanitation Commission (ORSANCO), was initiated in 1975 and included four stations on the Ohio River: City of East Liverpool, Ohio (ORM-40.2); Pike Island Locks and Dam (ORM-84.2); Belleville Locks and Dam (ORM-203.9); and the City of Huntington, West Virginia (ORM-306.9). Beginning in 1979 five additional stations were sampled: City of Weirton, West Virginia (ORM-60.0); Hannibal Locks and Dam (ORM-126.4); Willow Island Locks and Dam (ORM-161.8); Keyger Creek Power Station (ORM-260.0); and Gallipolis Locks and Dam (ORM-279.2).

Macroinvertebrates were collected with Hester-Dendy multiple plate samplers as modified by Fullner (1971). Each sampler consisted of fourteen 2.7 in. square hardboard plates separated by 1 in. square spacers. Plates and spacers were mounted serially on an eyebolt. Spacing between the plates varied from 0.12 to 0.48 in. A hanging weight was attached to each multiplate to maintain the sampler in a vertical position when submerged.

The location of the multiplates at each site was dependent upon the facilities available for securing the samplers. Six stations were located at navigation locks. At these sites the samplers were fastened to the guardrail of the upper guidewall of the main lock chamber. Samplers in Weirton and Huntington were secured to private boat docks. At the Keyger Creek Power Station, multiplates were tied to a floating walkway between two mooring cells.

From 1975 to 1977, only one sampler was installed per station. This number was increased to four in 1978, then reduced to two in 1979. In 1980 and 1981, three samplers were placed at each station.

Multiplates were exposed at a depth of approximately 3 feet for 6 to 8 weeks. Samplers were retrieved by carefully removing the substrates from the water and placing them in individual buckets. The multiplates were then disassembled, and the plates were scraped to remove silt, periphytic growth, and aquatic organisms. The resulting material from each sampler was concentrated in a U. S. standard 30-mesh sieve, transferred to a 4-oz jar, and preserved with 75% ethanol. Samples were returned to the lab, and macroinvertebrates were segregated with a 3X scanning lens. Larger organisms were identified and enumerated with a 0.8X-4.0X dissecting scope. Heads of chironomid larvae were mounted on glass slides and identified with a 40X-1000X compound microscope. The majority of the organisms were identified to the generic level. The numbers of individuals and taxa were determined.

The diversity for each site was analyzed using Brillouin's diversity index, defined as

$$H = \frac{1}{N} \log \frac{N!}{\Pi N_i!}$$

where N is the total number of individuals in the sample and N_i is the number of individuals in the ith species for $i = 1, \ldots, s$ (Pielou, 1975).

Diversity indices can be used to detect an impact of a factor on an ecosystem or community. Studies have shown that pollution and other stresses tend to lower the diversity index by the loss of more sensitive species and the increases in numbers of tolerant species (Ward, 1978). When a community is considered to have been completely censused, as it was in this study, diversity can be determined without error. Brillouin's index is the most appropriate method to assess such a community (Pielou, 1975).

Results

Results are presented by station to facilitate temporal as well as spatial comparisons.

East Liverpool

Diversity values at East Liverpool showed general improvement during the study period (Figure 1), with the highest values being recorded for the years 1980 (1.43) and 1981 (1.63). These differences were not significant. The higher number individuals collected in 1978 (495) was due

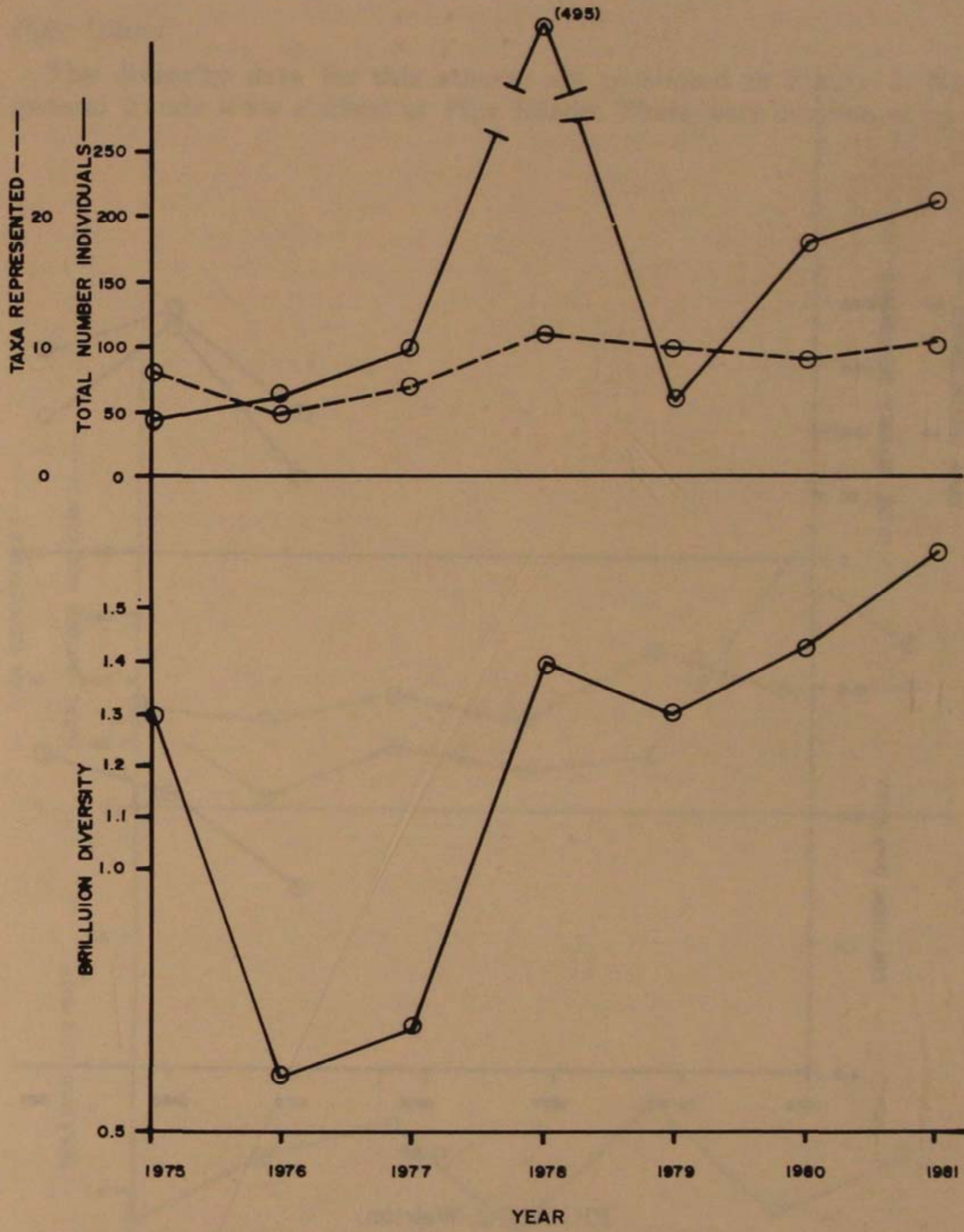

FIGURE 1. East Liverpool.

to a large number (56 percent of the sample) of oligochaetes. No similar values were observed during other sampling periods. The only other taxa that were present in large numbers were the caddisfly genus *Cyrnellus* and the chiromonid genera *Nanocladius* and *Cricotopus*.

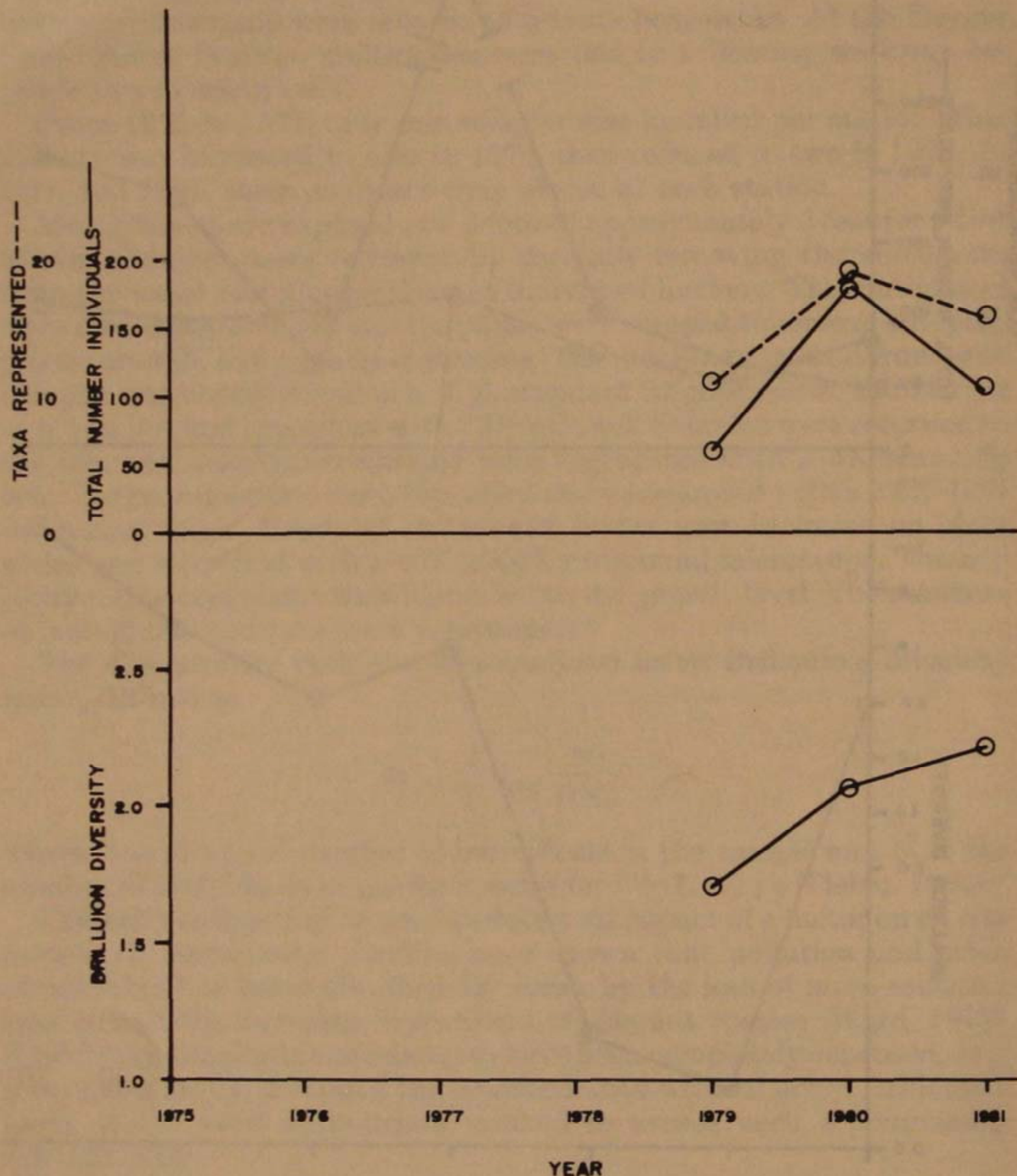

FIGURE 2. Weirton.

Weirton

Although Weirton had been sampled only three times (1979, 1980, and 1981), the trend appeared to be one of improvement (Figure 2), even though the differences in diversity (1.7-2.21) were not statistically significant. The most common encountered taxa were chironomids in the genera *Cricotopus*, *Polypedilum*, and *Rheotanytarsus*. Oligochaetes were common in 1979 and 1980, but declined in 1981. Caddisflies in the genera *Cyrnellus* and *Neureclipsis* were also common.

Pike Island

The diversity data for this station are presented in Figure 3. No general trends were evident at Pike Island. There were periods of ap-

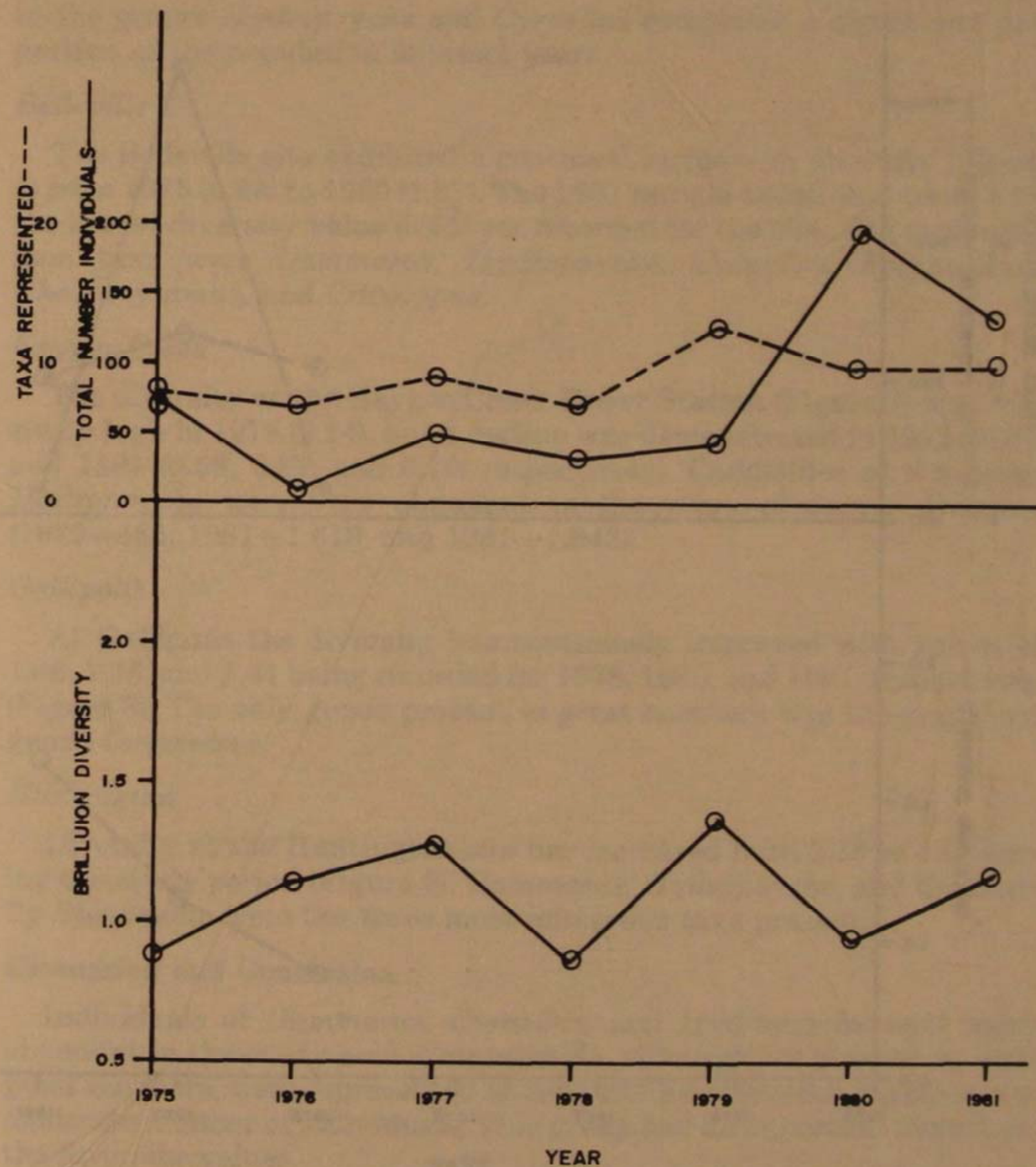

FIGURE 3. Pike Island.

parent improvement followed by declines in numbers of individuals and taxa. The higher numbers of individuals in 1980 and 1981 were primarily due to increases in numbers of the amphipod genus *Gammarus*.

Hannibal

The diversity data for this station are presented in Figure 4. The three years (1979-1981) of data at Hannibal indicate a general improvement in

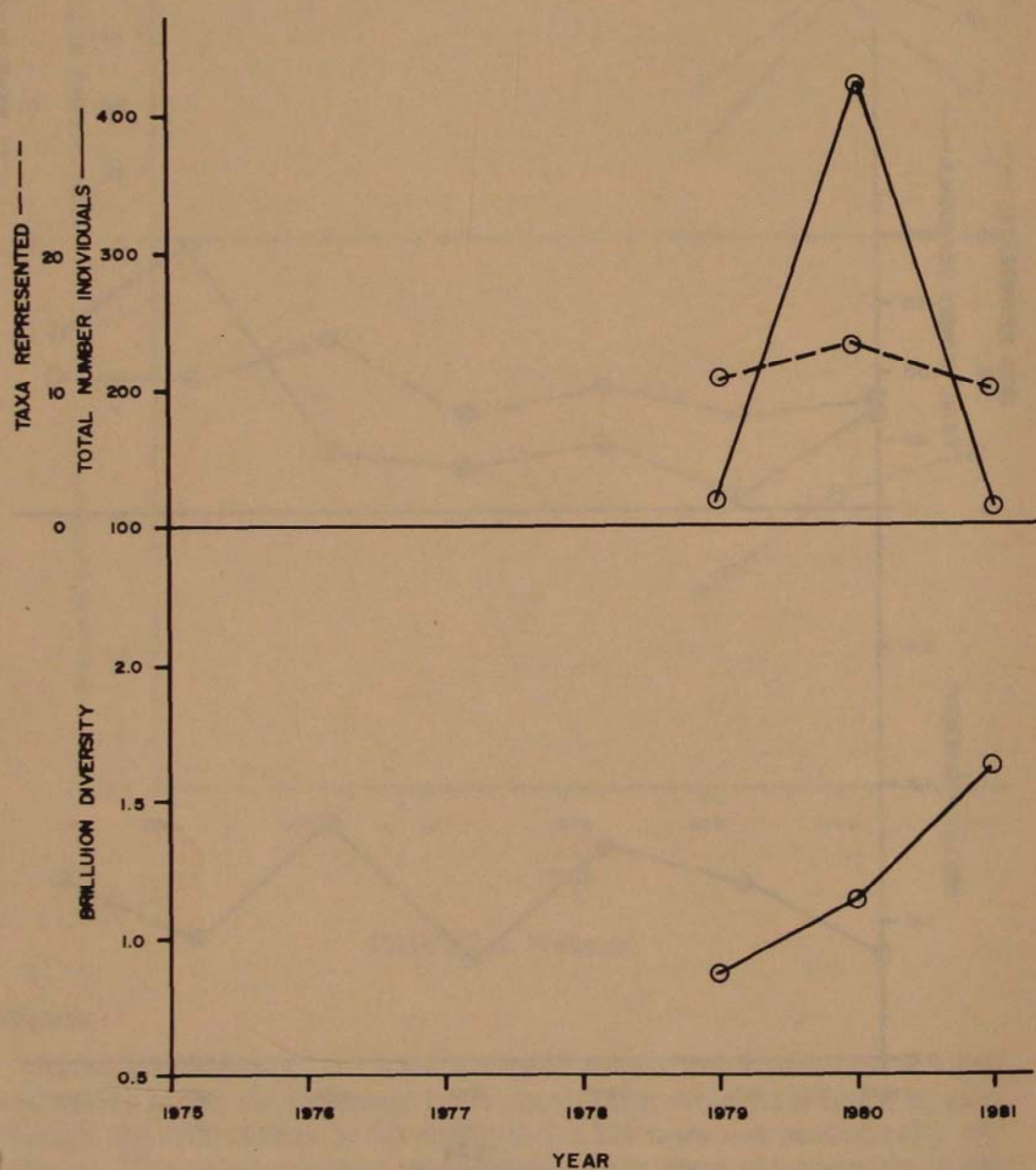

FIGURE 4. Hannibal.

the biological community as diversity increased from 0.87 to 1.64. The high numbers of individuals in 1980 (424) were due to numerous amphipods (*Gammarus* sp.—221) and flatworms (Turbellaria—156) in the sample. Caddisflies in the genus *Cyrnellus* were common throughout the sampling period.

Willow Island

The Willow Island site exhibited an overall decline in diversity, as values dropped from 1.63 to 0.64 during the study period (Figure 5). The reduction in the number of taxa was significant (one-way analysis of variance, 95 percent confidence level). An increase in the total number of individuals in 1981 was due to a disproportionate number of amphipods (*Gammarus* sp.—85 percent of total number of individuals). Caddisflies in the genera *Hydropsyche* and *Cyrnellus* comprised a significant proportion of the population in select years.

Belleville

The Belleville site exhibited a continual increase in diversity (Figure 6) from 1975 (0.84) to 1980 (1.87). The 1981 sample ended that trend with the lowest diversity value (0.55) yet recorded for the site. The most common taxa were *Gammarus, Hydropsyche, Cyrnellus, Polypedilum, Rheotanytarsus,* and *Cricotopus.*

Keyger Creek

The diversity at the Keyger Creek Power Station (Figure 7) was relatively high in 1978 (2.14), but a decline was demonstrated in 1979, 1980, and 1981 (0.59, 0.87, and 0.70, respectively). Caddisflies of the genus *Hydropsyche* were very abundant in the years of poorer diversity (1979—483, 1981—1,610, and 1981—1,043).

Gallipolis

At Gallipolis the diversity has continually improved with values of 1.08, 1.38, and 1.41 being recorded for 1978, 1980, and 1981, respectively (Figure 8). The only genus present in great numbers was the amphipod genus *Gammarus.*

Huntington

Diversity at the Huntington site has increased from 0.88 to 1.69 during the study period (Figure 9). *Gammarus, Hydropsyche,* and the mayfly *Stenonema* were the three most numerous taxa present.

Discussion and Conclusion

Individuals of *Gammarus, Cyrnellus,* and *Hydropsyche* were most abundant in the study area. Chironomids, although not present in such great numbers, were represented at each site by numerous genera and a moderate number of individuals. This group had an important impact on the diversity values.

Three stations showed a marked drop in diversity over the study period

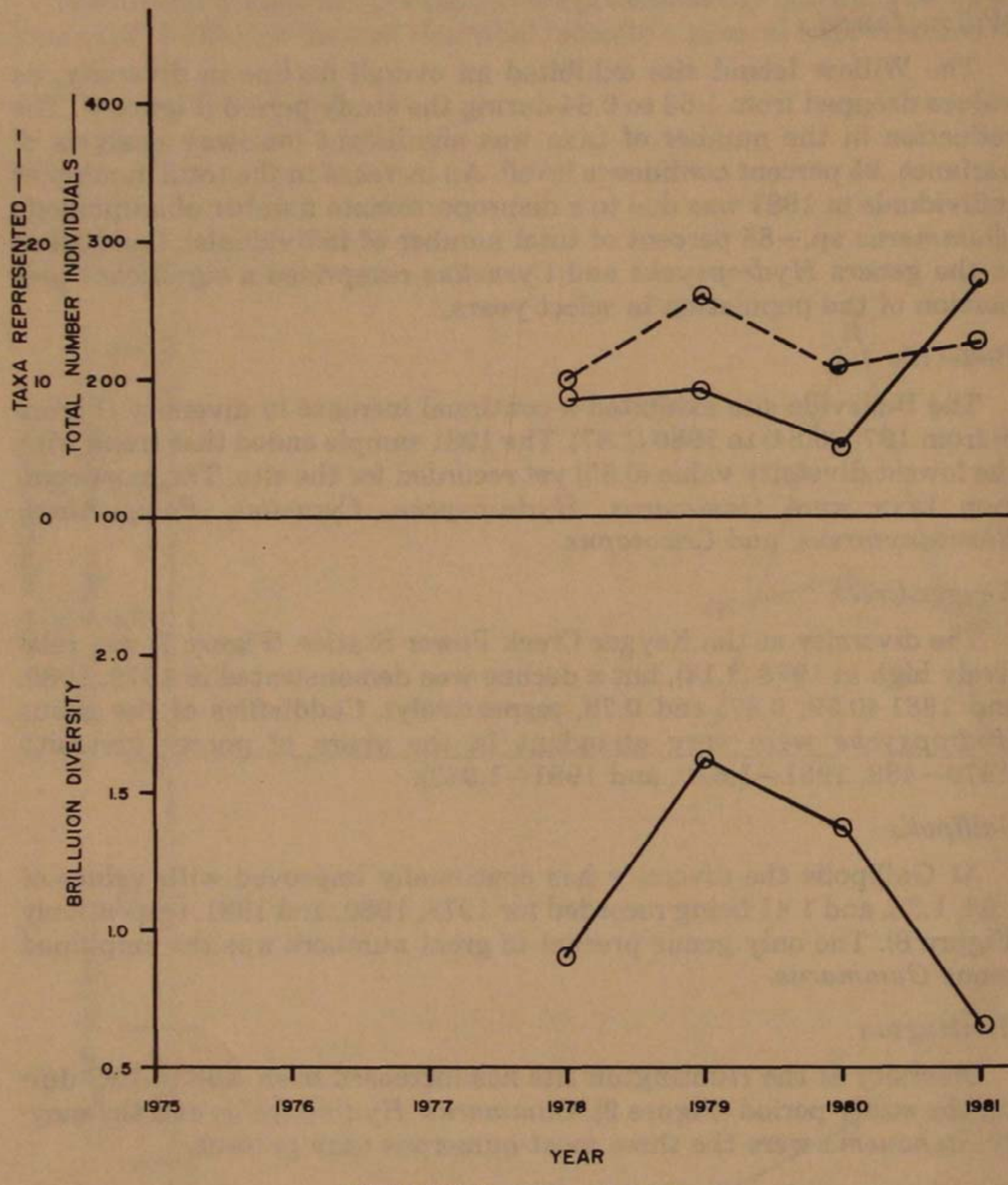

FIGURE 5. Willow Island.

(Willow Island, Belleville, and Keyger Creek). The low values at Keyger Creek for 1979-1981 possibly resulted from a lack of suitable sampling sites. Samplers were located on a floating walkway between two mooring cells at the power station. This site was not characteristic of conditions in the river proper. No specific reason can be identified for the decline in diversity at the Belleville and Willow Island stations.

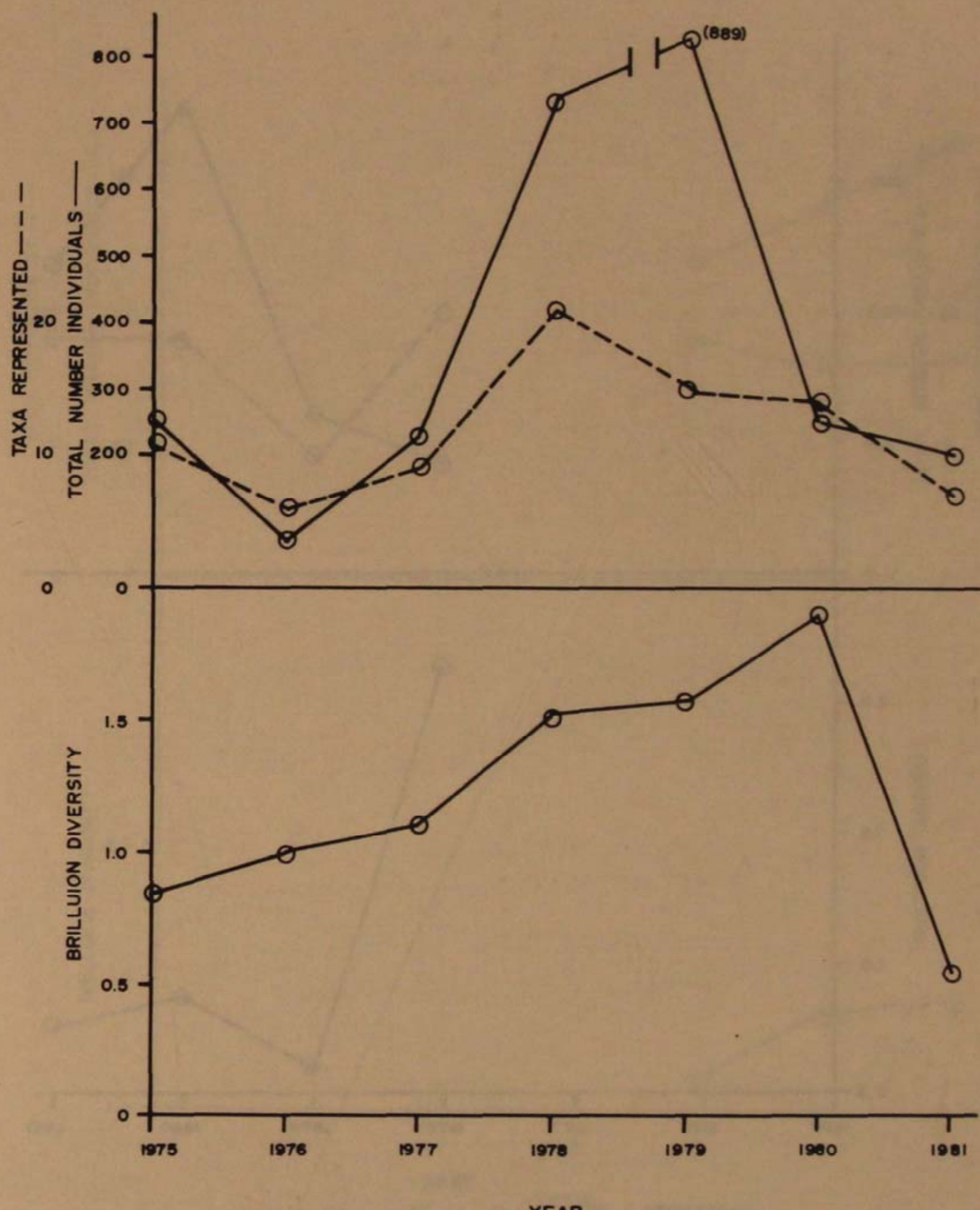

FIGURE 6. Belleville.

Extensive macroinvertebrate sampling on large sections of the Ohio River has not commonly been undertaken due to the size of the system and the amount of effort needed to generate this type of data. Mason et al. (1971) presented data along the course of the river. No great differences between Mason's data and our own data were noted. However,

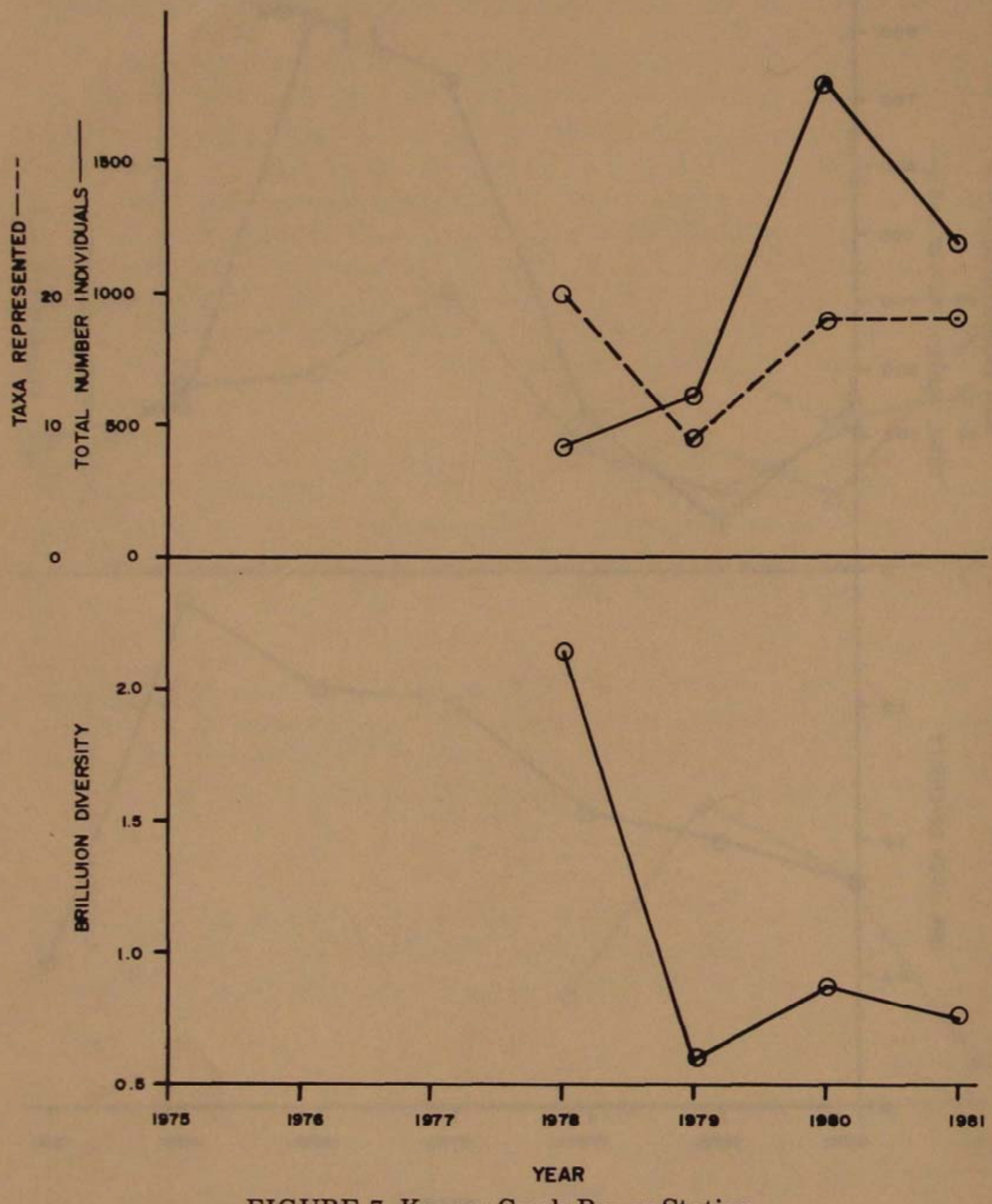

FIGURE 7. Keyger Creek Power Station.

care must be taken in this type of comparison due to differences in technique and levels of identification.

Elbert's work (1978) on the Cannelton and Uniontown pools of the Ohio River in Kentucky yielded consistently higher diversity values than found in this study. In the latter study basket samplers were employed which commonly select for more diverse communities than the

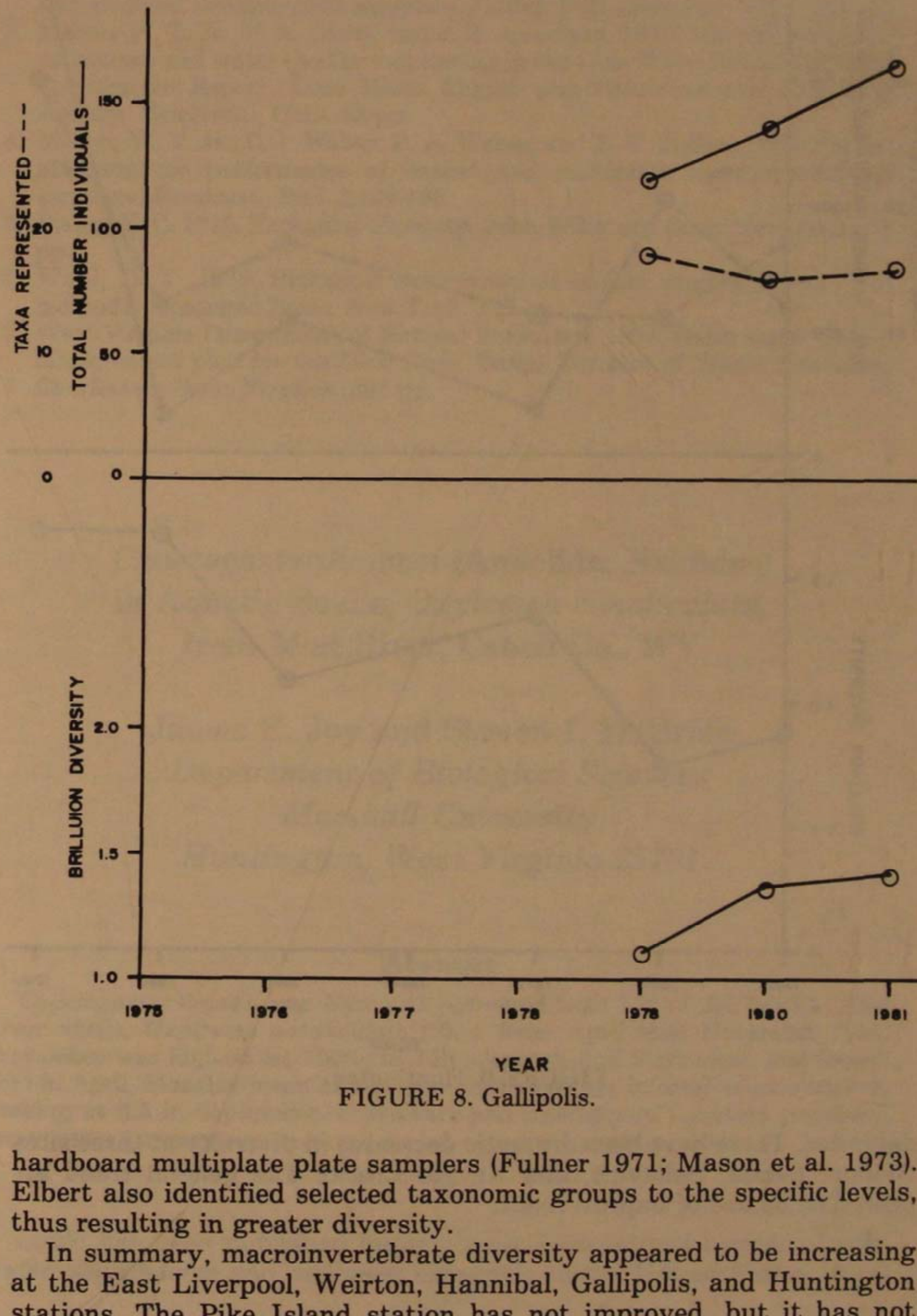

FIGURE 8. Gallipolis.

hardboard multiplate plate samplers (Fullner 1971; Mason et al. 1973). Elbert also identified selected taxonomic groups to the specific levels, thus resulting in greater diversity.

In summary, macroinvertebrate diversity appeared to be increasing at the East Liverpool, Weirton, Hannibal, Gallipolis, and Huntington stations. The Pike Island station has not improved, but it has not

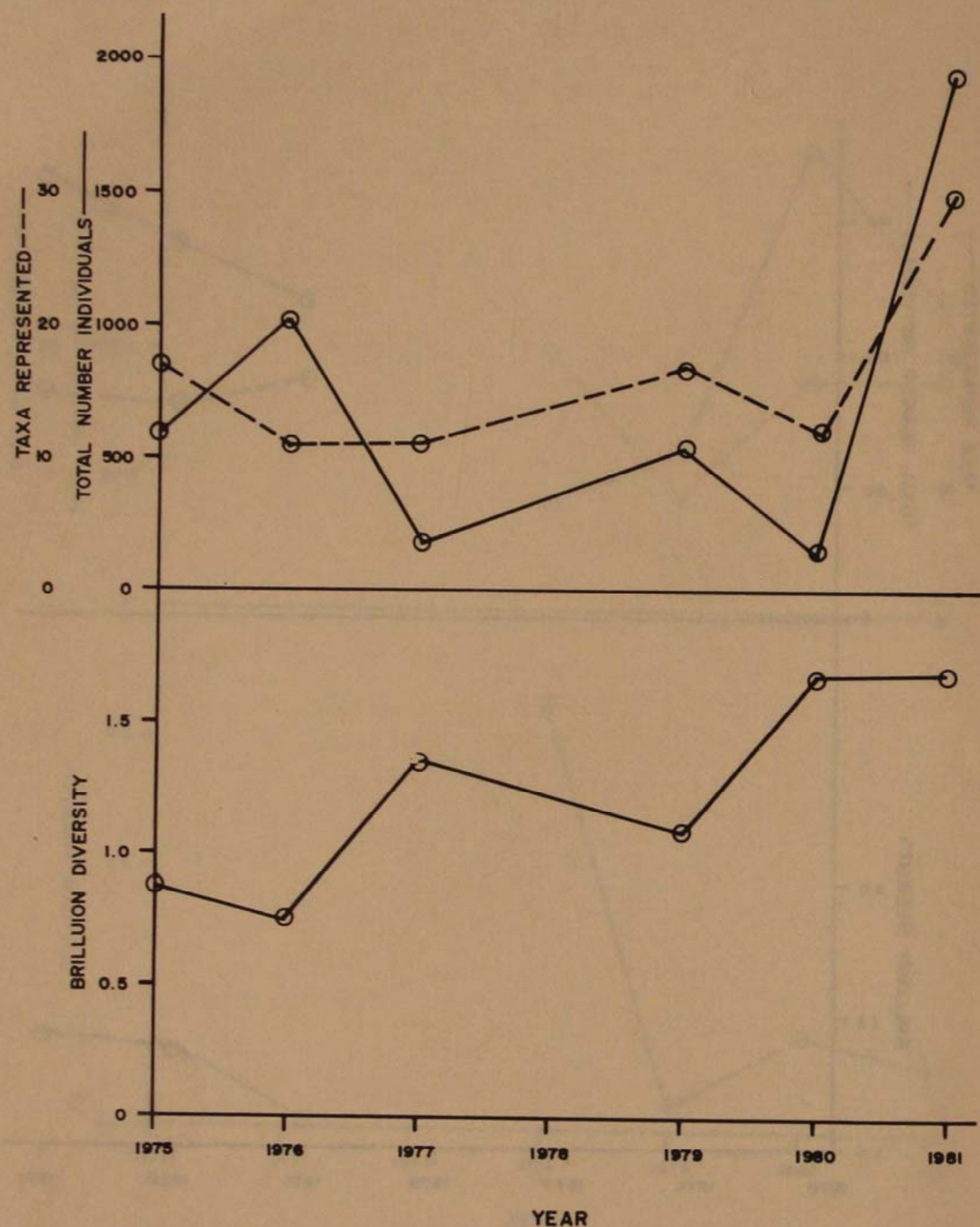

FIGURE 9. Huntington.

degraded. There have been dramatic decreases in diversity at three sites (Willow Island, Belleville, and Keyger Creek). The general trend appeared to be one of improvement.

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Chaetogaster limnaei (Annelida: Naididae) in Aquatic Snails, *Oxytrema canaliculata*, from Mud River, Cabell Co., WV

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Abstract

Chaetogaster limnaei von Baer was recovered from 130 of 235 (55.3%) Mud River snails, *Oxytrema canaliculata* (Say), from April thru November 1981. Prevalence was highest (at 100%) in July, August, and September, and lowest (0%) in April. Monthly mean numbers of *C. limnaei* per infected snail were low, peaking at 5.5 in September. Prevalence and intensity of infection paralleled mean water temperature.

Little has been published on symbiotic associations between freshwater oligochaetes and molluscs, especially in the United States. As a result, the present work was done to determine prevalence and intensity of *Chaetogaster limnaei* infections in snails from a selected study site in Cabell Co., WV.

Materials and Methods

Two hundred thirty-five operculate river snails, *Oxytrema canaliculata* (Say), were examined for aquatic oligochaetes from 20 April to 19 November 1981. Snails were collected by hand from a shallow riffle area of Mud River, West Virginia (Military Grid 92885315). Only those snails measuring 18 to 23 mm from tip of spire to leading edge of aperture (as measured by vernier calipers) were utilized. Monthly samples consisted of 15 to 40 *O. canaliculata* individuals transported to the lab in 20-liter containers. Once in the laboratory, snails were transferred to a 60-liter aquarium where they were held no longer than 48 hours in aerated river water approximating outdoor temperatures. Each snail was handled separately by crushing the shell and examining, with the aid of a stereomicroscope, the viscera and internal shell surface for active oligochaetes. Oligochaetes were identified, while in water mounts, as *Chaetogaster limnaei.* Keys used for identification were: Goodnight (1959); Pennak (1978); and Hiltunen and Klemm (1980).

Results and Discussion

Chaetogaster limnaei was recovered from 55.3% (130 of 235) of the snails examined. Prevalence paralleled mean water temperatures and was highest (at 100%) for July, August, and September, and lowest (at 0%) for April (Figure 1). Streit (1974) reported a somewhat earlier but similar seasonal pattern for *C. limnaei* infecting the river limpet, *Ancylus fluviatilus* (e.g., prevalence was 100% during May and June). Gruffydd (1965) recorded high prevalence rates for *C. limnaei* on *Lymnaea pereger* during February thru May (100%) and again in November ($\cong$ 90%). However, unlike the present work, Gruffydd noted that prevalence was virtually zero in June due to large numbers of young snails hatching that were not infected. Young (1974) reported a similar seasonal pattern for *C. l. limnaei* on *Physa frontalis* and *L. pereger,* while Buse (1971) reported a decrease of *C. l. vaghini* in *L. stagnalis* populations after May or June also due to hatching of young snails.

Intensity levels (mean number of *C. limnaei* per infected snail) virtually paralleled prevalence rates with a peak of 5.2 occurring in September (Figure 1). Intensity levels were comparable to those found by Streit (1974) who reported means of 1.0 and 7.1 worms per infected limpet in January and May of 1973, respectively. Streit also noted that larger limpets generally carried more *C. limnaei* individuals; a finding that could not be corroborated by the present study because all *O. canaliculata* individuals were nearly the same size. Buse (1971) also reported a positive correlation between size of snail and the number of worms it carried. The intensity reported by Gruffydd (1965) was more variable, with a peak of $\cong$ 50 in May, and a low of < 5.0 from June thru December.

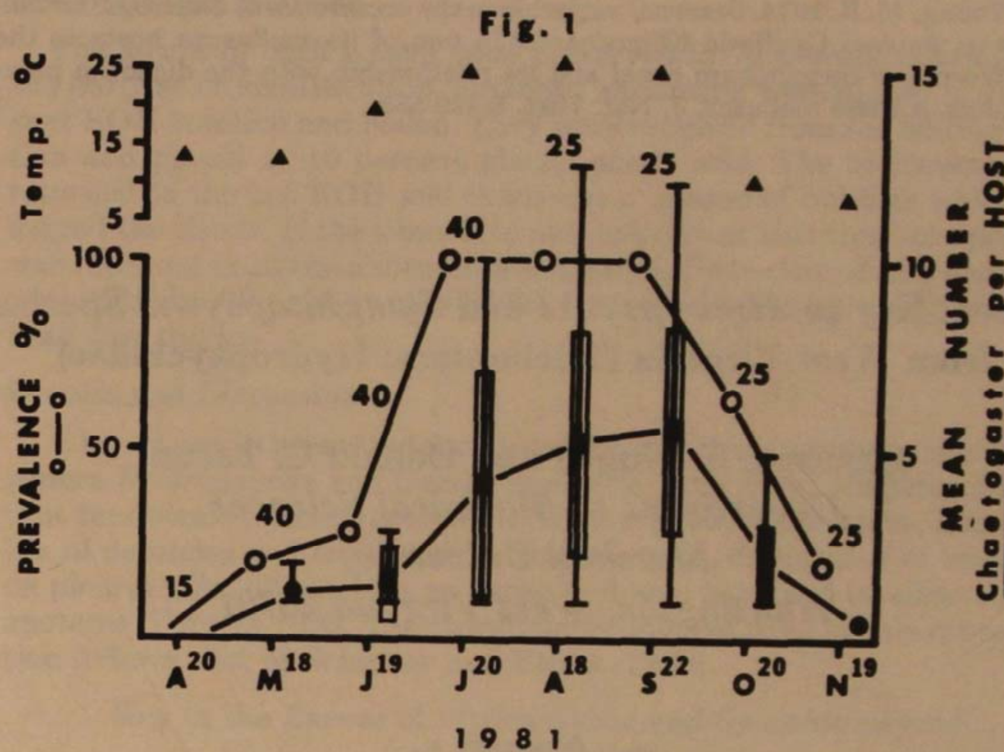

FIGURE 1. Monthly variations in prevalence and mean number of *C. limnaei* individuals per host snail. Numbers above open circles represent the number of snails examined. Number to upper right of each monthly designation is the date of sample. Vertical lines = range; vertical bars = one standard deviation. Closed triangles represent mean monthly water temperatures. Source: WV Department of Natural Resources.

Acknowledgments

We would like to thank Dr. Carol Stein, The Ohio State University Museum of Zoology, for identifying snails collected in this study. They have been catalogued into that museum's collection as OSUM-14700.

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Larval Key to *Hydropsyche* and *Symphitopsyche* Species from West Virginia (Trichoptera: Hydropsychidae)

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Abstract

A larval key is presented for 15 species and two species groups of the genera *Hydropsyche* and *Symphitopsyche* from West Virginia. The following species and species groups are included in the key: *H. depravata* group, *H. dicantha* Ross, *H. hageni* Banks, *H. hoffmani* Ross, *H. leonardi* Ross, *H. orris* Ross, *H. phalerata* Hagen, *H. scalaris* Hagen, *H. simulans* Ross, *S. bifida* group, *S. bronta* (Ross), *S. macleodi* (Flint), *S. morosa* (Hagen), *S. slossonae* (Banks), *S. sparna* (Ross), *S. ventura* (Ross), and *S. walkeri* (Betten and Mosely). Important taxonomic characters include (1) color patterns, setation, and number of denticles and tubercles on frontoclypeus, (2) number of branches on pleural gills, (3) setation on genae and anal legs, and (4) tubercles on apotome. Additional comments are made regarding the environmental influence on head patterns.

Introduction

Presently, 16 species and two species groups of the genera (*Hydropsyche* and *Symphitopsyche* have been recorded from West Virginia (Ross, 1944; Flint, 1965; Tarter and Hill, 1979; Nugen and Tarter, 1983). Using over 4,000 larvae from 225 sites in West Virginia, 13 state records were reported by Nugen and Tarter (1983). Of the 16 species recorded from West Virginia, only the larval stage of *H. opthalmica* Flint is unknown (Flint, 1965).

The primary objective of this paper was to write a larval key to *Hydropsyche* and *Symphitopsyche* species from West Virginia.

Materials and Methods

The larvae of both genera were preserved in 70 percent ethanol. For the purpose of identification, detached abdomens were placed in 10 percent KOH solution and boiled. They were removed from the boiling solution and placed in 10 percent glacial acetic acid. The abdomens were returned to the hot KOH and there was a release of bubbles which dislodged the tissue. If the tissue did not dislodge at this time, the process was repeated until the abdomen was cleared. Once cleared, the abdomen was stored in 70 percent ethanol for future examination along with the head and thorax.

Results and Discussion

A larval key is presented for 15 species and two species groups of the genera *Hydropsyche* and *Symphitopsyche* from West Virginia. Important taxonomic characters include (1) color patterns, setation, and number of denticles and tubercles on frontoclypeus, (2) number of branches on pleural gills, (3) setation on genae and anal legs, and (4) tubercles on apotome (Figures 1-24). The classification system used in this investigation follows that of Schuster and Etnier (1978).

Key to the Larvae of *Hydropsyche* and *Symphitopsyche* of West Virginia

1	Abdomen with minute spines present on at least segments I-III (Figure 7) . . . . . *Hydropsyche*	9
1′	Abdomen without minute spines . . . . . *Symphitopsyche*	2
2	Frontoclypeus with checkerboard pattern (Figures 19, 20)	3
2′	Frontoclypeus unicolored or with different pattern	4
3	Frontoclypeus with three light spots at posterior angle (Figure 20) . . . . . *S. morosa*	
3′	Frontoclypeus with single light spot at posterior angle (Figure 19) *S. bifida* group (*S. bifida*, *S. cheilonis*, Central Form of *S. bronta*)	
4	Frontoclypeus with V-shaped marks or stripes	5
4′	Frontoclypeus without such marking	6
5	Frontoclypeus with two brown V-shaped marks; thoracic sclerites yellow (Figure 17) . . . . . *S. walkeri*	
5′	Frontoclypeus with three brown stripes and a light spot in middle of center stripe; brown band anteriorly and posteriorly on thoracic sclerites (Figures 18a,b) . . . . . Appalachian Form of *S. bronta*	
6	Head and thoracic sclerites brown to dark brown; one to three yellow spots on frontoclypeus; central spot brightest; if more than one spot, in a longitudinal row (Figures 12a,b) . . . . . *S. slossonae*	
6′	Head and thoracic sclerites golden brown to brown; frontoclypeus pattern not as above	7
7	Frontoclypeus with dark brown triangular mark on posterior half (Figure 23) . . . . . *S. macleodi*	

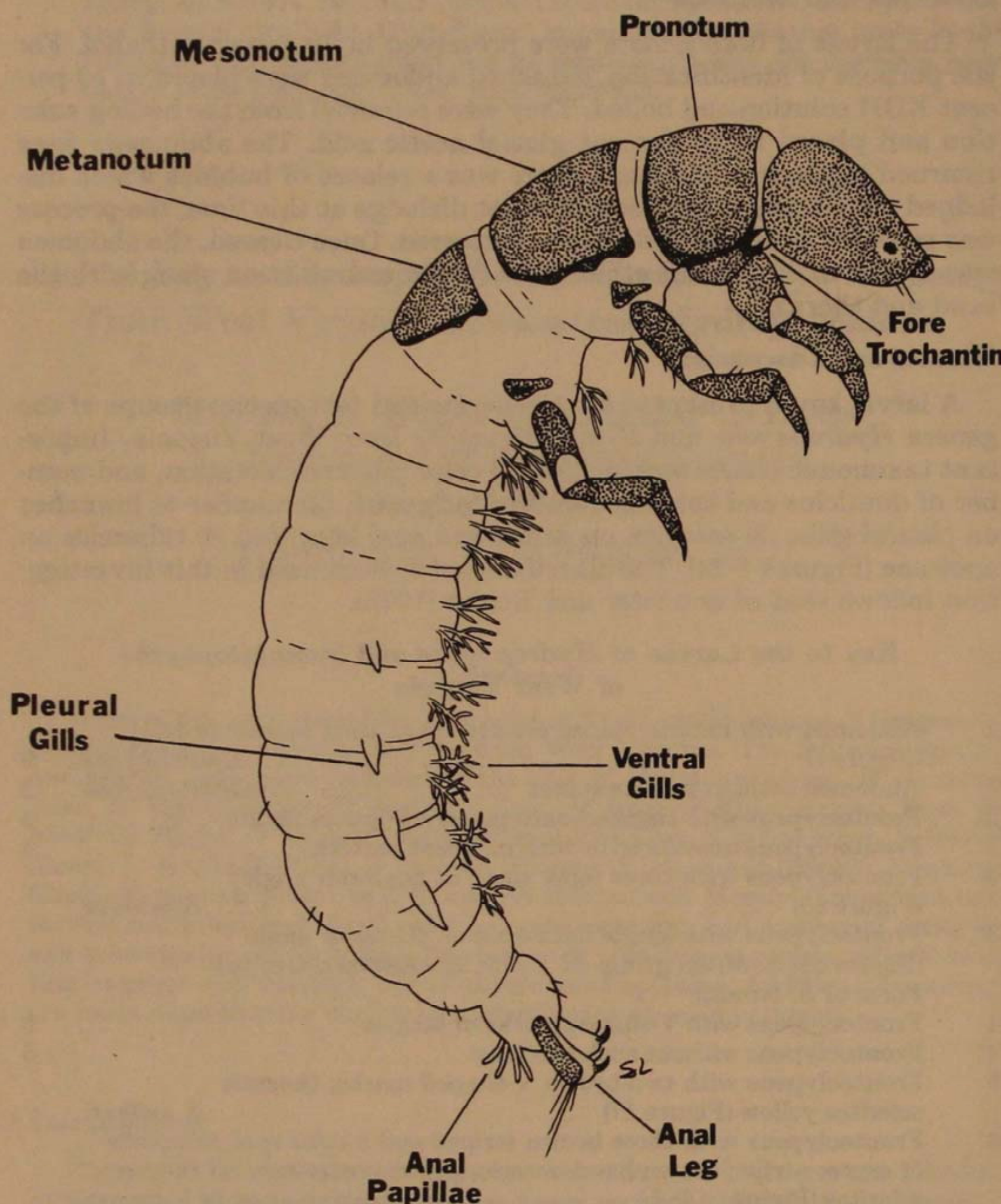

FIGURE 1. *Hydropsyche depravata* group larva, lateral view (Nugen, 1981).

7′	Frontoclypeus not as above	8
8	Frontoclypeus with bright central spot and two lighter antero-lateral spots; all spots light and not distinct; many short bristle-like setae on thoracic sclerites; pleural gills with more than ten branches (Figure 22) ....*S. sparna*	
8′	Frontoclypeus without spots; bristle-like setae on thoracic sclerites few; pleural gills with ten or less branches (Figure 21)..*S. ventura*	
9	Two denticles on anterior margin of frontoclypeus (Figures 9a,b) ....*H. orris*	

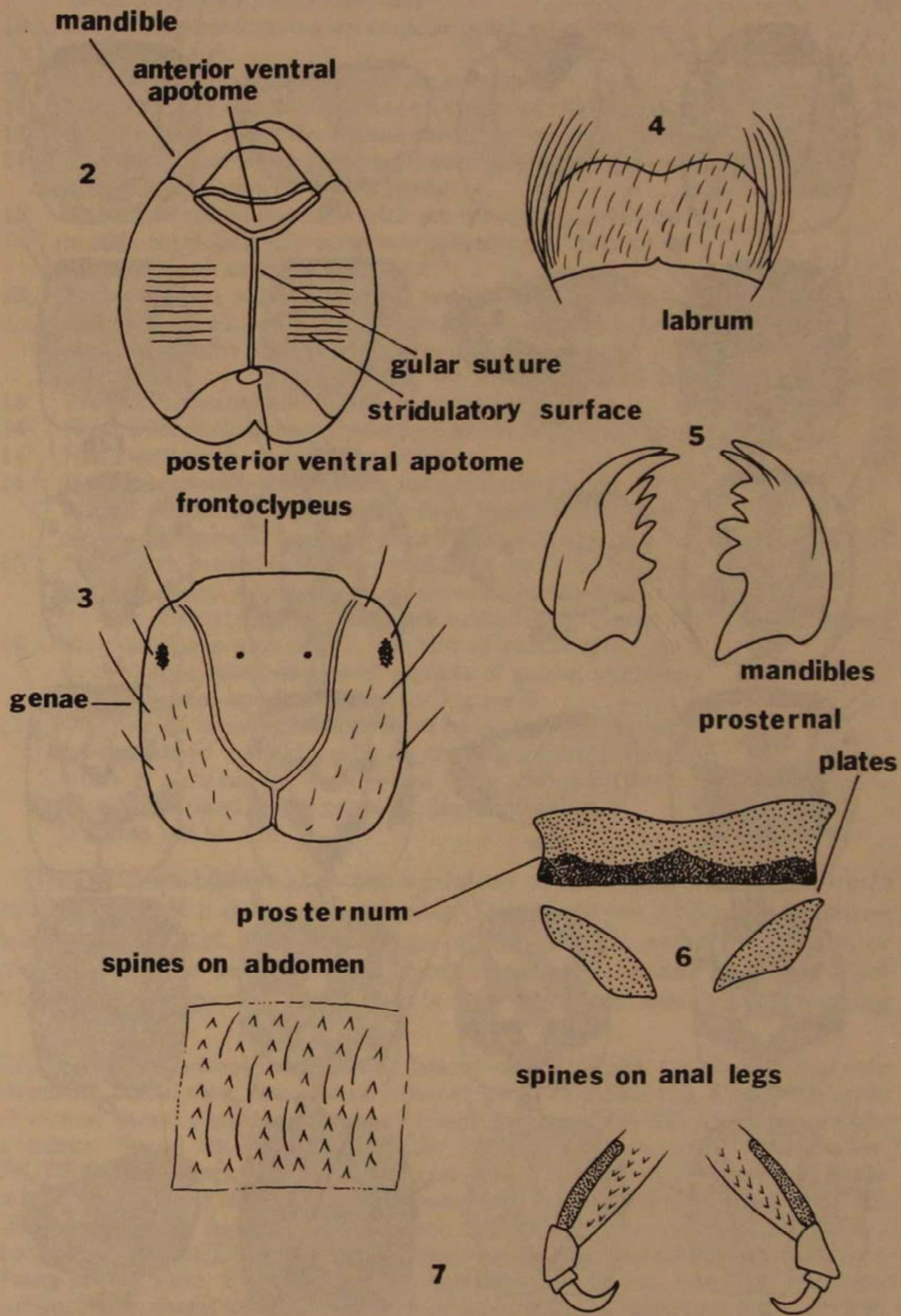

FIGURE 2. Ventral aspect of head. FIGURE 3. Dorsal aspect of head. FIGURE 4. Labrum. FIGURE 5. Mandibles. FIGURE 6. Prosternal plates. FIGURE 7. Spines on the abdomen of *Hydropsyche* and spines on the anal prolegs of *Hydropsyche* and *Symphitopsyche*.

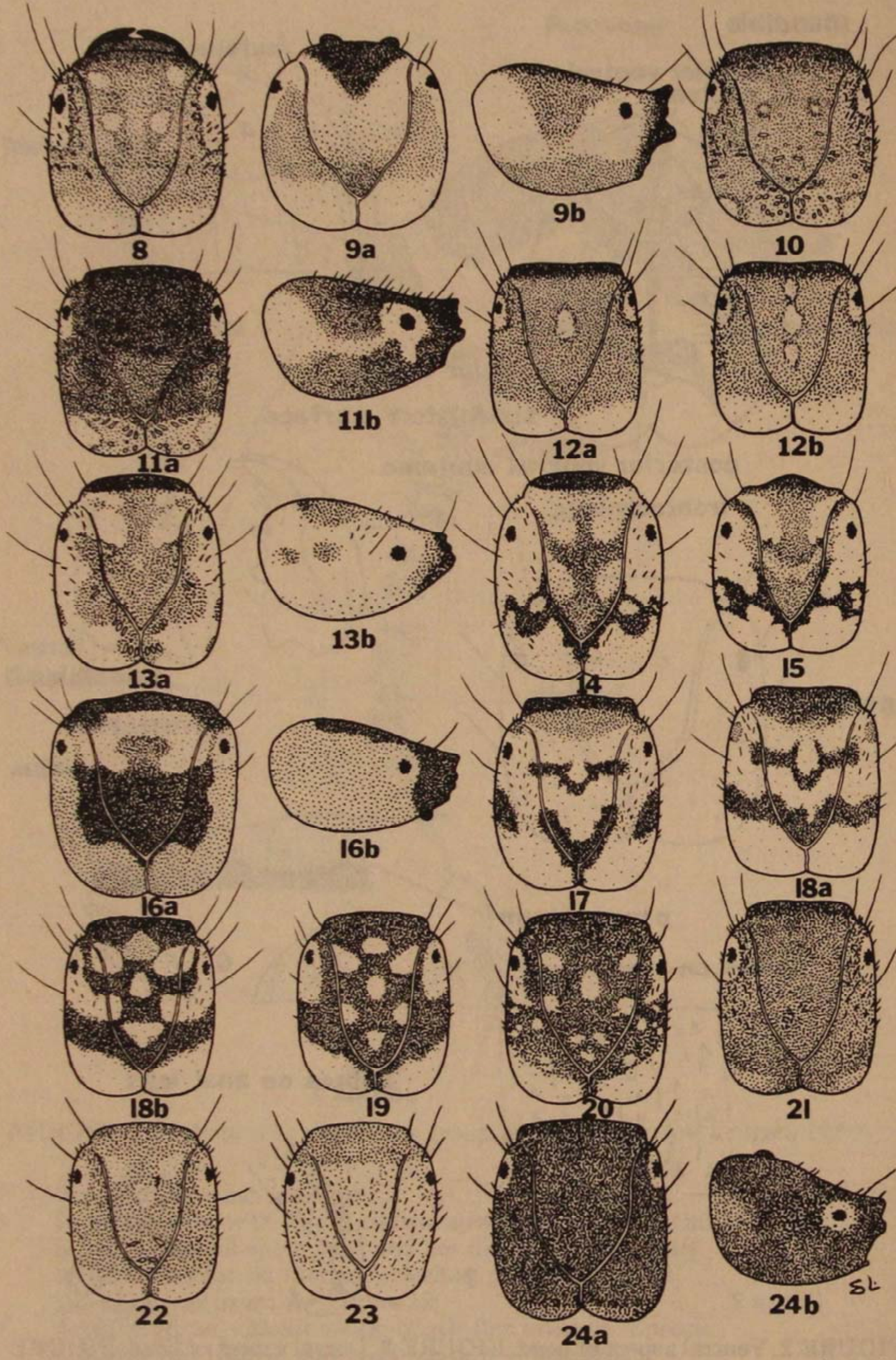

FIGURE 8. *Hydropsyche dicantha*, dorsal view. FIGURE 9a. *Hydropsyche orris*, dorsal view. FIGURE 9b. *Hydropsyche orris*, lateral view. FIGURE 10. *Hydropsyche hageni*, dorsal view. FIGURE 11a. *Hydropsyche leonardi*, dorsal view.

9 Frontoclypeus without denticles 10
10 Frontoclypeus forming an angular point anteriorly (Figure 15) . . . . *H. phalerata*
10′ Frontoclypeus straight or convex anteriorly 11
11 Large heavily sclerotized setae on venter of anal legs (Figure 7) 12
11′ Large heavily sclerotized setae absent on venter of anal legs 13
12 Rounded tubercle on center of anterior ventral apotome (seen best in lateral view) (Figures 16a,b) . . . . *H. hoffmani*
12′ Anterior ventral apotome without tubercle; bowed row of muscle scars laterally on genae behind eyes; pattern on frontoclypeus as in Figure 14 . . . . *H. scalaris*
13 Frontoclypeus with tubercle at posterior angle (seen best in lateral view); head dark brown except around eyes; occasional light areas on genae and frontoclypeus (Figures 24a,b) . . . . *H. depravata* group (*H. betteni*, *H. depravata*)
13′ Frontoclypeus without tubercle at posterior angle 14
14 Head with duck-shaped pattern on genae laterally (Figure 11b) 15
14′ Head without duck-shaped pattern 16
15 Head completely dark brown except duck-shaped mark behind and around eyes; many dark brown bristle-like setae on genae and frontoclypeus (Figures 11a,b) . . . . *H. leonardi*
15′ Head dark brown with two small light spots on frontoclypeus; many muscle scars on dorsum; bristle-like setae few, dorsum shiney; duck-shaped mark behind eyes (Figure 10) . . . . . . *H. hageni*
16 Frontoclypeus with one or two pair of yellow spots; no duck-shaped mark on lateral aspects of genae; numerous setae on genae and frontoclypeus (Figure 8) . . . . *H. dicantha*
16′ One pair of large yellow spots on frontoclypeus; brown flower-shaped mark dorsally on head; duck-shaped mark laterally replaced by large yellow areas with a broken transverse band; setae on genae less in number (Figures 13a,b) . . . . *H. simulans*

The authors believe that the variation of head patterns of *S. bronta* could represent a defense mechanism for the larvae and could be correlated with habitat type (e.g., large or small rocks, rocks with algae, or tree limbs). The two forms of *Symphitopsyche bronta* found in West Virginia give a good example of this type of natural selection suggesting

FIGURE 11b. *Hydropsyche leonardi*, lateral view. FIGURE 12a. *Symphitopsyche slossonae*, dorsal view, one spot on frontoclypeus. FIGURE 12b. *Symphitopsyche slossonae*, dorsal view, three spots on frontoclypeus. FIGURE 13a. *Hydropsyche simulans*, dorsal view. FIGURE 13b. *Hydropsyche simulans*, lateral view. FIGURE 14. *Hydropsyche scalaris*, dorsal view. FIGURE 15. *Hydropsyche phalerata*, dorsal view. FIGURE 16a. *Hydropsyche hoffmani*, dorsal view. FIGURE 16b. *Hydropsyche hoffmani*, lateral view. FIGURE 17. *Symphitopsyche walkeri*, dorsal view. FIGURE 18a. *Symphitopsyche bronta*, variation of Appalachian Form, dorsal view. FIGURE 18b. *Symphitopsyche bronta*, variation of Appalachian Form, dorsal view. FIGURE 19. *Symphitopsyche bifida* group, dorsal view. FIGURE 20. *Symphitopsyche morosa*, dorsal view. FIGURE 21. *Symphitopsyche ventura*, dorsal view. FIGURE 22. *Symphitopsyche sparna*, dorsal view. FIGURE 23. *Symphitopsyche macleodi*, dorsal view. FIGURE 24a. *Hydropsyche depravata* group, dorsal view. FIGURE 24b. *Hydropsyche depravata* group, lateral view.

environmental pressures against the larvae. Possibly, these two forms represent two different habitats. These head patterns serve as a good taxonomic characteristic as well as a link to the past environment which influenced these patterns. The transition forms of these two larvae can also be found in West Virginia and provide a starting point for research in this area.

Acknowledgments

The authors are grateful to Dr. Guenter A. Schuster, Eastern Kentucky University, for his time and effort to confirm all West Virginia species. Many thanks to Mr. Steve Lawton, Marshall University, for illustrating the figures, and Ms. Vickie Crager for typing the manuscript.

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The Relationship Between Body Size and Body Coloration of *Baetisca carolina* Traver Nymphs in Panther Creek, Nicholas County, West Virginia (Ephemeroptera: Baetiscidae)

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Abstract

Considerable inconsistency was noted in the regularity of the coloration exhibited by *Baetisca carolina* nymphs during monthly collections from Panther Creek, Nicholas County, West Virginia, from October 1981 to September 1982. During fall and winter months, the majority of the nymphs exhibited a dark body coloration, with dark pigmentation on the legs and on the ventral surface of the head, thorax, and abdomen. In spring and summer, as the nymphs grew and approached the emergence period, the dark pigmentation diminished among most of the nymphs. A total of 775 nymphs were categorized into 0.1-mm size intervals based on head width, and the percent of individuals with light coloration in each size interval was determined. The correlation coefficient between the midpoint of each size class and the percent frequency of light-colored individuals in that size interval was determined to be 0.87.

The nymphs were closely examined for the presence or absence of a dark basal band on the caudal filaments. A total of 146 immature nymphs (< 1.0 mm head width) were examined and 100 percent of these nymphs exhibited the basal band. A total of 196 mature nymphs with developed wing pads were examined and only 11.2 percent of these nymphs exhibited the basal band. A total of 740 shed nymphal exuviae were examined and only 20.8 percent of these exuviae exhibited the basal band.

Introduction

Baetisca carolina Traver was originally described in 1931 from the Piedmont region of North Carolina. Traver (1937) described *B. thomsenae* (which Berner (1955) synonymized with *B. carolina*) and noted considerable variation in nymphal coloration in the original descriptions of *B. carolina* and *B. thomsenae* (=*carolina*). Tarter and Kirchner (1978) described *B. berneri* from Laurel Fork, Mingo County, West Virginia. They noted that *B. berneri* is closely related to *B. carolina*, but the nymphs can be separated by the intense dark pigmentation on the ventral surface of the head, thorax, and abdomen of *B. berneri*. They observed no color variation in the nymphs of *B. berneri*. Pescador and Berner (1981) reported that absence of distinctive morphological characters to separate the two species casts some doubts as to the distinctive species status of *B. berneri*. They noted that *B. berneri* may be a color variant of *B. carolina*.

Baetisca nymphs were collected from Panther Creek, Nicholas County, West Virginia, from October 1981 to September 1982. On the basis of previous collections and the use of existing taxonomic keys, it was thought that two species, *B. carolina* and *B. berneri*, were present in Panther Creek at the onset of the study. As information was collected throughout the year, however, it became evident that instead of two species, only one species existed in Panther Creek. Resource partitioning did not exist on the spatial, temporal, or trophic dimension. Multivariate analysis indicated that morphologically only one species was present. The original descriptions of *B. carolina* and *B. thomsenae* (= *carolina*) were studied along with the original description of *B. berneri*. Additional specimens from seven states were closely examined, including specimens from both holotype localities. Due to the amount of accepted variation in coloration and morphology of *B. carolina*, and the lack of such variation in *B. berneri*, as originally described by Tarter and Kirchner (1978), the authors decided that the population from Panther Creek is *B. carolina*.

Taxonomy and Distribution

The endemic family Baetiscidae contains only the genus *Baetisca* Walsh. The genus *Baetisca* is Nearctic in distribution, though most abundant and diverse in the southeastern United States. Presently the genus contains ten species. *Baetisca carolina* occurs in Georgia, South Carolina, North Carolina, Tennessee, Virginia (Pescador and Berner, 1981), and West Virginia (Needham et al., 1935; Berner, 1955). *Baetisca carolina* has been collected from Nicholas, Greenbrier, Monongalia, Pocahontas, and Webster Counties in West Virginia.

Materials and Methods

The relationship between body coloration and body size was determined by calculating the correlation coefficient between color and size. Nymphal head width was used as the measurement of body size. Nymphs were grouped into 0.1-mm size intervals based on head width. The percentage of light-colored individuals in each size interval was determined. An individual was classified as a light or dark individual based on coloration and banding of the legs, and coloration on the ventral surface of the head, thorax, and abdomen. The correlation coefficient between the midpoint of each size interval was determined. Because of size superiority exhibited by female nymphs, the correlation coefficient was calculated for three differing groups: 331 female nymphs; 301 male nymphs; and 775 nymphs which included females, males, and nymphs too small to be sexed.

The nymphal size where coloration changed most conspicuously was determined by graphing size versus percent light individuals. A procedure known as moving averages was used to smooth the curve; this eliminated any irregularities in the curve caused by low sample sizes. The curve was smoothed by calculating the percent of light individuals for three consecutive size intervals and plotting that percent versus the midpoint head width of the middle size interval. The percent of light individuals for the head width of 0.65 mm was determined by combining the data for 0.55 mm, 0.65 mm, and 0.75 mm, etc.

The Panther Creek *Baetisca* population was closely examined for the presence or absence of the basal band on the caudal filaments in order to determine the reliability of this banding as a valid taxonomic character. The color of the band, whether black or brown, was not considered to be important, as both colors were present. One hundred and forty-six immature nymphs, too small to be sexed, were examined; one hundred and ninety-six mature nymphs, having developed wing pads, were examined; and seven hundred and forty shed nymphal exuviae were examined. The percentage of each group which exhibited the presence of the basal band was determined and differences were noted.

Results and Discussion

During the months of October through February, less than 28 percent of the nymphs collected exhibited a light body coloration (Figure 1). The percentage of light individuals increased for the months of March through May, peaking at 89 percent in May. The percentage of light individuals greatly decreased during June, dipping to 38 percent, while the percentage greatly increased (83 percent) in July. The percentage of light individuals showed large decreases for the months of August and September. These monthly increases and decreases in percentage of light individuals corresponded to the monthly increases and decreases in the growth pattern shown by nymphs (Figure 2), indicating that body coloration is associated with body size. If these observed fluctuations had been caused by an environmental factor, such as temperature or chemical changes in the water, the decreased percentage of light individuals in the June collection should not have occurred. The temperature showed no extreme fluctuations, nor did the chemical parameters measured. This indicates that the source of the color fluctuations is probably endogenous rather than exogenous.

The correlation coefficient between the midpoint of each size interval and the percent frequency of light individuals in that size interval was determined to be 0.87 (Figure 3). The nymphs used in this correlation included females, males, and nymphs too small to be sexed (head width less than 1.0 mm). Because of size superiority of the female nymphs, additional correlation coefficients were determined separately for the female population and the male population. The correlation coefficient for females was 0.86 and for males was 0.84, indicating that change in coloration occurred uniformly in both sexes. All correlations differed significantly from zero with $p < 0.005$.

Nymphal coloration changed most conspicuously when the head width approached 2.25 mm (Figure 4). When the head width was less than 2.25 mm, less than 50 percent of the population exhibited light coloration. When the head width was greater than 2.25 mm, more than 50 percent of the population exhibited light coloration. The size where coloration changed most conspicuously was additionally determined

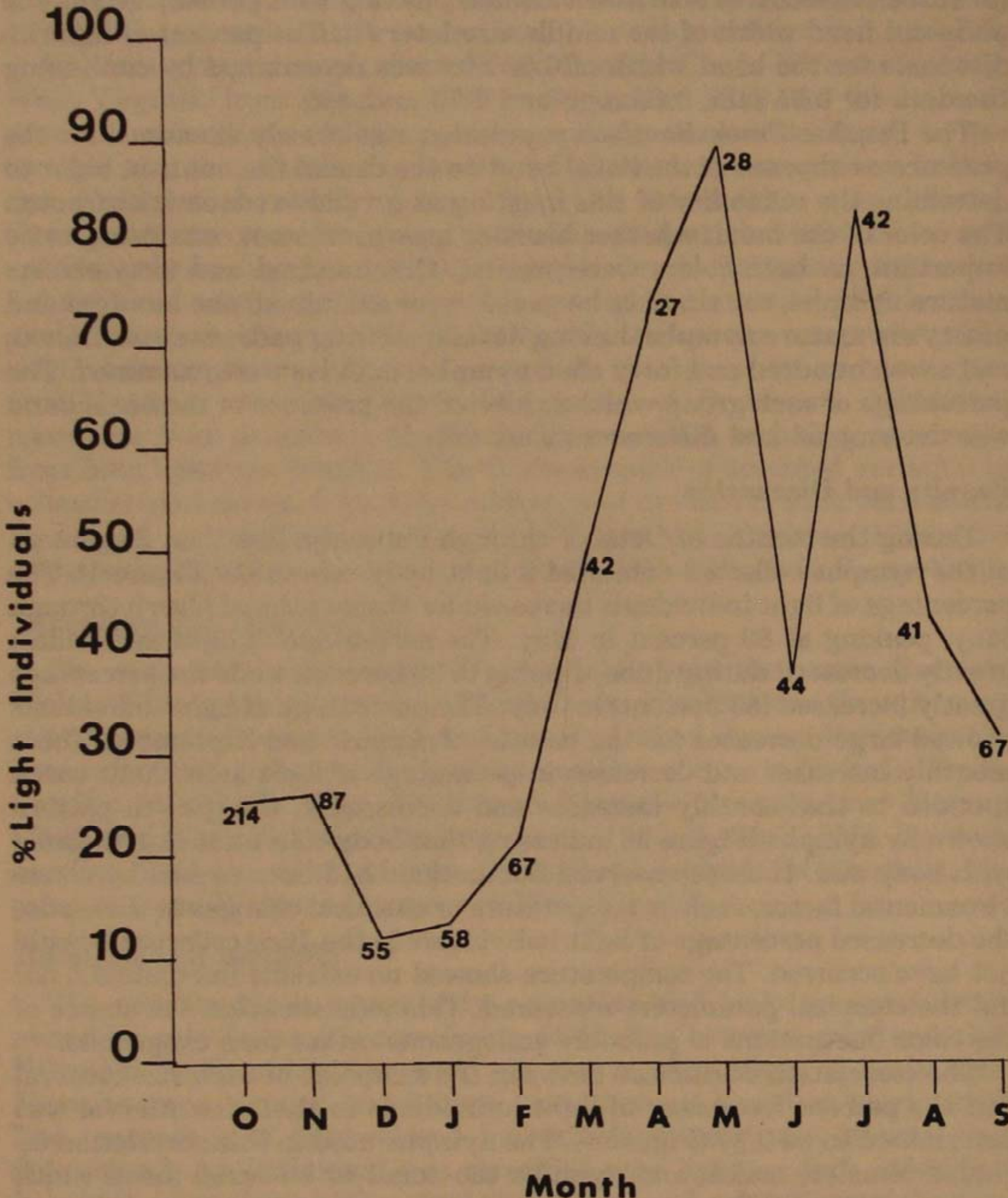

FIGURE 1. Percentage of *Baetisca carolina* nymphs exhibiting light body coloration, Panther Creek, Nicholas County, West Virginia, from October 1981 to September 1982. Number of individuals collected is given each month.

separately for female and male nymphs. Because of female size superiority, more than 50 percent of the females exhibited light body coloration at a head width of 2.15 mm; for males, this change occurred at a head width of 2.25 mm. This also indicates that change in coloration occurred uniformly in both sexes.

Examination of the dark basal band on the caudal filaments indicated that changes occurred as the nymphal size increased. One hundred per-

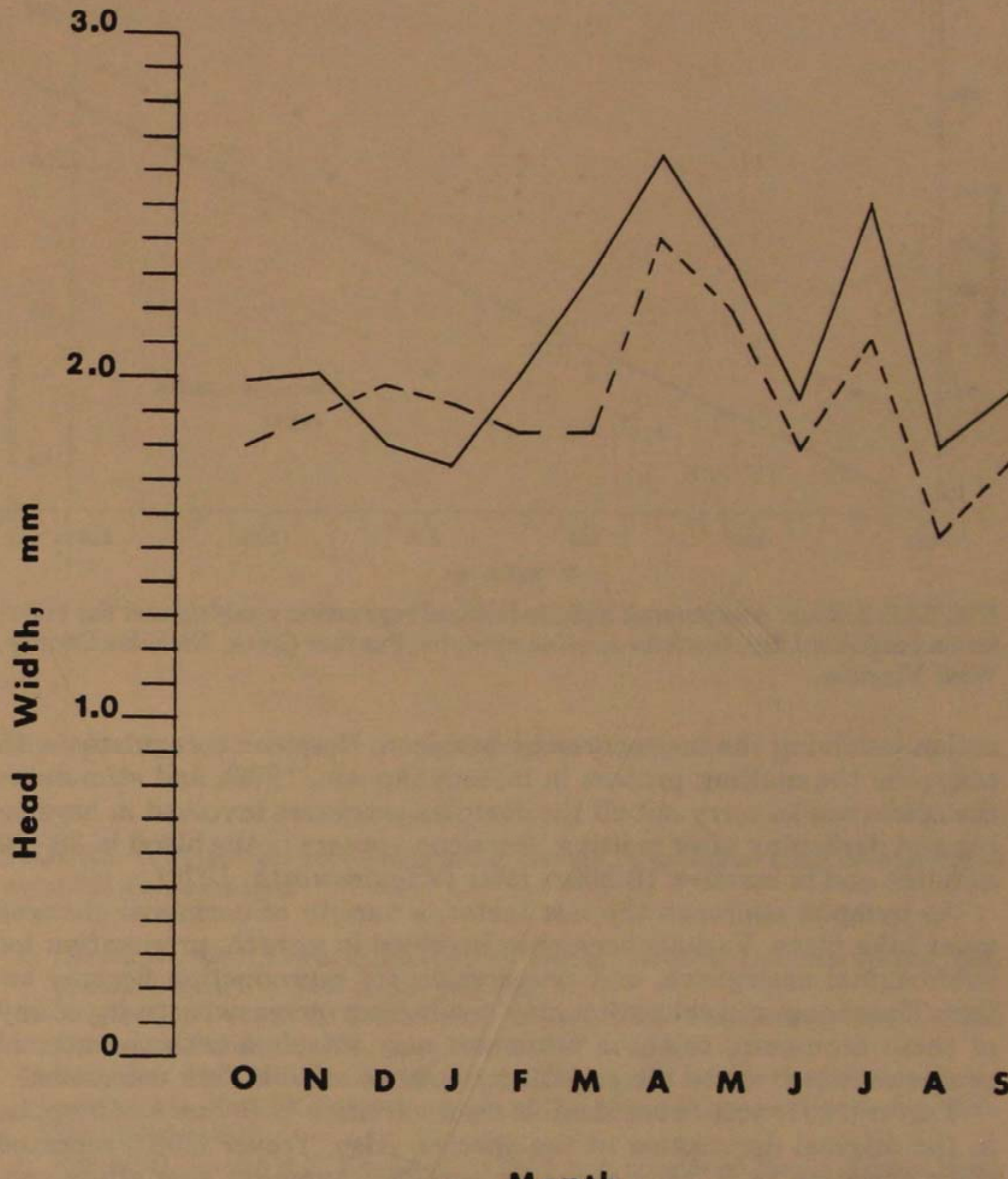

FIGURE 2. Growth of *Baetisca carolina* nymphs based on mean monthly head widths. Solid line represents female growth; broken line represents male growth.

cent of the immature nymphs too small to be sexed (head width less than 1.0 mm) exhibited the basal band. Only 11.2 percent of mature nymphs with developed wing pads exhibited the basal band. Only 20.8 percent of the shed nymphal exuviae exhibited the basal band. This indicates that the percentage of nymphs which exhibited the basal band changed dramatically as nymphal size increased.

The precise mechanism involved in this change is not known at the present time. The change probably is caused by some type of hormonal

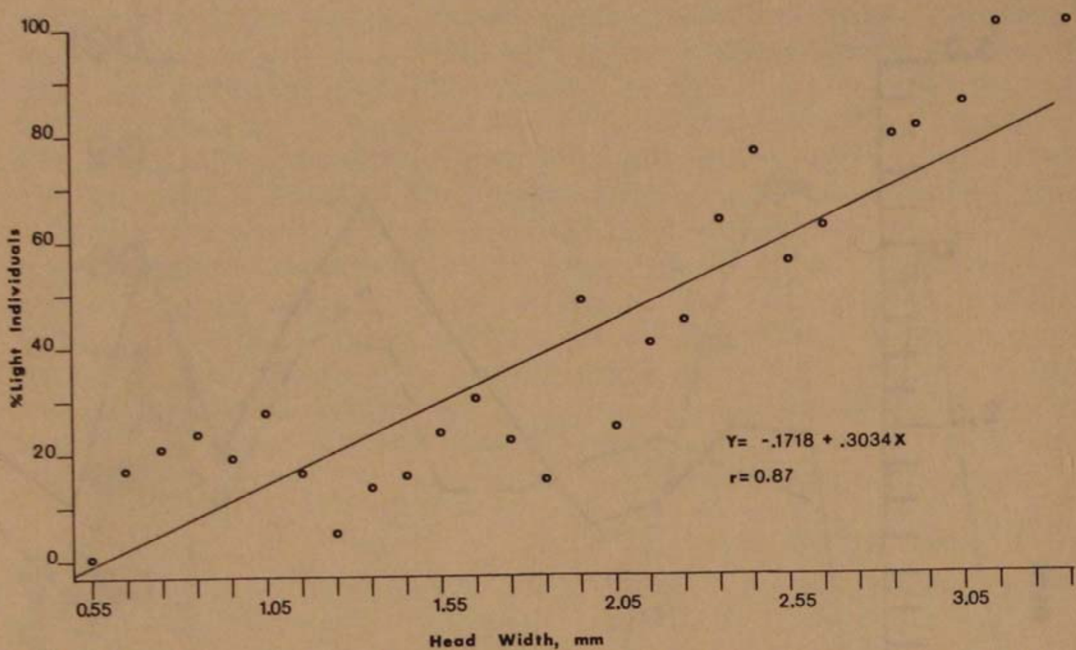

FIGURE 3. Body size-percent light individual regression analysis and the correlation coefficient for *Baetisca carolina* nymphs, Panther Creek, Nicholas County, West Virginia.

action involving the neurohormone bursicon. Bursicon coregulates with ecdysone the molting process in insects (Agosin, 1978), and stimulates the epidermis to carry out all the complex processes involved in hardening and darkening after molting. Bursicon appears in the blood in 30 - 60 minutes and is inactive 10 hours later (Wigglesworth, 1970).

As nymphs approach the last instar, a variety of hormonal changes must take place. Various hormones involved in growth, preparation for subimaginal emergence, and preparation for reproduction become active. The changes in coloration may result from increased activity of any of these hormones, or these hormones may interfere with the normal processes which cause the smaller nymphs to exhibit dark coloration.

Traver (1931) noted considerable color variation in *B. carolina* nymphs in the original description of the species. Also, Traver (1937) reported color variation in *B. thomsenae* (= *carolina*) nymphs. This study confirms Traver's original observations, and additionally indicates that two colormorphs which exhibit changes in coloration exist in Panther Creek. These findings further indicate that coloration is not suitable as a characteristic upon which to differentiate between two closely-related species such as *B. carolina* and *B. berneri*. If *B. berneri* is indeed a separate species, rather than a color variant of *B. carolina*, more distinctive evidence than is presently known is needed.

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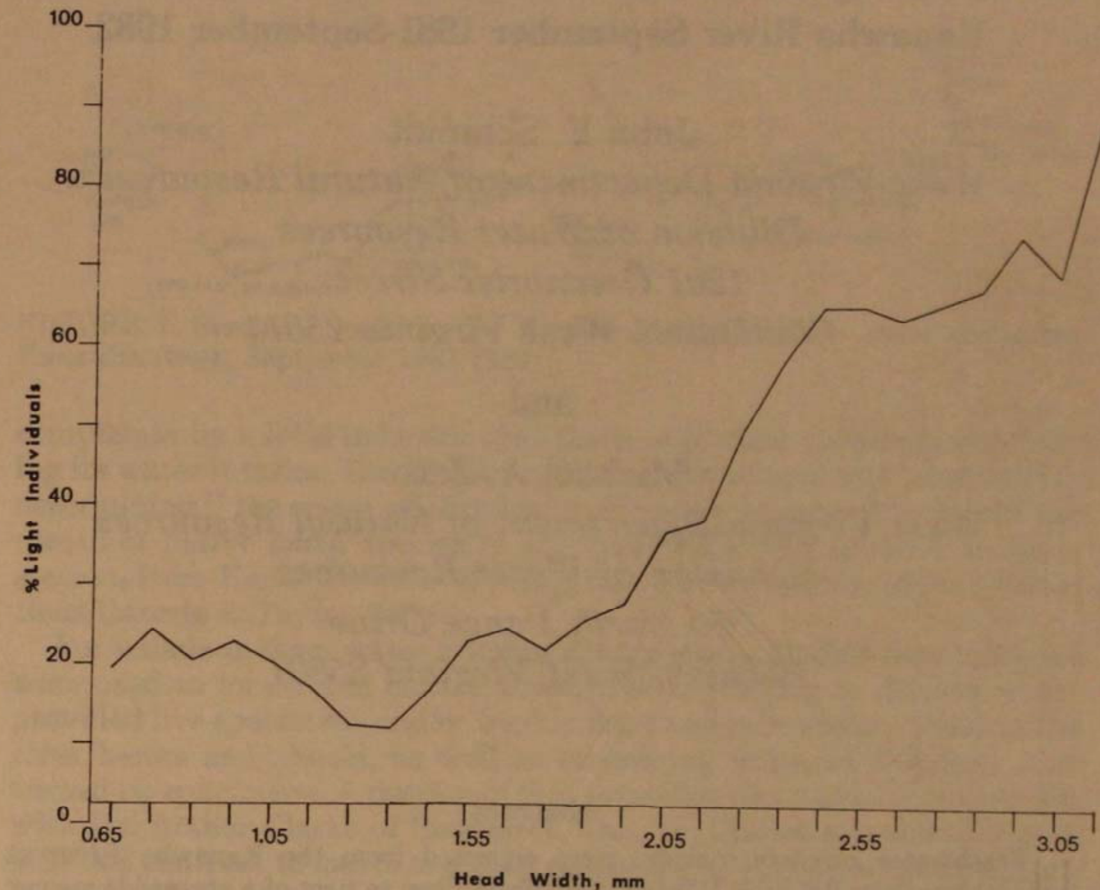

FIGURE 4. Smoothed curve indicating change in nymphal body coloration as nymphal size increases.

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A Survey of the Freshwater Mussel Fauna of the Kanawha River September 1981-September 1982

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Abstract

Freshwater mussels (naiads) were collected from the Kanawha River at several locations between Winfield and Falls View as part of a statewide survey to identify naiad populations. Sampling took place during the Fall of 1981 and the Fall of 1982 when the river was low and clear. Naiad populations were sampled with a 10-foot dovetail mussel brail and sight/hand collecting.

Nineteen species of naiads and the asiatic clam *Corbicula* sp. were collected. The majority (18 species) were collected in the seven-mile stretch of the Kanawha River downstream of Kanawha Falls. Two species—*Cyprogenia stegaria* and *Obliquaria reflexa* are very rare in West Virginia. Only *Corbicula* sp. and one naiad species, *Anodonta g. grandis,* were collected downstream of Charleston. No endangered species were collected, although a population of *Lampsilis abrupta* (= *orbiculata*) is known to occur downstream of Kanawha Falls near Deepwater.

Introduction

The West Virginia Department of Natural Resources, Division of Water Resources is currently involved in a statewide survey of West Virginia's freshwater mussel (naiad) resources. The purpose of this survey is to locate and map significant naiad populations throughout the state to aid in water quality monitoring. As part of this survey the Kanawha River was surveyed at several locations between Kanawha Falls and Winfield from September 1981 to September 1982.

Methods and Materials

A total of 31.6 miles of the Kanawha River was investigated (Figure 1). The lower section, from St. Albans to Winfield, was investigated after

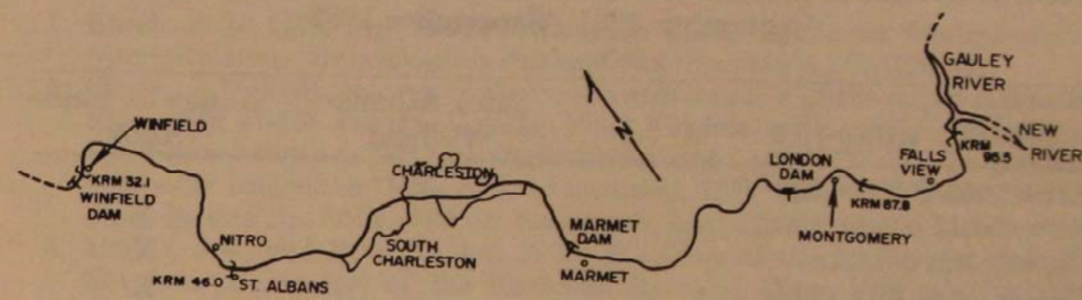

FIGURE 1. Sampling locations for Bivalve Mollusks in the lower and upper Kanawha River, September 1981-1982.

complaints by a local industry that the asiatic clam *Corbicula* was fouling its water intakes. The Division of Water Resources was interested in determining if the water quality had sufficiently improved to permit the return of native naiad species to the lower Kanawha River. The upper section, from Kanawha Falls to Alloy, was known to have naiad populations (Morris & Taylor, 1978).

For naiads in deep water a Ponar dredge and a 10-foot dovetail brail were used to locate and collect, respectively. Wading in shallow water provided live specimens and/or freshly dead and relic shells. Walking the river banks and shoals, as well as examining muskrat middens, also turned up specimens. A portion of this sampling was done in conjunction with Dr. Arthur Clarke of Ecosearch, Inc. Dr. Clarke was working on a USFWS contract to locate and map suspected populations of two endangered species in the upper Kanawha River.

Initially, all live specimens collected were returned to the lab for cleaning and identification. Afterwards, only unusual specimens and those unidentifiable in the field were returned to the lab. All dead shell material collected was bagged and labeled as to collection location and returned to the lab for cleaning and identification. All specimens were identified to the species level using descriptions and keys provided in Pennak (1978), Burch (1975), and Parmalee (1967). In addition Drs. G. A. Cole and S. E. Neff of the University of Louisville and Dr. D. H. Stansbery of Ohio State University provided confirmation on difficult specimens.

Results and Discussion

Lower Section—St. Albans to Winfield

Only one specimen of the naiad species, *Anodonta g. grandis,* was collected in the lower section of the Kanawha River (Table 1). It was found along the left descending bank across from Nitro, West Virginia. The asiatic clam, *Corbicula fluminea,* was also collected, but not in great abundance.

Upper Section—Kanawha Falls to Alloy

This section of the river yielded 18 naiad species and the asiatic clam (Table 1). The majority were collected between miles 92.0 and 95.0. No

Table 1. Species of Freshwater Mussels Collected in the Kanawha River, September 1981 - September 1982

SPECIES	Saint Albans-Winfield	Kanawha Falls-Alloy
Anodonta g. grandis	X	
Strophitus u. undulatus		X
Lasmigona costata		X
Quadrula p. pustulosa		X
Amblema p. plicata		X
Fusconaia m. maculata		X
Cyclonaias tuberculata		X
Pleurobema sintoxia		X
Elliptio c. crassidens		X
Elliptio dilatata		X
Ptychobranchus fasciolaris		X
Obliquaria reflexa		X
Cyprogenia stegaria		X
Actinonaias ligamentina carinata		X
Obovaria subrotunda		X
Leptodea fragilis		X
Potamilus alatus		X
Lampsilis ventricosa		X
Lampsilis fasciola		X
Corbicula fluminea	X	X

endangered species were collected despite the suspected occurrence of *Epioblasma t. torulosa* and the known occurrence of *Lampsilis abrupta* (=*orbiculata*) within this reach (Clarke, 1982). Two other species collected, *Cyprogenia stegaria* and *Obliquaria reflexa*, are considered very rare in West Virginia.

Summary and Conclusions

A total of 19 naiad species and the asiatic clam were collected from the Kanawha River during the one-year period, September 1981 to September 1982. Only one naiad was collected on the lower section of the Kanawha River (downstream of Charleston). Two of the eighteen naiad species collected on the upper section of the Kanawha River (below Kanawha Falls) are considered rare in West Virginia. No endangered species were collected, although a population of *Lampsilis abrupta* does exist in the upper section.

Acknowledgment

Dr. S. E. Neff of the University of Louisville provided initial aid with his instruction of brailing methods.

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The Taxonomic Status and Distribution of the Stoneflies *Malirekus hastatus* (Banks), *Yugus arinus* (Frison), and *Y. bulbosus* (Frison) in West Virginia (Plecoptera: Perlodidae)

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Abstract

Malirekus hastatus (Banks) and *Yugus bulbosus* (Frison) are distributed throughout 12 and 11 counties, respectively, in all drainage basins of West Virginia except the Little Kanawha River and slow, low gradient streams along the Ohio River. Naiads of both species are found from first-order streams to fifth-order rivers. Fifteen watersheds, including two rivers, contain naiads of both species. Based on more definitive characteristics, *Y. arinus* (Frison) is not found in West Virginia as previously reported in the literature.

Introduction

Originally, the genera *Malirekus* and *Yugus* were subgenera in the genus *Isogenus* (Ricker, 1952). Illies (1966) elevated both subgenera to the generic level. Hissom and Tarter (1976) recorded *Malirekus hastatus*

(Banks), *Yugus arinus* (Frison), and *Y. bulbosus* (Frison) as state records from West Virginia. However, they were cautious about the identification of *Y. arinus* and *Y. bulbosus*. "There is so much discrepancy in the identification of these two species that the authors feel that further study is necessary to ascertain more definitive characteristics to distinguish the *Yugus* species" (Hissom and Tarter, 1976: p. 320). Presently, the following characters can be used to separate mature naiads of all three species (Kirchner, pers. comm.): (1) left mandible (ventral view) with five teeth—*M. hastatus* and *Y. bulbosus*, (2) left mandible (ventral left) with four teeth—*Y. arinus*, (3) one row of occipital spinules—*M. hastatus*, and (4) several rows of occipital spinules—*Y. bulbosus*.

The primary objectives of this investigation were (1) to clarify the taxonomic status of *Malirekus hastatus*, *Yugus arinus* and *Y. bulbosus* in West Virginia and (2) to report revised distribution patterns of the three species.

Results

Malirekus hastatus

Geographic range. Georgia, New England, New Hampshire, North Carolina, South Carolina, Quebec, Tennessee, Virginia, West Virginia (Illies, 1966; Zwick, 1973; Hissom and Tarter, 1976; and Kondratieff and Voshell, 1982).

Distribution in West Virginia. Except in small tributaries along the Ohio River and the Little Kanawha River, the naiads are found throughout 12 counties: Clay Co.—Elk River; Fayette Co.—Smithers Creek; Kanawha Co.—Dempsey Creek, Pack's Branch, Slater Creek; Logan Co.—Frogtown Hollow, Trace Fork of Copperas Mine Fork; McDowell Co.—Elkhorn Creek, East River; Mingo Co.—Laurel Fork; Nicholas Co.—Bear Run, Bryant Run, Desert Run, Hocking Run, Hinkle Branch, Jake Run, Line Creek, Little Run, Lower Cabin Run, North Fork Cherry River, Persinger Creek, Sugar Branch; Pendleton Co.—Seneca Creek, White's Run; Pocahontas Co.—Williams River; Randolph Co.—Gandy Creek, Glady Fork, Otter Creek, Red Creek, Tygart River; Webster Co.—Big Laurel Run, Dogway Fork, Dry Bread Run, Elbow Branch.

Yugus bulbosus

Geographic range. Georgia, North Carolina, Pennsylvania, Tennessee, Virginia, West Virginia (Ricker, 1952; Illies, 1966; Hissom and Tarter, 1976; Surdick and Kim, 1976; and Kondratieff and Voshell, 1982).

Distribution in West Virginia. Calhoun Co.—Little Bear Fork; Clay Co.—Elk River; Fayette Co.—Smithers Creek; Logan Co.—Frogtown Hollow; Mingo Co.—Laurel Fork; Nicholas Co.—Lick Run, Little Run, Prince Fork, Right Fork, Rock Camp, South Fork of Cherry River; Pendleton Co.—Seneca Creek, White's Run; Pocahontas Co.—Charlie's Creek; Preston Co.—Roaring Creek; Randolph Co.—Gandy Creek, Glady Fork; Webster Co.—Camp Creek, Elk River, Gauley River, Laurel Creek, Turkey Creek, Williams Camp Run.

Discussion and Conclusions

Hissom and Tarter (1976) reported state records and distribution data for *Malirekus hastatus, Yugus arinus,* and *Y. bulbosus.* More definitive characters have shown that *Y. arinus* is known only from Georgia, North Carolina, Tennessee, and Virginia (Ricker, 1952; and Kondratieff and Voshell, 1982). The naiads of *M. hastatus* and *Y. bulbosus* are often found together from first-order streams to fifth-order rivers in West Virginia. Generally, the naiads of both species are absent from low gradient streams and rivers along the Ohio River.

Acknowledgments

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The Status of Jumping Mice (Family Zapodidae) in West Virginia

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Abstract

Materials from the West Virginia Mammal Survey, Marshall University Mammal Collection and published scientific literature are brought together to produce a concise picture of known records of occurrence for these two species in the state.

This report mentions specimens of *Zapus hudsonius* from ten counties including previously unreported records from Putnam County. The Putnam County record represents a significant extension of the known range of distribution for this species within the state. All previous reports were from the northern and eastern panhandles.

The records for *Napaeozapus insignis* cover fourteen counties and include previously unreported records from Wayne, Putnam and Kanawha counties. These records are important in that they not only extend the known distribution into southwestern West Virginia, but they also are at low elevations (Ca. 500′ to 700′). All previous records were from elevations ranging between 1,700′ and 4,700′.

Introduction

The family Zapodidae is represented in West Virginia by two species: *Zapus hudsonius,* the meadow jumping mouse; and *Napaeozapus insignis,* the woodland jumping mouse. Hamilton and Whittaker (1979) give the distribution of *Z. hudsonius* as covering most of the eastern United States, Barbour and Davis (1974), however, mention a hiatus in the distribution of this species in eastern Kentucky and the western half of West Virginia. The preferred habitat for *Z. hudsonius* is said to be grassland marshes, lakeside weeds, and weedy, wet meadows (Barbour and Davis, 1974). Hamilton and Whittaker (1979) give the distribution of *N. insignis* as the extreme northeastern United States and along the Appalachian Mountains to Georgia and South Carolina. According to the currently available literature, this mouse is found only at higher elevations. Wet woodlands and grassy stream banks are listed as their preferred habitat (Barbour and Davis, 1974). Houtcooper (1982), however, has found that both species of jumping mice occur throughout Kentucky at various elevations.

It is hoped that this paper will shed light on the following two questions: (1) What is the known distribution of jumping mice in West Virginia? (2) Is there a preference exhibited by either mouse for habitat at a particular elevation?

Methods

During the months April, May, and June of 1982, routine small mammal trapping was done in Putnam County, West Virginia. This was part of a pre-construction environmental analysis being conducted by the U.S. Army Corps of Engineers in the area of Winfield Locks and Dam on the Kanawha River. Snap-back kill traps were set along parallel transects (5 m between traps and between lines) and baited with peanut butter and rolled oats. Interestingly, both resident species of jumping mice were collected during this period.

As a result of this rather unexpected find, a search was conducted for additional low elevation and/or western West Virginia specimens. West Virginia Mammal Collection specimens were checked, in addition to literature records. Mr. Gene Frum, a mammalogist and faculty member at Marshall University, provided data from his extensive personal collection. Information on elevation was taken, when available, from museum cards or published records. These data are presented in Tables 1 and 2.

Results

Data on four previously unpublished records of jumping mice in West Virginia are presented in Table 3. The presence of *Z. hudsonius* in Putnam County, in western West Virginia, in conjunction with Houtcooper's work in eastern Kentucky, indicates that the hiatus for *Z. hudsonius* mentioned by Barbour and Davis does not exist. *Napaeozapus insignis* was not previously known to extend west of the mountainous region in eastern West Virginia, and many of the previously known specimens were collected at rather high elevations (1000 m and above). The average elevation at which the western West Virginia specimens were collected was less than 200 m.

Conclusions

Both species of jumping mice occurring in West Virginia are probably much more widespread than the earlier literature had indicated. Houtcooper (1982) and Barbour and Davis (1974) both mention that jumping mice are extremely trap-shy and difficult to catch using standard trapping techniques. Additional trapping throughout the state, using sunken bucket traps instead of the familiar snap-back trap, will most likely produce specimens of both species in every county.

The proposed absence of *Z. hudsonius* from western West Virginia and the belief that *N. insignis* has a preference for habitats located at higher elevations does not appear to be indicative of reality. The natural beauty and relatively pristine conditions found in mountainous eastern West Virginia would have great appeal to mammalogists, and it is only logical that study efforts would be concentrated there. The more densely populated urban areas of western West Virginia would have little appeal

Table 1. Elevation of Collecting Sites of *Napaeozapus insignis* in West Virginia Counties

County	*Elevation (in meters)*			
Greenbrier	954			
Hancock	277	246		
Monongalia	615	338		
Nicholas	769			
Pendleton	1446			
Pocahontas	1015	1354		
Preston	523	646		
Randolph	1077	923	1200	1338
Tucker	954	985		
Wayne	231			
Cabell	169			
Putnam	172			
Kanawha	185			

Table 2. Elevation of Collecting Sites of *Zapus hudsonius* in West Virginia counties

County	*Elevation (in meters)*
Hancock	215
Jefferson	192
Pleasants	185
Pocahontas	1046
Wetzel	200
Putnam	172

to most field-oriented biologists. This type of sampling bias may be the reason why only scant records exist for wildlife of all kinds in this area.

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Table 3. New Records of Jumping Mice in West Virgina

Species	*Sex*	*Weight* (g)	*Total Length* (mm)	*Tail Length* (mm)	*Hind Foot Length* (mm)	*Ear Length* (mm)	*Collector*	*County*	*Locality**
Zapus hudsonius	M	17.0	184	108	26	10	K. Horn	Putnam	1
Napaeozapus insignis	M	NA	215	130	28	15	J. Rohr	Kanawha	2
N. insignis	F	16.3	198	118	28	12	R. Taylor	Putnam	3
N. insignis	M	NA	212	120	27	10	R. Taylor	Putnam	3

*Trapping localities:
1. Winfield City Park, near equestrian ring
2. Off Hampton Road, Charleston, West Virginia
3. Along Hurricane Creek, 500 m west of State Route 35

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Associations of Cancer Mortality Rates and Exogenous Environmental Factors in West Virginia

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Abstract

Correlation analyses were completed on West Virginia county data for cancer mortality rates and on county geological, water quality, air quality, and coal production variables. The individual cancer mortality variables most frequently observed to be in association with environmental variables were: mouth, pancreas, and rectal cancers in males, and nasal, lip, and stomach cancers in females. The environmental variables most frequently associated with these cancers were: (1) levels of alkalinity, water flow, acidity, zinc, dissolved oxygen, phosphate, and manganese found in the natural waters of the various counties; (2) levels of particulates, hydrocarbons, and nitrous oxides in the air; (3) the percentage of the county underlain by brine, medium bituminous coals, and three types of limestone; and (4) to a minor degree, the number of sand quarries in the county.

An "acid mine drainage" environmental factor as defined by factor analysis was highly associated with two cancer mortality groupings viz., "male digestive" and "female upper digestive" cancers. Two other water factors "alkalinity" and "zinc" were also strongly associated with the "male digestive" cancer factor.

The environmental factors are likely to be, at least in part, surrogates for other populational or occupational aspects of the demography such as urban-industrialized and rural-coal-producing areas.

Introduction

The hypothesis that relationships exist between environmental characteristics and human cancers has been suggested many times. However, most studies have assessed one, or only a few, environmental characteristic(s). For example, Carlow and Meiere[1] examined the relationship between airborne levels of benzo(a)pyrene (BaP) and pulmonary cancer. They found that airborne BaP is present in large quantities in industrial complexes where workers have been found to have high rates of pulmonary cancer.

Other investigators examined large geographical regions. Inaba et al.[2] and Cudmore et al.[3] examined geographical patterns of cancer, and concluded that clusters of certain types of cancer exist. Generally, the reasons for the observed clustering are unknown. However, on occasion, suggestive causative agents appear. For instance, there is a high incidence of skin cancer in the sunbelt of the U.S. as noted in the Atlas of Cancer Mortality for U.S. Counties.[4] When using this geographical approach, Davies and Chilvers[5] emphasize the need for the examination of data gathered in small geographical units. This was the precise strategy chosen for this project viz., that a small, geographically heterogeneous region (West Virginia) with highly diverse environmental attributes be examined for significant associations among 52 environmental characteristics and 12 types of cancer (separately in white males and in females).

Methods

Fifty-two environmental variables measured in the 55 counties of West Virginia were compared with cancer mortality variables for Caucasian males and females. These include lip, intestine, bile duct, larynx, mouth, nasal, esophagus, nose, rectum, stomach, pancreas, and salivary gland cancers. The cancer mortality rates were reported as deaths per 1,000 individuals for each county.[4] The environmental variables included geological, water quality, and air quality parameters.* These two data bases (environmental and cancer mortality variables) were first scanned by use of stepwise regression analyses, in order to identify significant predictors among the 52 environmental variables for each of the 24 cancer mortality rates.

Multiple linear regression analyses were thereafter used to more precisely determine the relationships. The six cancer mortality rates showing the highest degree of association with environmental variables as measured by the magnitude of the coefficient of determination (R^2) were those chosen for presentation.

Factor analyses were performed on four sets of data: 1) the 24 types of cancer; 2) the air pollution variables; 3) the water quality variables of natural waters**; and 4) the geologic variables. Only the first three factors (the three most important***) from the factor analysis of the water quality data set were chosen for further analysis. Additive indices of the major component variables of the factors (factor loadings) were subsequently constructed and correlated to the component variable indices of the three most important factors of the cancer mortality data set (Table 1).

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*The sources of these variables are given in more detail in Strouse, Keller, and Tucker. (This volume of these Proceedings.)

**By natural waters we refer to the streams, rivers, and reservoirs of West Virginia.

***Those accounting for the greatest proportion of variability.

Table 1. Results of Factor Analyses Showing the Three Most Important Factors for the 24 Types of Cancer Mortality and for the Natural Waters[1] of WV

	Factor Components	
Factor	*County Cancer Mortality Rates*	*County Natural Water Quality Variables*
First Factor	("male digestive" factor) male cancers of the: esophagus intestine mouth rectal pancreas	("acid mine drainage" factor) average and maximum acidity average and max. total hardness average and maximum sulfate average and maximum iron average pH
Second Factor	("female upper respiratory" factor) female cancers of the: larynx pancreas nose	("alkalinity" factor) average, maximum, and minimum alkalinity
Third Factor	("female upper digestive" factor) female cancers of the: salivary glands mouth stomach esophagus	("zinc" factor) average, maximum, and minimum zinc maximum dissolved oxygen

[1]See note on page 83.

The linear correlation analyses were completed in order to examine the extent of associations among the two index groups (the three indices from the most important cancer mortality factors and the three indices from the most important natural water quality factors). The objective in this part of the analyses was to determine the extent of association among the sets of dependent and independent variables defined by factor analysis. This is similar to the methodology of canonical correlation analysis.

These six linear indices were examined in all combinations via linear correlation. For example, the index for the first factor of the cancer mortality data set was called the "Male Digestive Index" and was computed as the number of male cancer deaths per 1000 due to cancer of the esophagus, intestine, mouth, rectum, and pancreas. Further, even though strong linear correlations occurred for these indices, log, square root, and other power transformations of the sums of these linear combinations

Table 2. Probability Levels for the Hypothesis that $R^2=0$ for the 24 Linear Regressions with Models Having Four Independent Variables, by Types of Cancer Mortality

Types of Cancer White males and females	*Males Probability that $R^2=0$*	*Females Probability that $R^2=0$*
lip	.0037	.0001[a]
intestine	.0143	.0019
bile duct	.0012	.3135
larynx	.1086	.2146
mouth	.0001[a]	.1000
nasal	.1621	.0008[a]
esophagus	.0372	.0392
nose	.0897	.0247
rectal	.0001[a]	.0067
stomach	.0016	.0001[a]
pancreas	.0001[a]	.0012
saliva	.2045	.1316

[a]The six analyses reported in detail in Table 3.

were also computed in an attempt to mitigate the possible scalar effects of the process used in creating the indices.

The correlation of these derived indices does not allow for precise hypothesis testing, since the components of the indices themselves were not randomly chosen. The correlation results do, however, demonstrate the interpretative strength of examining indices based on factor loadings of the principal factors of each data set, similar to canonical correlation on raw indices.

All of the above analyses were completed using the Statistical Analyses System[6] of the West Virginia Network for Educational Telecomputing.

Results

Using stepwise linear regression, Table 2 shows the levels of relationship (using R^2 values) and their associated probabilities for each cancer variable as functions of the independent environmental variables. Of the 24 initial regression analyses, 16 showed statistically significant associations. Six of these models were chosen for presentation because of their low probabilities for rejection of R^2 under the null hypothesis (Table 3). These six models are cancer mortalities of the mouth, rectum, and pancreas in males, and cancer of the lip, nose, and stomach in females. Only models with four independent variables were presented since the inclusion of additional variables generally resulted in considerably smaller increases in R^2.

The rate of mouth cancer in males showed a significant association

Table 3. Stepwise Regression Results for Six Cancer Models with Four Independent Variables

Types of Cancer	*Degrees of Freedom*	*Probability*	R^2	*Independent Variables (−) indicates a negative coefficient*
Males				
mouth	39	0.0001	.6059	HC emitted minimum alkalinity maximum flow (−) particulates emitted
pancreas	39	0.0001	.5817	minimum alkalinity mean acidity sand quarried maximum flow
rectal	44	0.0001	.5207	minimum zinc (−)% brine (−)% medium bitum NOx emitted
Females				
nasal	42	0.0008	.3860	(−) minimum DO (−) maximum DO mean DO minimum PO_4
stomach	43	0.0001	.5812	mean SO_4 brine/lime (−) maximum DO (−) % slime
lip	42	0.0001	.9186	minimum zinc (−) maximum DO mean PO_4 maximum Mg

DEFINITIONS:
probability = probability that $R^2 = 0$.
R^2 = coefficient of determination.
HC emitted = tons/year of hydrocarbons emitted.
Minimum alkalinity = minimum average levels of total alkalinity found in natural waters.
Maximum flow = maximum average rate of water flow found in natural waters.
Particulates emitted = tons/years of particulates emitted.
(Table 3—continued at bottom of page 87.)

with two air quality variables (the amount of particulates and of hydrocarbons) and two water quality variables (the amount of alkalinity and the amount of water flow) (Table 3). The rate of pancreas cancer in males showed significant positive associations with three water quality variables viz., the amount of alkalinity, the amount of acidity, and the amount of water flow. The amount of sand quarried was also related to cancer of the pancreas. The rate of rectal cancer in males showed significant associations with the amount of nitrous oxide in the air and the amount of zinc in natural waters, as well as with the percentage of the county underlain by brine. The rate of rectal cancer in males also showed a significant association with the amount of bituminous coal mined.

The rate of nasal cancer in females showed a significant association with four water quality variables (the average, minimum, and maximum levels of dissolved oxygen in the county waters*, as well as the level of phosphates) (Table 3).

The rate of stomach cancer in females showed an association with two water quality variables (the level of sulfates and the level of dissolved oxygen) and with the geological attribute the percentage of the county not underlain with natural brine nor Silurian, Ordovican, Devonian, and Mississippian age limestone nor Silurian age rock salt.[4] The final variable involved with female stomach cancer was the percentage of the county underlain with Silurian and Devonian age limestone.

The amount of lip cancer in females was associated with four water quality variables (the minimum amount of zinc, the maximum amount of

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*All three components (maximum, minimum, and average) of dissolved oxygen levels correlate well with nasal cancer mortality. This indicates that the range was very tight and such a variable with its mean, maximum, and minimum all highly correlated, (in this case dissolved oxygen) is clearly the prime independent variable in this association.

Mean acidity = mean average levels of total acidity found in natural waters.
Sand quarried = short tons/years of the amount of sand mined in the county.
Minimum zinc = minimum average levels of zinc found in natural waters.
% brine = percentage of the county underlain with natural brine.
Medium bitum = percentage of the county underlain with medium volatile bituminous coals.
NOx emitted = tons/year of nitrous oxides emitted in the county.
Minimum DO = minimum average level of dissolved oxygen found in natural waters.
Mean DO = mean average level of dissolved oxygen found in natural waters.
Maximum DO = maximum average level of dissolved oxygen found in natural waters.
Minimum PO_4 = minimum average levels of phosphate found in natural waters.
Mean SO_4 = mean average levels of sulfates found in natural waters.
Brine/lime = percentage of the county not underlain with natural brine of Silurian, Ordovican, Devonian, or Mississippian age limestone.
% slime = percentage of the county underlain with silurian and devonian age limestone.
Maximum Mg = maximum average levels of manganese found in natural waters.

dissolved oxygen, the average phosphate level, and the maximum manganese levels of natural waters) (Table 3).

The factor analyses were done separately for the cancer mortality data and for the natural water quality data (Table 1). Only the three most significant factors are presented for the two categories since, for both data sets, only three factors showed major amounts of variation accounted for. The first cancer mortality factor is termed the "male digestive" factor (Table 1). This name and the other factor names are labels and are not meant to imply the existence of known biological/environmental relationships but are so labeled because of their logical grouping.* The two other cancer mortality factors are "female upper respiratory" and "female upper digestive" factors (Table 1). The three natural water factors were labeled "acid mine drainage," "alkalinity," and "zinc" factors (Table 1).

The result of the linear regression analyses (Table 3) shows the degree of relationship among the *individual cancer and individual environmental variables,* whereas the results of the correlations of the indices indicate the degree of relationship between the *linear indices involving the set of environmental variables and the principal cancer mortality factor vectors* as independently produced from the environmental data and the cancer mortality set, respectively.

Both indices from the two primary factors (male digestive and acid mine drainage) are significantly correlated to indices of the opposite data set (Table 4). The "acid mine drainage" index shows significant correlations of $r=0.406$, $r=0.350$, and $r=0.664$ with all three cancer mortality indices viz., "male digestive," "female upper respiratory" (negative), and "female upper digestive" cancer mortality indices, respectively (Table 4). In addition, the "male digestive" indices relate to both the "alkalinity" and "zinc" natural water quality indices at $r=0.486$ and 0.451; respectively (Table 4).

Discussion

Six individual cancer mortality rates (male mouth, pancreas, and rectal cancers, and female nasal, stomach, and lip cancers) were found to be highly associated with several environmental variables; the most notable were the levels of alkalinity, acidity, zinc, dissolved oxygen, sulfate, phosphate, and manganese in natural waters. Hydrocarbons, particulates, and nitrous oxides were the few air quality variables observed in these equations.

The inclusion of such water variables as occur in the acid factor grouping would also suggest that most of the natural water quality variables appearing in the above equations are those characteristically high in areas

*This usage of the term "Factor" in the context of factor analysis may not satisfy everyone since only one "factor" was previously identified (the acid factor from other data) among the six used in the final analyses. It was decided to use the term because of the familiarity of statisticians with the terminology of factor analysis.

Table 4. Maximum Correlations Between the Cancer Mortality Indices and the Natural Water Quality Indices (Components of the Factors are Given in Table 1)

County Cancer Mortality Indices	*County Natural Water Indices*		
	"Acid Mine Drainage Index"	*"Alkalinity" Index*	*"Zinc" Index*
"Male Digestive" Index	r = 0.406[a,b] P[c,d] = 0.0069 N[e] = 43	r = 0.486[f] P = 0.0008 N = 44	r = 0.451[g] P = 0.0024 N = 43
"Female Upper Respiratory" Index	r = −0.350[h] P = 0.0215 N = 43	r = −0.288[i] P = 0.5800 N = 44	r = 0.242[j] P = 0.360 N = 43
"Female Upper Digestive" Index	r = 0.664[g] P = 0.0001 N = 43	r = −0.130[g] P = 0.401 N = 44	r = 0.242[g] P = 0.118 N = 43

a) Linear correlation coefficient.
b) This correlation is computed on the square root of the water index and the square of the cancer index.
c) P = The significance probability for the hypothesis $r = 0$.
d) See the methods section concerning hypothesis testing.
e) N = The number of paired observations.
f) This correlation is computed from the cube of both indices.
g) This correlation is computed from the log of both indices.
h) This correlation is computed from the cube of the cancer index and the log of the water index.
i) This correlation is computed from the cube of the cancer index and the log of the water index.
j) This correlation is computed from the log of the cancer index and the linear form of the water index.

of little or no acid mine drainage. Hence, in the areas where these variables have high levels, there is a strong association with certain elevated cancer mortality rates. In areas where hydrocarbon, nitrous oxides, and particulate emissions are high (in highly populated areas), other cancer mortality rates are elevated (e.g., mouth cancer).

The principal correlation among the indices involved the "female upper digestive" and the "acid mine drainage" indices. The "male digestive" index was also significantly associated with all three indices of the water group. The "acid mine drainage" index was strongly and positively associated with both "male digestive" and "female upper digestive" indices. Conversely, the acid mine drainage complex was only modestly (and negatively) associated with the "female upper respiratory" index. The only anatomical/physiologic inconsistency here appears to be the inclusion of male pancreas cancer in the male digestive cancer index and female pancreas cancer in the "female upper respiratory" index. Pancreas cancer might be included in the original factor because of an indirect (but strong) association with life-style aspects of the coal mining families of those counties having high acid mine drainage. Those counties having a large proportion of coal mines in the population also have a high acid mine drainage index.

Associations of "alkalinity" and "zinc" indices with the "male digestive" indices are not as clear as those with the acid drainage factor, but are of high statistical significance ($P=0.0024$ for both sets). Further analyses will be required in order to elucidate these latter associations. Recall that all the indices were additive constructs and no weighting was applied in a search for optimal models.

The environmental factors detected above are likely to be surrogates, at least in part, for occupational and population concentration conditions. The geographical distribution for the higher or lower cancer mortality rates is probably split into three socio/geographic areas viz., industrialized, high amount of mining, and those areas where neither of the previous two conditions exist, to any degree.

Conclusions

Both independent environmental variables and indices of groups of variables were highly associated with certain cancer mortality rates.

Those cancers showing high singular associations with environmental variables were male mouth, pancreas, and rectal cancers and female nasal, stomach, and lip cancers. The environmental variables showing singular correlations with the cancer variables were alkalinity, acidity, zinc, dissolved oxygen, sulfate, phosphate, and manganese levels of natural waters. Hydrocarbon, particulate, and nitrous oxide levels of the air were also highly associated with some of the cancer levels. The most important natural water indices were "acid mine drainage," "alkalinity," and "zinc." The most important cancer mortality indices were "male digestive," "female upper respiratory," and "female upper digestive" cancers. Strong associations were found between the "acid mine drainage" index and the "male digestive" and "female upper digestive" indices. Further, both the "alkalinity" and "zinc" environmental indices were strongly related to the "male digestive" cancer index.

The environmental variables and factors probably reflect, at least in part, populational and occupational aspects of the demographic distribution of these cancer mortality rates. The industrialized urban, and rural coal mining areas are probably those areas with highest cancer incidence.

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Ecology Section

Aquatic Vegetation of a Natural Marl Lake in West Virginia

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Abstract

Lake Louise is a 14.5 m deep natural marl lake in Jefferson County, West Virginia. The aquatic vegetation of the lake occurs primarily in four concentric zones associated with increasing water depth. Each zone is characterized by a distinct plant community. In July 1982 the percent cover of each vascular and bryophytic species was recorded for each community. Dominant macrophytic species in these communities included the emergents *Sparganium eurycarpum*, and *Nasturtium officinale* and *Veronica anagallis-aquatica* in the two shallowest zones, respectively; *Potamogeton* spp. in an intermediate zone; and *Elodea canadensis* in the deepest zone. In addition, a fifth separate community dominated by *Potamogeton crispus* has developed in a small cove of the Lake. Within a community, vertical stratification also occurred. For example, the floating thalloid *Lemna minor* often formed a prominent surface layer. The flora of Lake Louise is similar to that of marl lakes in the glaciated northeastern United States. Community structure, such as species richness and number of dominants, was generally less complex at Lake Louise than in the northern lakes.

Introduction

Marl is an unconsolidated calcareous material consisting primarily of calcium carbonate and lesser amounts of clay and organic material. The marl originates from the physiochemical/biochemical precipitation of the carbonate as a result of carbon dioxide loss from bicarbonate in water, usually during photosynthesis (Terlecky, 1972). Freshwater marl deposits are most frequent in glaciated portions of North America and are often associated with extant wetlands and lakes (Dachinowski, 1912; Vreeken, 1981). Twenty-seven marl deposits covering a total of 1153 ha occur within the unglaciated Shenandoah Valley of West Virginia (Bartgis and Lang, 1984). Only ten extant wetlands are associated with these marl deposits. These marl wetlands have numerous rare species characteristic of northern marl wetlands (Bartgis and Lang, 1984) and plant communities dominated by calcicolic species (Bartgis, 1983). Only one marl deposit and wetland is presently associated with a natural marl lake, Lake Louise. Wohlschlag (1950) defines a marl lake as a perennial body of water with a deep, unvegetated bottom and a marl substrate. Lake Louise is probably the only natural marl lake in the Southern Appalachians.

The aquatic vegetation of Lake Louise has not been previously described. This study was conducted to describe the vegetation of this unusual Southern Appalachian lacustrine ecosystem and to complement information collected on the vegetation of the West Virginia marl wetlands (Bartgis, 1983). This paper reports the species composition and community distribution for Lake Louise and compares the flora and vegetation with that found in marl lakes of the glaciated northeastern United States.

Description of Study Area

Lake Louise (39°18′00″N; 77°58′24″W) is located along Turkey Run, a small first-order stream of the Potomac River system, near Middleway, Jefferson County, West Virginia. The lake lies at an elevation of 152 m in a shallow basin of Beekmantown limestone (Dean, 1966) and covers 0.45 ha within a 12 ha wetland. Lake Louise is reportedly 14.5 m deep (Bushong, 1972) and appears to be a collapsed doline subsequently filled with water. In addition to surface drainage by Turkey Run, feeder springs exist within the Lake. These springs have a recorded flowage rate of 9300 to 17000 L/min and give Lake Louise a water temperature of about 13°C year-round (Bieber, 1961).

A continental type climate covers the Shenandoah Valley, between drier conditions to the west in the lee of the Allegheny Mountains and wetter conditions along the Atlantic coast to the east (Weedfall, 1973). Climatic information for the area is based on observations made at the U.S. Weather Service Station at Kearneysville, West Virginia (39°23′N; 77°53′W—elevation 168 m), 12 km northeast of Lake Louise (NOAA, 1930 - 1982). The average annual temperature is 11.8°C, the average frost-free period is 163 days, and the average annual precipitation is 99.2 cm. August is the wettest month (average 9.8 cm) and February is the driest month (average 5.6 cm).

Ninety percent of the 1060 ha watershed draining into Lake Louise is in agricultural use; the remainder is divided between residential use and woodland. Water draining from Lake Louise is diverted downstream by the 3M Corporation for industrial use. The Lake is leased by the 3M Corporation to The Nature Conservancy for conservation purposes.

Methods

The aquatic vegetation of Lake Louise was sampled in July 1982. Ten 1 m wide belt transects were arranged radially from the center of the

Lake to the edge of the surrounding marl wetland (Figure 1). The boundary between the Lake and the adjacent wetland was defined operationally by the point where standing water was approximately 0.5 m in depth. Within the Lake discrete community boundaries were evident, as seen by shifts in species composition. Percent cover of each vascular and bryophytic species was recorded in each community along each transect. There appeared to be no marked change in species composition as the season progressed, although no quantitative measurements were taken to verify this.

Water depths within each community were measured with a graduated 2 m rod; depths greater than 2 m were estimated.

Nomenclature for vascular species and bryophytes follow Fernald (1950) and Ammons (1940), respectively.

Results

The aquatic vegetation of Lake Louise occurs in four discrete, concentric zones associated with increasing water depth (Figure 1). Each zone is characterized by a distinct plant community; community names are based on the dominant macrophytic species, the initials of which designate the communities in the figures. A fifth community has developed in a small cove of the Lake. In most communities the species are stratified into distinct vegetation layers.

Sparganium eurycarpum community (Sp)

Sparganium eurycarpum is the dominant species in a 9.1 (±5.5 s.d.) m wide transitional zone between the surrounding wetland and the Lake to a depth of 0.8 m (Figure 1). Within the Lake percent cover is generally low (20 to 30%) for *S. eurycarpum*, although it rises to 60% in some areas. On the average, percent cover for *S. eurycarpum* is 40% (Table 1). Other emergents in this community include *Sium suave, Solanum americanum, Carex comosa*, and *Bidens cernua*; all are of minor importance. The thalloid *Lemna minor* (61%) and the floating bryophytes *Ricciocarpus natans* (10%) and *Riccia fluitans* (11%) form a well-developed layer of vegetation at the surface. *Potamogeton amplifolius* also is found in the floating surface layer, but is restricted to the northern portion of the Lake. *Utricularia vulgaris* is a prominent subsurface species (26%). This community has the greatest number of species encountered by the transects; the only species absent were those characteristic of the deepest areas of the lake.

Nasturtium officinale—Veronica anagallis-aquatic community (NV)

Because of a considerable overlap of leaves and large stems, these two species form a dense mat of vegetation in a 4.1 (± 2.6) m wide zone, where the water ranges from 0.8 to 1.2 m in depth (Figure 1). Generally, each species is found in near equal abundance; but along transect H, *N. officinale* increases to 70 percent cover, and along portions of transect B, *V. anagallis-aquatica* increases to 90 percent cover. *L. minor* ranges from 40 to 70 percent cover and dominates a floating layer; bryophytes are absent.

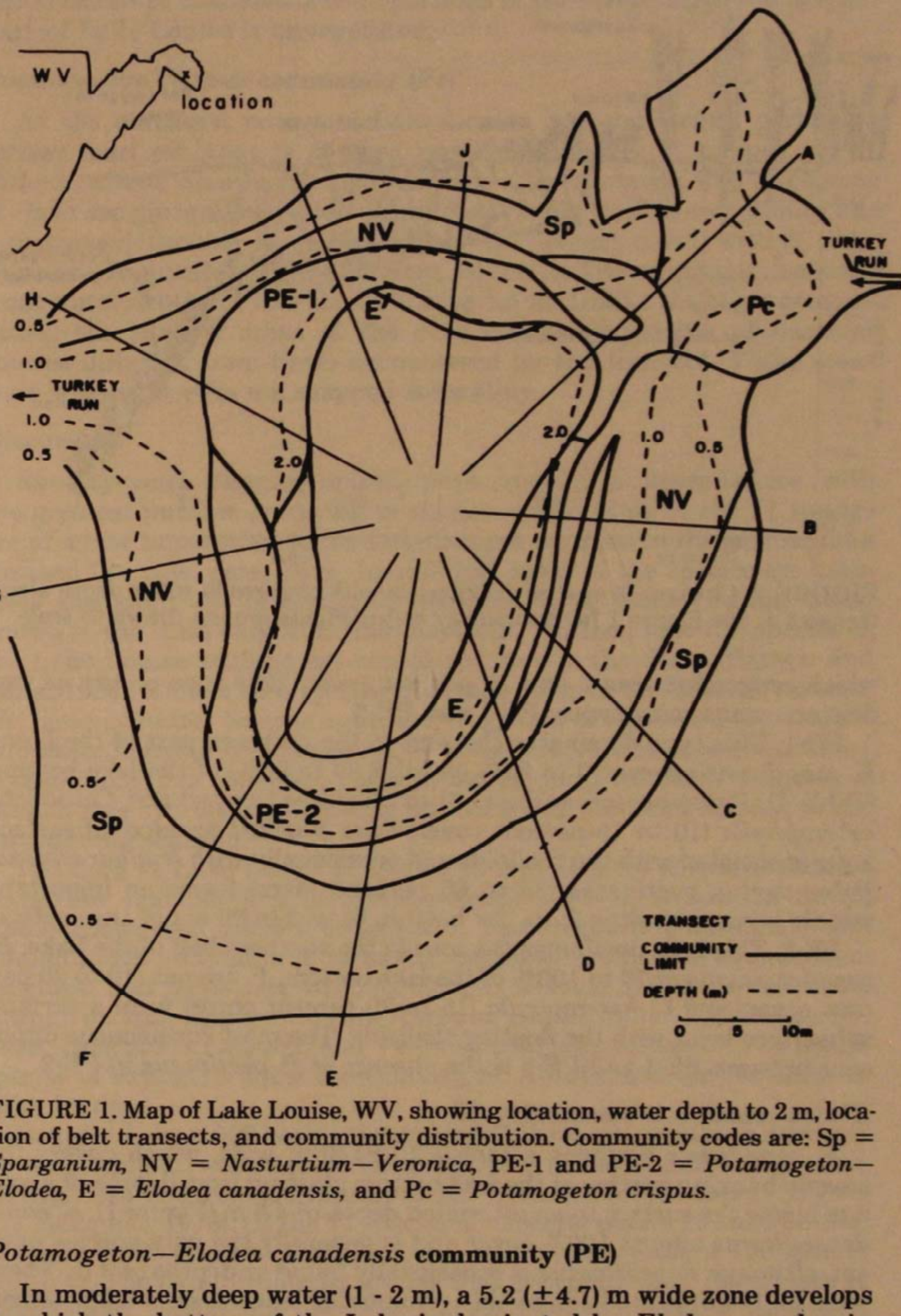

FIGURE 1. Map of Lake Louise, WV, showing location, water depth to 2 m, location of belt transects, and community distribution. Community codes are: Sp = *Sparganium*, NV = *Nasturtium—Veronica*, PE-1 and PE-2 = *Potamogeton—Elodea*, E = *Elodea canadensis*, and Pc = *Potamogeton crispus*.

Potamogeton—Elodea canadensis community (PE)

In moderately deep water (1 - 2 m), a 5.2 (±4.7) m wide zone develops in which the bottom of the Lake is dominated by *Elodea canadensis*. Species of *Potamogeton* form one or two distinct layers in shallower depths (Figure 2). A floating layer of the thalloids includes *L. minor*, which ranges between 20 and 60 percent cover, and *Spirodela polyrhiza*,

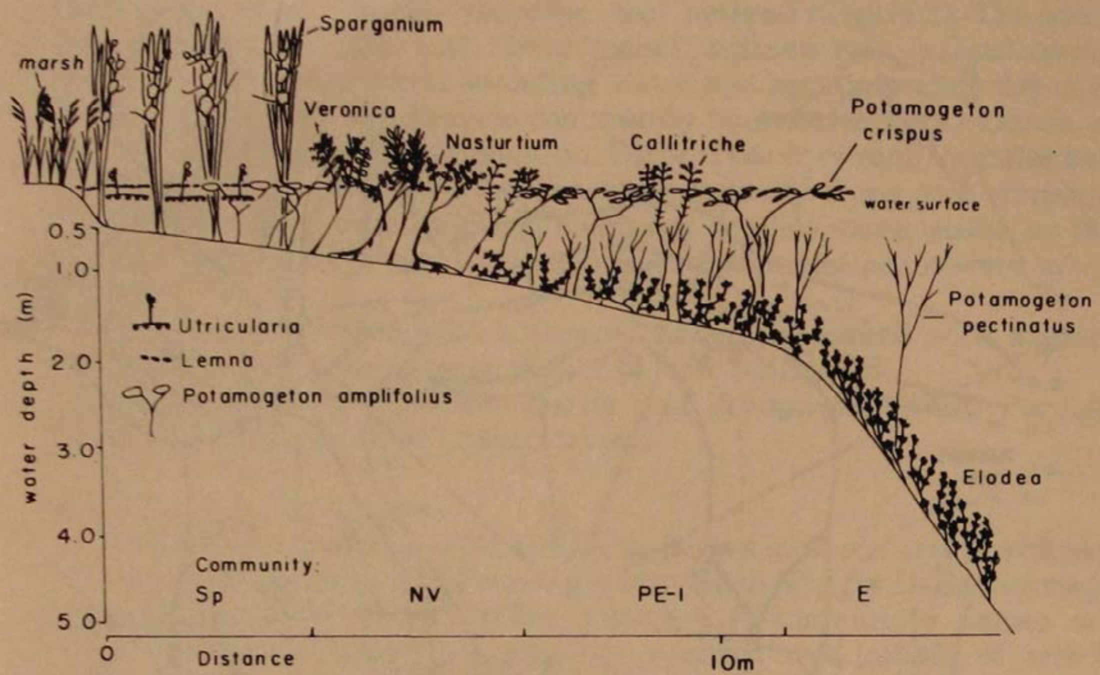

FIGURE 2. Changes in species distribution with changes in water depth along transect J. See Figure 1 for community codes. Plants are not drawn to scale.

which ranges between 0 and 10 percent cover. This zone occurs as two distinct community types: PE-1 and PE-2.

PE-1. This type dominates the zone in the northern part of the Lake. *E. canadensis* covers 20 to 90% (usually 80 to 90%) of the lake bottom (Table 1). *Potamogeton crispus* (40 to 60 percent cover) and *Callitriche heterophylla* (10 to 15 percent cover) form a mixed surface/subsurface layer associated with the thalloids and occasionally with *Nuphar advena*. *Potamogeton pectinatus* (35 to 60 percent cover) forms an important middle layer extending from the bottom to within 20 cm of the surface.

PE-2. This type dominates the zone in the southern half of the Lake. *E. canadensis* covers 70 to 100% of the lake bottom. *P. crispus* (10 to 30 percent cover) and *C. heterophylla* (15 to 20 percent cover) form a surface/subsurface layer with the floating thalloids. The most conspicuous difference between PE-1 and PE-2 is the absence of *P. pectinatus* in PE-2.

Elodea canadensis community (E)

E. canadensis occupies a zone 3.2 (±1.3) m wide, which covers the steeply banking portion of the lake bottom starting from depths of about 2 m below the surface to an estimated depth of 4.5 m (Figure 1). *E. canadensis* forms almost 100% cover and is generally the only species present, although *P. pectinatus* is occasionally found to depths of 3 m. There were no floating thalloids in this community since there were no emergent or floating macrophytes to restrict the movement of the thalloids in wind. In this community, as well as in the *Potamogeton-Elodea* community, avalanches of marl up to a meter in width and several meters long have cleared *E. canadensis* from portions of the steep slope. The deepest part of Lake Louise is unvegetated.

Potamogeton crispus **community (Pc)**

At the northeast corner of Lake Louise is a small cove, perhaps a former marl pit, that is covered predominantly by *P. crispus* (30%). *Bidens cernua, Sparganium eurycarpum, Carex comosa,* and *Sagittaria latifolia* are present but in low abundance (Table 1). This community has a prominent floating layer of *L. minor* (90 percent cover) with *S. polyrhiza* as a frequent but less abundant associate. The community extends from water depths of less than 0.5 m to 1.5 m. Unlike the other communities, the shallow areas of the cove contained patches of vascular species different from those encountered by the transect. These areas were small and were not mapped separately.

Discussion

Seventy-seven vascular species were recorded at Lake Louise, with the greatest number occurring in shallow areas. Most of the 77 species are of minor importance in the Lake but are common in the surrounding wetland (Bartgis, pers. obs.). In addition, most of the species are calcicoles and many are of restricted distribution in West Virginia, being known in the state only from marl habitats. Thirteen vascular species at the Lake Louise wetland are considered rare in the State (Bartgis and Lang, 1984). Eleven rare species of plants occur in the Lake: *Hydrocotyle ranunculoides, Scirpus acutus, Polygonum amphibium, Equisetum fluviatile, Scutellaria epilobiifolia, Carex suberecta, Carex comosa, Carex lanuginosa, Carex conoidea, Carex lacustris,* and *Utricularia vulgaris.* A twelfth rare species, *Juncus balticus,* occurs in the Lake but not in the surrounding wetland.

The flora at Lake Louise is similar to that of more northern alkaline lakes. For example, in a review of alkaline lakes in Wisconsin, Curtis (1959) considered *Elodea canadensis, Potamogeton amplifolius,* and *Potamogeton pectinatus* to be modal species of submerged aquatic communities, and *Sagittaria latifolia, Scirpus acutus, Scirpus americanus, Scirpus validus, Sparganium eurycarpum, Lemna minor, Spirodela polyrhiza, Utricularia vulgaris,* and *Veronica anagallis-aquatica* to be modal species of emergent aquatic communities. All of these species occur in Lake Louise.

Douglas Lake (1509 ha; maximum depth 21 m), a marl lake in northern Lower Michigan, was selected for comparison to Lake Louise since an inclusive flora and vegetation survey has been completed there (Haynes and Hellquist, 1978). Of the 77 species of vascular plants at Lake Louise, forty-six (61%) occur at Douglas Lake, which has a total of 110 species (Table 2). The two introduced species that are community dominants at Lake Louise, *Nasturtium officinale* and *Potamogeton crispus,* are absent from Douglas Lake, and many other northern marl lakes, as well.

At Lake Louise, there is a continuum of species change in relation to changing water depth (Table 1) and factors associated with the change

Table 1. Mean Percent Cover for Each Species Encountered by the Transects (Values Within Parentheses Are One Standard Deviation. + Indicates a Mean Value < 1%)

	Plant Community Type				
Species	*Elodea canadensis*	*Potamogeton/ Elodea**	*Nasturtium/ Veronica*	*Sparganium eurycarpum*	*Potamogeton crispus***
Elodea canadensis	97 (8)	76 (22)			
Potamogeton crispus		38 (7)			30
Potamogeton pectinatus	+	40 (12)			
Lemna minor		45 (22)	48 (31)	61 (28)	90
Spirodela polyrhiza		3 (2)	2 (4)	5 (3)	10
Callitriche heterophylla		11 (7)	+	+	
Nuphar advena		+			
Veronica anagallis-aquatica			42 (23)	2 (4)	
Nasturtium officinale			52 (25)	+	
Bidens cernua			+	2 (4)	5
Potamogeton amplifolius				10 (14)	
Sparganium eurycarpum				40 (17)	+
Sium suave				+	
Carex comosa				3 (5)	+
Phalaris arundinacea				2 (3)	
Scirpus validus				+	
Solanum americanum				2 (4)	
Utricularia vulgaris				26 (8)	
Ricciocarpus natans				10 (4)	
Riccia fluitans				11 (6)	
Sagittaria latifolia					+

*Includes both types (PE-1, PE-2). See text.
**Restricted in distribution to one transect.

Table 2. Species Found at Both Lake Louise, West Virginia, and Douglas Lake, Michigan. Asterisk Denotes a Species Considered Rare in West Virginia (Bartgis and Lang, 1984)

Acorus calamus	*Mimulus ringens*
Asclepias incarnata	*Onoclea sensibilis*
Bidens frondosa	*Phalaris arundinacea*
Calamagrostis canadensis	*Polygonum amphibium**
*Carex comosa**	*Polygonum hydropiperoides*
Carex rostrata	*Polygonum persicaria*
Carex stricta	*Potamogeton amplifolius*
Eleocharis smallii	*Potamogeton pectinatus*
Elodea canadensis	*Ranunculus scleratus*
*Equisetum fluviatile**	*Sagittaria latifolia*
Eupatorium maculatum	*Scirpus acutus**
Eupatorium perfoliatum	*Scirpus americanus*
*Juncus balticus**	*Scirpus cyperinus*
Juncus dudleyi	*Scirpus validus*
Juncus effusus	*Scutellaria epilobiifolia**
Juncus nodosus	*Scutellaria laterifolia*
Lathyrus palustris	*Sium suave*
Lobelia cardinalis	*Solanum americana*
Ludwigia palustris	*Solidago graminifolia*
Lycopus americanus	*Sparganium americanum*
Lycopus uniflorus	*Thelypteris palustris*
Mentha arvensis	*Typha latifolia*
Mentha piperita	*Utricularia vulgaris**

in depth. The strong relationship between water depth and species presence or absence is in agreement with patterns found in the marl lakes of the glaciated northeastern United States (Swindale and Curtis, 1957; Schmid, 1965; Haynes and Hellquist, 1978). Some of the shift in species may be associated with a change in alkalinity, which increases with an increase in depth. Hellquist (1980), for example, has shown that *Potamogeton pectinatus* typically occupies much more alkaline waters than *P. amplifolius* and *P. crispus.* In Lake Louise, these last two species occur at much shallower depths than *P. pectinatus.*

Patterns of species distribution in the northern marl lakes also have been attributed in part to the amount of organic matter in the marl (Wilson, 1941; Wohlsclag, 1950; Swindale and Curtis, 1957). At Lake Louise the marl of the *Sparganium* community is darker than the marl at greater depths and probably contains more organic matter.

As a consequence of the distinct patterns in species distribution, discrete bands of vegetation occur and form identifiable communities in Lake Louise (Figures 1 and 2). This observation is typical of that observed in many northern marl lakes (Fasset, 1930; Haynes and Hellquist, 1978; Schmid, 1965). Douglas Lake, for example, has two communities similar to those at Lake Louise: 1) a floating community dominated by *Potamogeton* species and thalloids in medium-depth water, and 2) a submerged community of *Potamogeton pectinatus* and *Elodea canadensis* on deep drop-offs (Haynes and Hellquist, 1978).

Compared to Lake Louise, community structure appears to be more complex in northern marl lakes, as reflected in greater numbers of both total and codominant species (cf. Fassett, 1930; Wilson, 1941; Moss, 1953; Swindale and Curtis, 1957; Schmid, 1965; Haynes and Hellquist, 1978). The northern marl lakes are much larger (over 250 ha) and have relatively heterogenous lacustrine deposits. In northern marl lakes, wave action plays a role in determining species distribution and community structure within a lake. Except for the absence of floating thalloids in the *Elodea canadensis* community, no apparent wind effects on vegetation were noted at Lake Louise. Northern marl lakes also usually have well-developed, floristically-diverse shoreline communities that are absent at Lake Louise, which grades into a wetland.

Lake Louise appears to be a unique habitat type in West Virginia. No other natural perennial body of water with the depth of Lake Louise has been reported in West Virginia (cf. Core, 1966). To enable a better understanding of Lake Louise, additional information is desirable, especially concerning the water chemistry and productivity of the Lake. Calcareous wetlands and lakes, especially those associated with marl, are considered rare in many northern, glaciated states and are protection priorities of conservationists (Crow and Storks, 1980; Tyler and Gawler, 1980). It is encouraging to see the conservation efforts of The Nature Conservancy and 3M Corporation for the protection of Lake Louise.

Acknowledgments

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Life History and Ecology of the Alderfly, *Sialis aequalis* Banks, From Flatfoot Creek, Mason County, West Virginia

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Abstract

The alderfly *Sialis aequalis* Banks, from Flatfoot Creek, Mason County, West Virginia, was studied relative to its life history and ecology between April 1978 and May 1979, and its low pH tolerance experimentally estimated in the laboratory. Larvae were collected along the stream margins from a substrate of vegetative debris, mud, and silt. Larvae were detritivorous in their feeding habits, despite the high food potential of their habitat. Their diet was infrequently supplemented with chironomids and other dipterans. Length frequency distributions for larvae indicated one size class for the population, and thus a univoltine life cycle. Growth rate, based upon mean head capsule width, was optimal during the first month of the larval stage (May-June). No increase in head capsule width was observed in February and March, the final months of the larval stage.

Pupation in the laboratory was variable in duration, ranging from 10 to 22 days. In the field, pupation began in late March and concluded 4 to 5 weeks later. Adults were first observed in late April, and none were sighted after May 10. Ovarian eggs of adult females ranged in number from 402 to 818, $\bar{x} = 657$. Mean egg length and width were 0.23 and 0.61 mm, respectively. The 96-hour median tolerance limit for low pH for *S. aequalis* larvae was 2.3.

Introduction

Aquatic insects play an important role in the dynamics of the stream community, serving as intermediate forms in the food web (Usinger, 1971). The alderfly *Sialis aequalis* Banks is found in close association with the aquatic environment in all stages of its life cycle. The taxonomy, distribution, ecology, and life history of *Sialis* spp. have been reported by Davis (1903), Ross (1937), Azam and Anderson (1969), Woodrum and Tarter (1973), Pritchard and Leischner (1973), Lilly et al.

(1978), and Canterbury (1978). The extreme tolerance of *Sialis* spp. to acid mine drainage has been noted by Roback and Richardson (1969), Warner (1971), and Tomkiewicz and Dunson (1977).

The life history and ecology of *Sialis aequalis* Banks from an acid mine stream have been the subject of prior investigation (Tarter and Woodrum, 1972; Woodrum and Tarter, 1973). The population of *S. aequalis* inhabiting Flatfoot Creek, however, differs from that previously observed in regard to its habitat: a comparatively clean-water stream unaffected by mine drainage and low pH conditions. It follows that the objective of this research was to report the life history and ecology of *Sialis aequalis* from Flatfoot Creek, in view of the findings obtained for the species in adverse environmental conditions.

Materials and Methods

Flatfoot Creek is a first-order, southwestern West Virginia stream which reaches its confluence with the Ohio River in the vicinity of Apple Grove, Mason County. The location of the *Sialis aequalis* population of Flatfoot Creek is at lower flood plain elevations, approximately 1.25 miles upstream of the mouth. The study area was subject to frequent backwater flooding from the Ohio River (Figure 1).

Larvae were collected monthly (conditions permitting) for a 12-month period commencing April 1978. Specimens were collected via a similar technique using both a two-man seine and a long-handled dredge. The substrate was disturbed by kicking and a net was used to collect the mud, silt, and organic debris. The alderflies were subsequently handpicked and preserved in 70 percent ethanol.

Water quality parameters were cursorily assessed via a Hach chemical kit (model AL-36-WR), with such analysis corresponding in time and location with monthly larval collections. Assessment of bicarbonate alkalinity, dissolved oxygen, and hardness was performed on site and recorded in mg/1. Hydrogen ion concentration was measured colorimetrically in the field.

Foregut analyses of sialid larvae were performed in order to establish the food preferences of the population. The foregut was excised following removal of the head and slitting of the abdomen, and the contents examined under a compound microscope at 440X. The percentage frequency of occurrence of each food item was determined, and subsequently compared, on a monthly basis. An estimate of the relative abundance of organic detritus present in foreguts was derived via random field selection (3) with an ocular grid (100 squares). For each excised foregut with detrital content, a total of 300 squares was selected and observed for the presence/absence of this nutrient source.

Length frequency distributions, arranged in 1 mm groups, were employed in determination of the size class(es) of the sialid larvae. Body length, exclusive of caudal filament, was measured to the nearest 0.1 mm with a dial vernier caliper. Head capsule width increment was selected as an index of growth, and was measured to the nearest 0.01 mm with a dissecting microscope equipped with an ocular micrometer. The range,

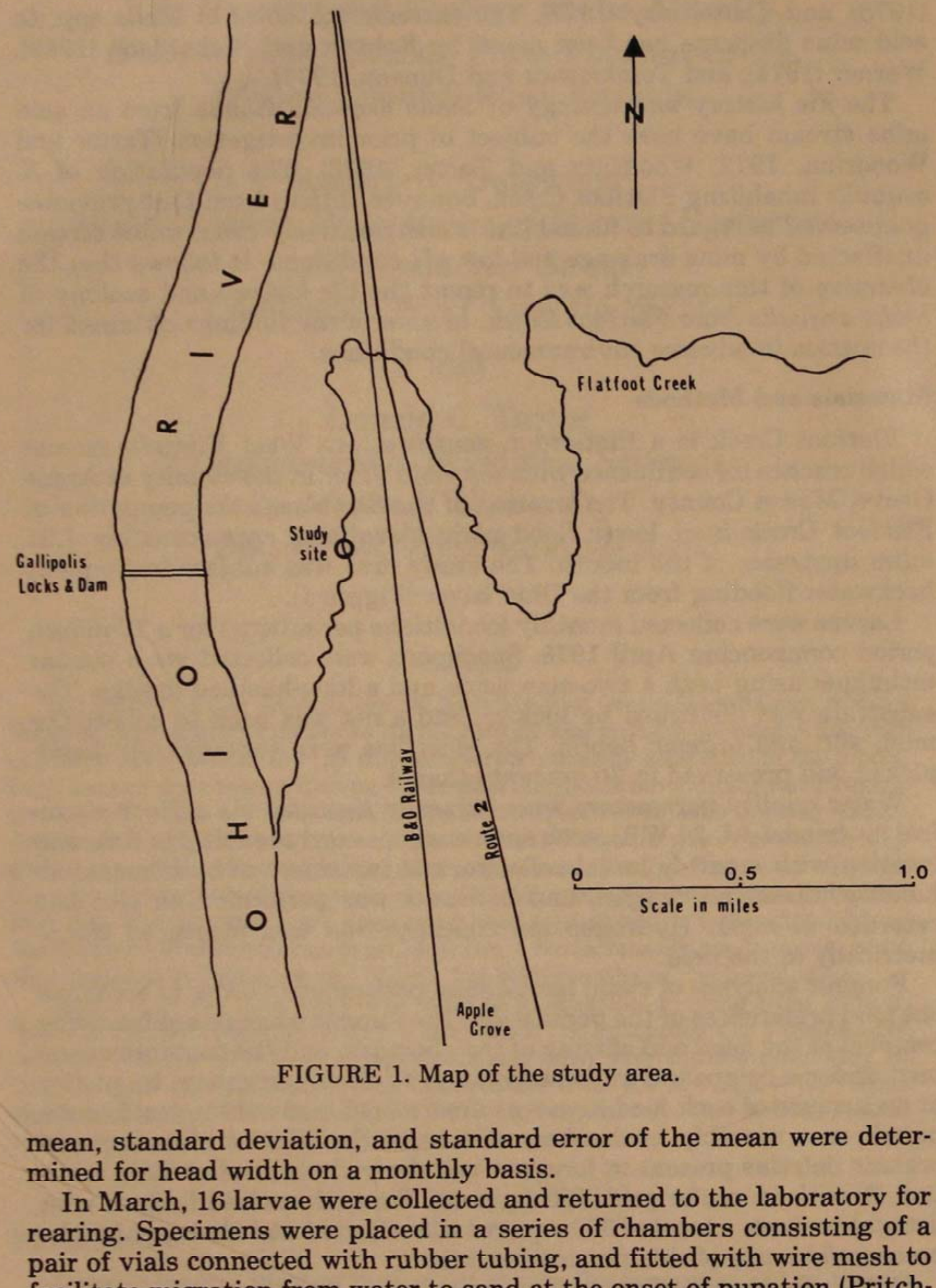


FIGURE 1. Map of the study area.

mean, standard deviation, and standard error of the mean were determined for head width on a monthly basis.

In March, 16 larvae were collected and returned to the laboratory for rearing. Specimens were placed in a series of chambers consisting of a pair of vials connected with rubber tubing, and fitted with wire mesh to facilitate migration from water to sand at the onset of pupation (Pritchard and Leischner, 1973).

Ovarian egg counts of reared adult females were performed in order to assess the reproductive potential of the species. A total of 3350 eggs were observed from the ovaries of 5 females. The dimensions of 162 ovarian eggs (approximately 5 percent of the total) were determined to the nearest 0.01 mm using a dissecting microscope with an ocular micrometer.

For assessment of relative pH tolerance, larvae were collected from Flatfoot Creek in October, returned to the laboratory, and acclimated for a 72-hour period. Specimens were segregated in seven finger bowls, each containing ten larvae, and placed in an incubation chamber. The experimental regime consisted of replicated exposure of 96-hour duration to: 1) sulfuric acid concentrations of pH levels of 1.5, 3.5, 5.0, and 7.7 (control); 2) temperatures approximating those of the natural environment (10-12°C); 3) total darkness; 4) absence of food; and 5) high concentrations of dissolved oxygen. Periodic measurement of pH with a Model 5 Corning Scientific pH meter facilitated the maintenance of specified pH conditions within narrow limits.

As an estimation of tolerance to low pH conditions, the 96-hour TL_m (median tolerance limit) test was employed (APHA, 1965). The pH value indicative of 50 percent survival of the sialid population after 96-hour exposure was derived through straightline graphical interpolation.

Results and Discussion

Water Quality

Results of field monitoring of water quality parameters for Flatfoot Creek indicated a moderately buffered system with neutral pH (Table 1). Dissolved oxygen concentrations, depressed (< 5 mg/1) during intervals of low flow and high temperatures (June-September), were at or approaching saturation from October-May. Hardness values typically exceeded 150 mg/l, indicative of hard water.

In addition, benthic community composition of Flatfoot Creek (Tarter et al., 1977c) proved useful in assessment of the general integrity of the stream. (This will be discussed further below.) Macroinvertebrate species diversity values (Lloyd and Ghelardi, 1964) for the study area were not suggestive of a polluted system. For Flatfoot Creek, constraints to benthic community productivity appeared largely physical in nature (i.e., stream size, substrate composition, warm weather flow rates, etc.).

Larval Stage

Food Habits. Analysis of foregut contents for the larvae of *S. aequalis* revealed a distinct detritivorous tendency (Table 2). Organic detritus was observed on the average in over 90 percent of excised foreguts containing food content. Filamentous algae, diatoms, and chironomids were, by relative abundance, insignificant secondary food sources, present in 2.9, 2.0, and 1.9 percent, respectively, of analyzed foreguts. Estimated relative abundance of organic detritus in foreguts indicated variable consumption by individuals during any given month, while a concurrent tendency to increased detrital consumption was collectively exhibited during cool- and cold-weather months (Table 3).

Larvae of *S. aequalis* from Flatfoot Creek appeared as more prolific feeders than those of acid mine Camp Creek (Woodrum and Tarter,

Table 1. Values for Temperature and Selected Water Quality Parameters for Flatfoot Creek

Month	*T*	*pH*	*DO mg/1*	*Bicarbonate Alkalinity mg/1*	*Total Hardness mg/1*
June	24.4	7.0	4	121	172
July	23.3	7.5	2	121	172
Aug.	24.4	7.0	2	121	172
Sept.	17.2	7.0	4	121	172
Oct.	11.7	7.0	9	52	138
*Nov.	—	—	—	—	—
*Dec.	—	—	—	—	—
Jan.	0.6	7.0	14	86	172
*Feb.	—	—	—	—	—
March	9.0	7.25	11	86	155
April	12.0	7.5	11	103	172
May	21.1	7.5	8	103	172
Mean	16.0	7.2	7.2	102	167

*No samples taken in conditions of backwater flooding.

1973, as the ratio of empty foreguts to those containing food was 1 : 6 at the former locale, 1 : 1 at the latter. Foregut analyses revealed larvae of the present study were overwhelmingly herbivorous and predominantly detritivorous in their feeding habits, while chironomids were exploited as an important secondary food source by the Camp Creek population (13 percent relative abundance). In addition, Flatfoot Creek sialids, unlike their Camp Creek conspecifics, were active feeders throughout the larvae stage, including the interval just prior to pupation.

The role of *Sialis* spp. as a secondary consumer in aquatic ecosystems has been previously reported. Canterbury (1978) found *Sialis* sp. to feed primarily on tubificid worms, chironomids, and ostracods, as did Pritchard and Leischner (1973) for *S. cornuta.* Azam and Anderson (1969), in their study of the western species *S. rotunda* and *S. californica,* noted that their diets consisted of chironomids, mayflies, caddisflies, and damselflies.

That *S. aequalis* in Flatfoot Creek exhibited a distinct preference for organic detritus assumes greater significance in view of the fact that the stream, unlike acid mine Camp Creek (Woodrum, 1971), supports a viable benthic community. Tarter et al. (1977c) reported a total of 14 orders and 53 genera of benthic organisms from the Flatfoot Creek study area, including chironomids, tubificid worms, ostracods, mayflies, and caddisflies. In contrast, Woodrum (1971) reported only 7 orders and 21 genera from Camp Creek. It thus appears that the availability of potential prey species was not a decisive ecological factor in the dietary preference of the present sialid population. Although Minshall (1967) found

Table 2. Data of Foregut Analyses of *S. aequalis* Larvae from Flatfoot Creek, Including Relative Abundance of Foregut Contents

Month	*Number Foreguts Examined*	*Number Empty Foreguts*	*Empty Foreguts Percent Total Examined*	*Plant Detr. (%)*	*Diatoms (%)*	*Filamen. Algae (%)*	*Mineral Detr. (%)*	*Digested Material (%)*	*Chiro. (%)*	*Unident. Dipteran (%)*
June	16	2	12.5	92.9	7.1	—	71.4	2.1	—	—
July	18	5	27.8	84.6	—	—	30.8	46.2	—	—
Aug.	11	1	9.1	80.0	—	—	30.0	40.0	—	—
Sept.	14	7	50.0	100.0	—	—	28.6	14.3	—	—
Oct.	16	1	6.3	100.0	6.7	20.0	13.3	6.7	—	—
Jan.	16	1	6.3	86.7	—	—	20.0	33.3	13.3	6.7
March	16	1	6.3	100.0	—	—	13.3	13.3	—	—
Mean	15.3	2.6	16.9	92.0	2.0	2.9	29.6	25.0	1.9	1.0

Table 3. Relative Abundance of Organic Detritus in Foreguts of *S. aequalis* larvae from Flatfoot Creek

	Percent of Foreguts Containing Organic Detritus			
Month	*No. Foreguts Containing Detritus*	*Min.*	*Max.*	*X*
June	14	5.7	20.3	9.2
July	12	4.7	9.7	7.0
Aug.	8	7.0	19.0	9.5
Sept.	7	6.7	23.0	11.1
Oct.	12	7.7	20.0	12.0
Jan.	13	7.7	65.0	17.6
March	15	5.0	20.3	13.5

organic detritus to be an important energy source for the stream community, and the detritus food chain to be "of major significance in terms of energy flow through stream ecosystems," the role of *Sialis* sp. at the primary trophic level in unpolluted waters has not been elucidated.

Growth and Development. Based upon field observations, the first-instar larvae appeared initially in mid-May (May 17). Nearly all the observed egg masses at the study site (~50) were hatched by May 21. The larval stage of *S. aequalis* from Flatfoot Creek was approximately 10.5 months in duration (mid-May—early April). The present findings regarding the onset and termination of the larval stage are consistent with those reported by Woodrum (1971) for the species in an acid mine environment (mid-May—late March).

Length-frequency distributions of monthly collections of the larvae of *S. aequalis* indicated one size class, and thus a univoltine life cycle (Figure 2). Body length ranged from 0.46 mm in the first-instar to 18.1 mm in January.

First-instar larvae were hatched in the laboratory to provide a reference point for assessing the growth of subsequent instars. Growth rate, based upon mean head width increment, was sharply accelerated (344 percent) during the first month of larval existence (Figure 3). The period of accelerated growth was followed by a moderation in growth rate through January. Larvae exhibited no net head capsule increment during the final two months of the larval stage (February-March).

Woodrum and Tarter (1973) also reported a one-year life cycle for *S. aequalis* in Camp Creek. Other sialids characterized by univoltine life cycles include: *S. itasca* (Lilly et al., 1978); *S. infumata* (Canterbury, 1978); and *S. rotunda* (Azam and Anderson, 1969).

The development of *S. aequalis* from Flatfoot Creek conforms in part with that described by Woodrum and Tarter (1973) for the species in an acid mine stream. Both larval populations exhibited an accelerated growth rate early in the larval stage, and a reduced, though positive rate through winter. However, the present population, unlike that of Camp

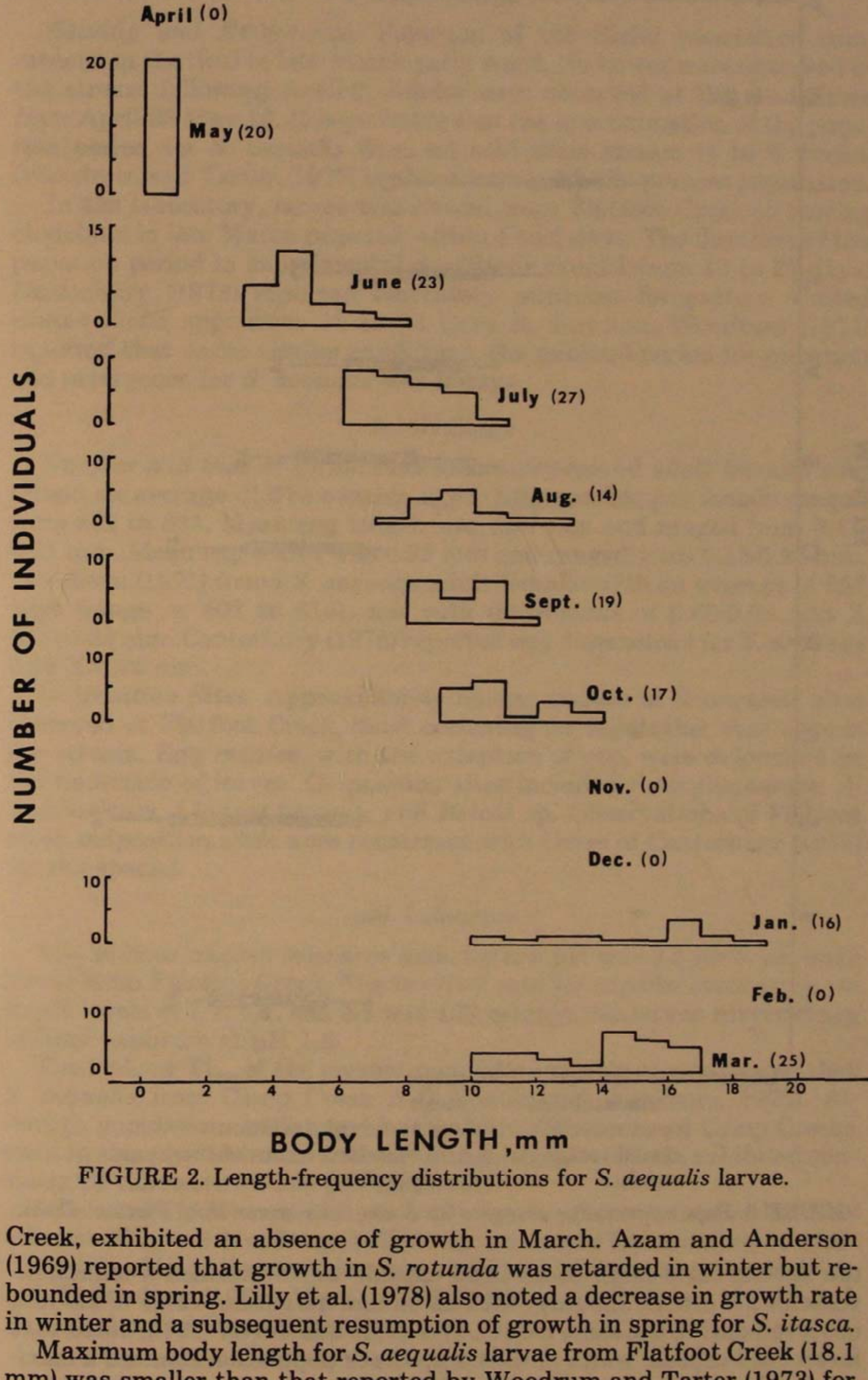
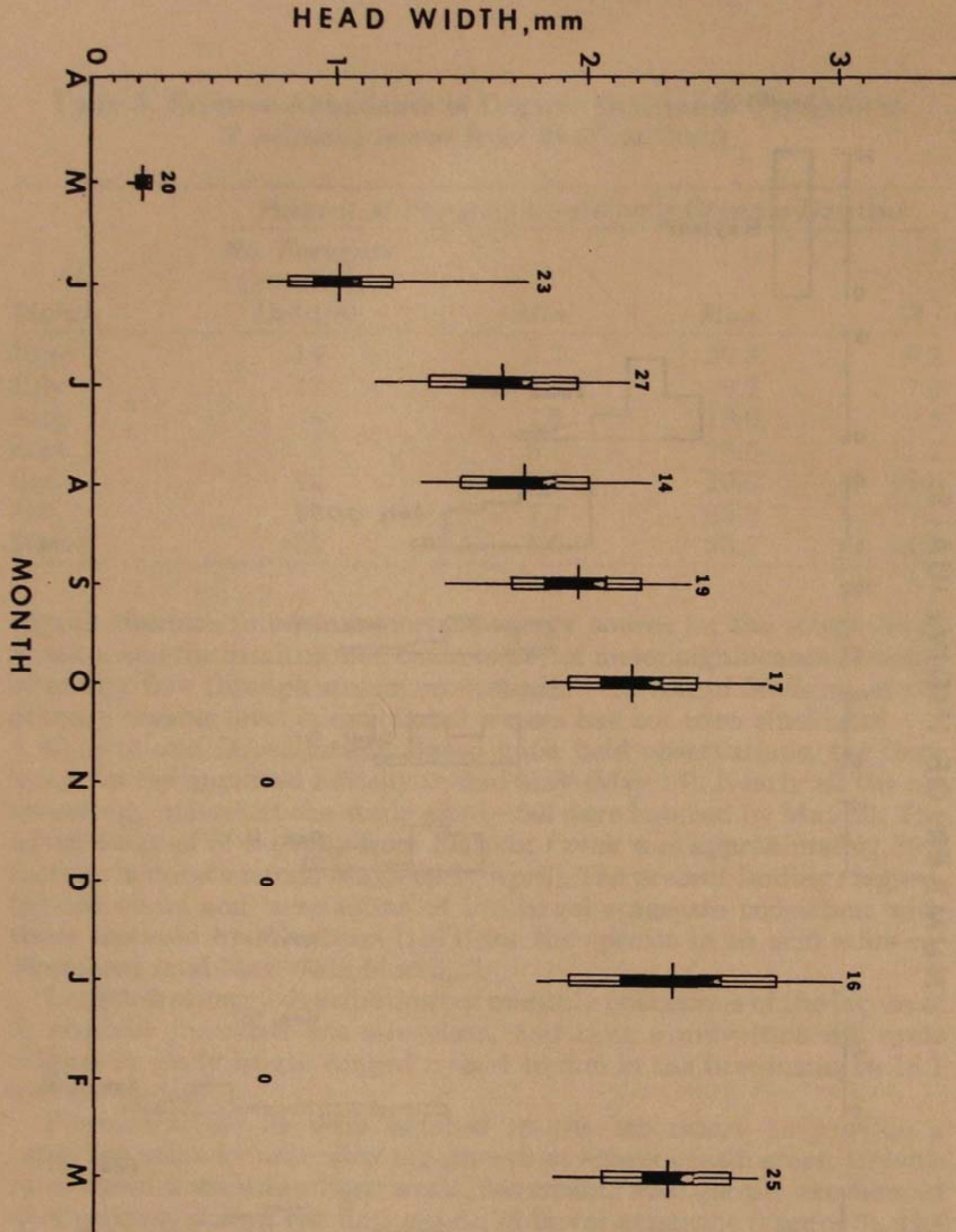


FIGURE 2. Length-frequency distributions for *S. aequalis* larvae.

Creek, exhibited an absence of growth in March. Azam and Anderson (1969) reported that growth in *S. rotunda* was retarded in winter but rebounded in spring. Lilly et al. (1978) also noted a decrease in growth rate in winter and a subsequent resumption of growth in spring for *S. itasca.*

Maximum body length for *S. aequalis* larvae from Flatfoot Creek (18.1 mm) was smaller than that reported by Woodrum and Tarter (1973) for



Legend: vertical line = range
horizontal line = mean
open rectangle = one standard deviation
closed rectangle = two standard errors of the mean
number = sample size

FIGURE 3. Population-range diagram for *S. aequalis* larvae from Flatfoot Creek.

the species (21.0 mm). Mean head capsule width attained a maximum value of 2.4 mm in January, with an annual maximum value of 3.0 mm observed during the same month. Woodrum and Tarter (1973) noted that mean head capsule width of the Camp Creek population attained a maximum value of 1.9 mm in March and November, never exceeding 2.2 mm for any month.

Pupal Stage

Rearing and Emergence. Pupation of the Sialid population commenced in the field in late March-early April. No larvae were observed in the stream following April 2. Adults were observed at the study area from April 25-May 10. It is probable that the approximation of the pupation period for *S. aequalis* from an acid mine stream (4 to 5 weeks) (Woodrum and Tarter, 1973) is also accurate for the present population.

In the laboratory, larvae transferred from Flatfoot Creek to rearing chambers in late March pupated within 1 to 5 days. The duration of the pupation period in experimental conditions ranged from 10 to 22 days. Canterbury (1978) reported laboratory pupation for eastern United States *Sialis* spp. from 10 to 14 days in duration. Woodrum (1971) reported that under similar conditions, the minimal period for pupation and emergence for *S. aequalis* was 9 days.

Adult Stage

Number and Size of Eggs. Five laboratory-reared adult females contained an average of 670 ovarian eggs. Egg number per female ranged from 492 to 835. Mean egg length was 0.61 mm and ranged from 0.41-0.71 mm. Mean egg width was 0.23 mm and ranged from 0.18-0.28 mm. Woodrum (1971) found *S. aequalis* adult females with an average of 657 eggs (range = 402 to 818), and with dimensions of 0.60-0.68 mm X 0.20-0.28 mm. Canterbury (1978) reported egg dimensions for *S. aequalis* 0.56 X 0.20 mm.

Oviposition Sites. Approximately 50 egg masses of *S. aequalis* were observed at Flatfoot Creek, most occurring on vegetation over or near the stream. Egg masses, with the exception of one, were oviposited on the underside of leaves. Oviposition sites included *Acer saccharum, A. saccharinum, Lindera benzoin,* and *Betula* sp. Observations of Flatfoot creek oviposition sites were consistent with those of Canterbury (1978) for the species.

pH Tolerance

The 96-hour median tolerance limit for low pH was 2.3 for *S. aequalis* larvae from Flatfoot Creek. The survival rate for experimental exposure to pH levels of 7.7, 5.0, and 3.5 was 100 percent. No larvae survived the 96-hour exposure at pH 1.5.

The 96-hour TL_m of the present population closely approximated that *S. aequalis* from Camp Creek (2.1) (Tarter and Woodrum, 1972). Although populations of *S. aequalis* inhabiting Flatfoot and Camp Creeks exist in sharply dissimilar environmental conditions, both exhibited considerable tolerance for low pH conditions.

Lilly et al. (1978) reported the lentic species *S. itasca* somewhat less tolerant ($TL_m = 3.1$) of low pH. *Sialis* sp. was noted for an ability to withstand low pH conditions associated with acid mine drainage by Roback and Richardson (1969), Warner (1971), Nichols and Bulow (1973), and Tomkiewicz and Dunson (1977).

Conclusion

Observations on the life history and ecology of *S. aequalis* in contrasting environments demonstrated many correlative and some contradictory tendencies. The feeding ecology of both the Camp Creek (Woodrum and Tarter, 1973) and Flatfoot Creek larval populations was extensively detritivorous. Whereas habitat food potential may have dictated the food preference of the former population, it was apparently not a decisive ecological factor in the latter's. Flatfoot Creek larvae were apparently both more active and more selective in their feeding habits.

Larval growth rates were similar in both populations through winter, after which time *S. aequalis* from Flatfoot Creek failed to exhibit a resumption of growth. Duration of the life cycle was one year in the two sialid populations. In general, the observations regarding the onset and termination of the stages of the holometabolous life cycle exhibited a high degree of temporal synchronization. Finally, extreme tolerance to low pH conditions was characteristic of both larval populations.

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Corbicula fluminea (Mollusca: Pelecypoda) as a Biological Indicator of Heavy Metals in the Kanawha River, WV

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Abstract

Two hundred large (16 to 24 mm) *Corbicula fluminea* individuals were monitored for 10 heavy metals at four different sites (50 clams at each site) on the Kanawha River over a nine week period. Analysis of the viscera revealed silver in the smallest concentrations (between 0.1 and 0.2 $\mu g/g$) of the metals at all four sites. Cadmium was also found in low concentrations (between 0.2 and 0.4 $\mu g/g$). Iron was found in the highest concentrations, in some cases surpassing 500 $\mu g/g$. Magnesium levels were also high, generally ranging between 100 and 200 $\mu g/g$ at all sites. Concentrations of zinc were interesting because of their virtually unchanging levels ($\cong$ 30 $\mu g/g$) at all four sites over the nine weeks. Copper concentrations were also very constant (between 7.0 and 9.0 $\mu g/g$) at all sites with the exception of weeks 7 and 9 at Marmet when copper levels reached 17.0 and 12.0 $\mu g/g$, respectively. While generally low, chromium levels were quite variable, ranging from 0.5 $\mu g/g$ at London, to a high of 12.0 $\mu g/g$ at Glen Ferris. Manganese levels were also quite variable, ranging from a low of 9.2 $\mu g/g$ at Winfield to a high of 100 $\mu g/g$ at London.

Introduction

The Kanawha River Valley is one of the largest and most diverse chemical manufacturing areas in the United States. Chemicals that find their way into the Kanawha River potentially affect not only a large proportion of West Virginia residents, but some 1.8 million people downstream who obtain their drinking water from the Ohio River (Moss, 1977).

Monitoring inland waterways is a difficult task. Because streams are not homogeneous mixtures, instantaneous grab samples may not be representative of actual river conditions (Saunders, 1979). Montgomery and Hart (1974) demonstrated that some indicators of water quality (e.g. dissolved oxygen, biological oxygen demand, and the presence of copper) exhibit diurnal fluctuations so that a number of daily samples would therefore be required to detect changes in those, and perhaps other, water quality parameters.

Bivalve molluscs have been proposed as continuous monitors of stream conditions because they are relatively stationary feeders that can be held in instream cages and retrieved for tissue analysis when investigators desire. Since *Corbicula fluminea* is known to accumulate chlorinated organics (Butler, 1973; Claeys et al., 1975) and some heavy metals (Graney et al., 1978; Cherry et al., 1980), it was selected as a potential biomonitor for heavy metals in the Kanawha River.

Materials and Methods

Five floating cages were placed at each of four sites on the Kanawha River: Winfield Dam, mile point 31.1; Marmet Dam, mile point 67.7; London Dam, mile point 82.8; and Glen Ferris, mile point 95.3. Cages at the U.S. Army Corps of Engineers dam sites were secured by 3/8″ diameter nylon rope to the outside wall of lock chambers, while those at Glen Ferris were tied to a fence on shore. Each cage measured 25 cm square and 30 cm deep, and contained a sand and gravel substrate approximately 3 cm deep. The cages, which were numbered 1 thru 5 at each site, were floated by a Styrofoam® collar so that water depth was maintained at approximately 15 cm.

All *Corbicula fluminea* individuals used in this study were collected on 29 July 1981 from the outfall area of Dewey Dam, near Prestonsburg, Kentucky. At the laboratory, the viscera were removed from 10 clams and were pooled, weighed for wet weight and then frozen. This sample was later analyzed to establish baseline data for ten metals (Ag, Cd, Cr, Cu, Fe, Mg, Mn, Ni, Pb, and Zn). The remaining clams were maintained in a 200 liter holding tank for two days.

Thirty clams, measuring 16 to 24 mm in length, were placed in each cage on 31 July 1981 (Day Zero). After one week (7 Aug.) 10 *C. fluminea* individuals were removed randomly from cage #1 at each site, and transported to Marshall University. The viscera were removed from the clams and were pooled by collection site, blotted dry on paper toweling, weighed on a Sartorius balance for wet viscera weight and then frozen. Thus four separate viscera samples, one from each site, were available for metals analysis. This procedure was repeated after three (21 Aug.), five (4 Sept.), seven (18 Sept.), and nine (2 Oct.) weeks for clams in the remaining cages. Metals analysis on clam tissues were conducted by WV Department of Natural Resources personnel. Surface water samples were taken from each site (excluding Glen Ferris) on 19 July, 16 August, and 15 September by U.S. Army Corps of Engineers personnel and analyzed for four dissolved metals: Fe, Mg, Mn, and Zn (Figure 1).

Results and Discussion

Perhaps the most striking observation of the present study was the absence of any pattern of accumulation or release of metals by the viscera of *C. fluminea* maintained at four Kanawha River locations over a nine week period.

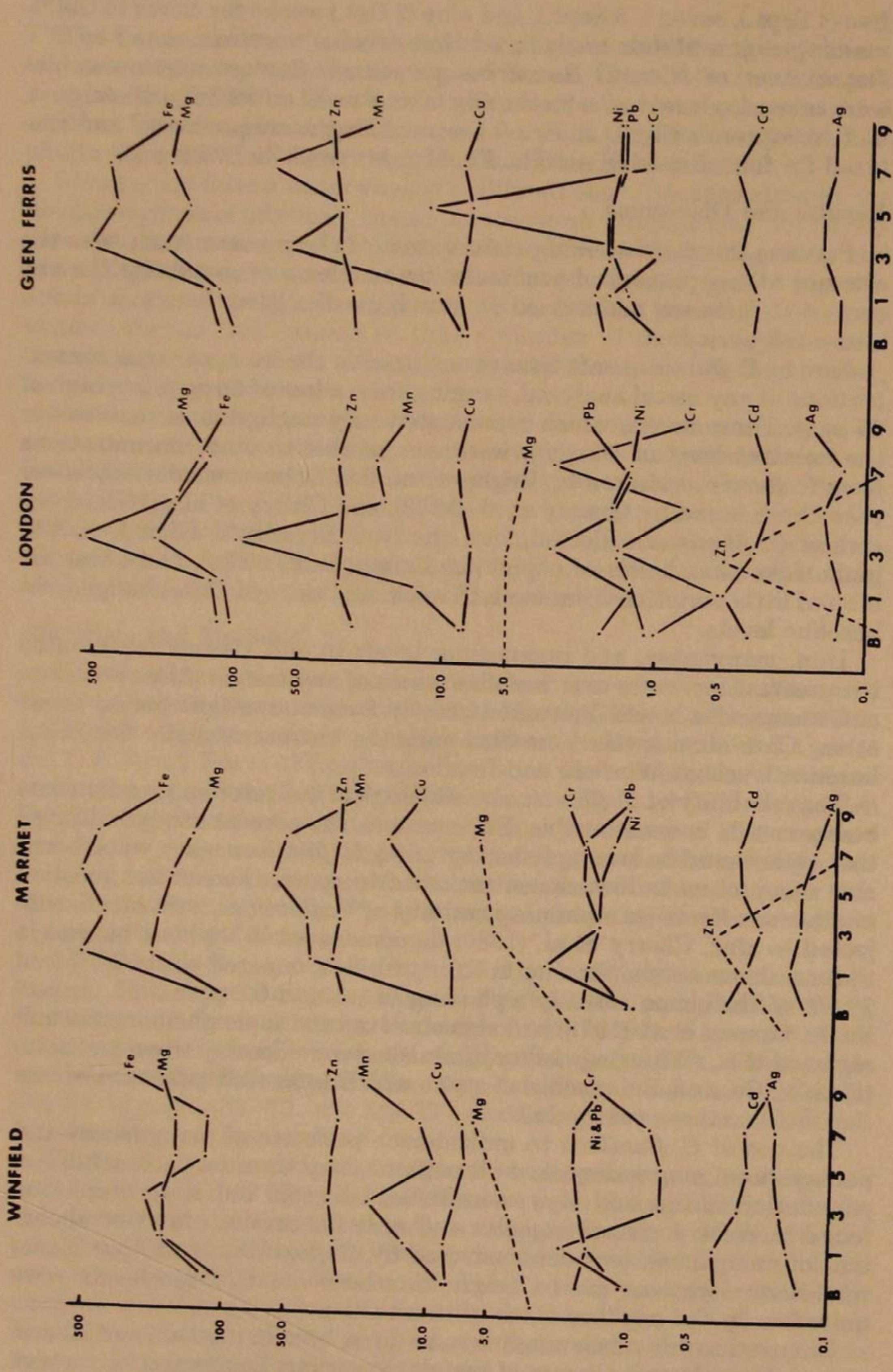
Zinc in *C. fluminea* soft tissues occurred in the least variable concentrations of any metal analyzed, ranging from a low of 28 μg/g to a high of 35 μg/g. These levels, which represented only negligible increases over the baseline level of 27 μg/g, were comparable to zinc concentrations from *C. fluminea* viscera by Rogers et al. (1977), but considerably lower than those found by Graney et al. (1978), and Cherry et al. (1980) in viscera of *C. fluminea* collected from the New River near Glen Lyn, Virginia. Like zinc, levels of copper, cadmium, lead, nickel, and silver exhibited little variation from week to week, and showed little change from baseline levels.

Iron, manganese, and magnesium levels in soft tissues represented the greatest increases over baseline levels of any metals. Moreover, iron and manganese levels fluctuated greatly from one sample period to another. Chromium levels were also variable, but occasionally fell below baseline levels at Winfield and London.

The reliability of *C. fluminea* as a biological indicator species for some heavy metals is questionable. For example, the present study indicated that little would be accomplished by using *C. fluminea* when waterborne zinc was present in low concentrations. Moreover, there is the question of adverse effects on siphoning activity of *C. fluminea* individuals subjected to zinc. Cherry et al. (1980) demonstrated in 96 hour bioassays that no clams were siphoning in 5.0 ppm zinc compared with 62.5% and 70.8% of the clams actively siphoning in 0.1 and 0.5 ppm zinc, respectively. Graney et al. (1978) had also observed the same phenomenon and reported that, "Filtering ability diminished considerably when test solutions of Cu and Zn reached 5 ppm which indicated potential stress threshold to these toxicants."

The use of *C. fluminea* to indicate the presence of manganese—and perhaps iron, magnesium, and chromium—may be more successful. Accumulation/release activity, as indicated by rapid initial accumulation found in Week 1 viscera samples and wide fluctuations in visceral content of manganese, was demonstrated by *C. fluminea* at all four Kanawha River locations even though waterborne manganese levels were quite low ($\leqq$ 0.1 mg/1) at three of those sites.

Unquestionably much remains to be done, both in the field and laboratory, using a broader range of metals at various concentrations under



WINFIELD
MARMET
LONDON
GLEN FERRIS
500
100
50.0
10.0
5.0
1.0
0.5
0.1
B
1
3
5
7
9
Fe
Mg
Zn
Mn
Cu
Cr
Ni
Pb
Ni & Pb
Cd
Ag

different water quality conditions before *C. fluminea* can be regarded as an effective tool for monitoring instream heavy metals.

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FIGURE 1. Metals analysis of viscera for *C. fluminea.* X-axis = Weeks at site. B = Baseline levels. Y-axis = Concentrations of metals: solid lines represent metals concentrations from clam viscera (in $\mu g/g$); dashed lines represent metals concentrations dissolved in surface water (in mg/1). Iron and manganese not diagrammed because they were found at $\leq$ 0.1 mg/1 at Winfield, London and Marmet. Zinc was < 0.1 mg/1 at Winfield. (Water Quality data source: U.S. Army Corps of Engineers, Huntington District, Hydraulics and Hydrology Branch.)

Myxomycetes Associated with Southern Appalachian Spruce-Fir Forests

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Abstract

A preliminary study of the Myxomycetes associated with southern Appalachian spruce-fir forests was carried out during the 1982 field season. Field and moist-chamber collections were made from three different study areas: (1) Blister Run in Randolph County, West Virginia; (2) Mount Rogers in Grayson County, Virginia; and (3) the Great Smoky Mountains National Park in North Carolina. Thirty-four species representing 20 genera were identified. This total includes a significant number of species that are either characteristically associated with the decaying wood of conifers or appear to have distributions centered in montane regions. Prominent examples include *Barbeyella minutissima, Cribraria rufa, Lepidoderma tigrinum, Licea minima,* and *Trichia erecta.* The collection of *Barbeyella minutissima* is particularly noteworthy, since it apparently represents the first record of this species from eastern North America.

Introduction

Myxomycetes (plasmodial slime molds) are common inhabitants of decaying plant material throughout the world. However, despite their abundance and widespread occurrence, relatively little is known about the general ecology of these organisms (Alexopoulos 1963, Eliasson 1981, Lakhanpal and Mukerji 1981). The investigation reported in this paper was undertaken to add to our knowledge of the distribution and ecology of Myxomycetes in the subalpine spruce-fir forests of the southern Appalachians. Relatively few collections of Myxomycetes have been made from the high mountain areas of southeastern North America where this forest type occurs.

Collection Sites

The following is a brief description of the three study areas:

1) Blister Run in Randolph County, West Virginia (38°40′ N latitude and 79°50′ W longitude); elevation 3650 feet (1112 m); mixed balsam fir (*Abies balsamea*)-red spruce (*Picea rubens*) swamp forest with yellow birch (*Betula lutea*) and hemlock (*Tsuga canadensis*) also present.

2) Mount Rogers in Grayson County, Virginia (36°40′ N latitude and 81°30′ W longitude); elevation 5700 feet (1737 m); fraser fir (*Abies*

fraseri)-red spruce forest with mountain ash (*Sorbus americana*) and yellow birch also present.

3) Mount Collins in the Great Smoky Mountains National Park, North Carolina (35°30′ N latitude and 83°30′ W longitude); elevation 5800 feet (1768 m); mixed fraser fir-red spruce forest with some yellow birch also present.

Materials and Methods

Field collections of Myxomycetes were made from the three study areas during the 1982 field season. In addition, samples of the dead outer bark were collected from 20-30 representative larger trees in each of the study areas. Bark samples were taken from a height of about 1.5 m, stored in sterile plastic bags, and then transported to the laboratory. In the laboratory, moist-chamber cultures were prepared in the manner described by Gilbert and Martin (1933). The moist chambers used in this study consisted of disposable plastic petri dishes (10 cm in diameter) lined with filter paper. Bark samples were moistened with distilled water adjusted with KOH to pH 7. After a period of 24 hours, the pH of each culture was measured with a glass electrode pH meter. Cultures were kept at room temperature in diffuse daylight and examined under a dissecting microscope every 3-4 days for a period of several weeks. After the cultures dried out, they were rewetted and examined at less frequent intervals for another 4-6 weeks. In addition, visual estimates of percent cover of bryophytes, lichens, and epiphytic algae were made for the bark samples in each culture.

Identifications of specimens collected in the field and obtained from moist chambers were made using the descriptions and keys provided by Martin and Alexopoulos (1969). Except for a few specimens which are now in the National Fungus Collections (BPI) in Beltsville, Maryland, all collections were deposited in the herbarium of Fairmont State College.

Results and Discussion

Thirty-four species of Myxomycetes representing 20 genera were identified from the material collected in the three study areas (Table 1). Twenty-seven of these are represented by specimens which had fruited in the field under natural conditions, 11 species were obtained from moist-chamber cultures (Table 2), and four species (*Arcyria cinerea, Comatricha nigra, Physarum nutans,* and *P. viride*) are represented by both field and moist-chamber collections.

Although many of the species of Myxomycetes recorded in the present study (e.g., *Arcyria denudata, Hemitrichia calyculata, H. serpula,* and *Lycogala epidendrum*) are among those considered to be cosmopolitan and largely independent of the type of substrate upon which they develop, a significant number of others are species that are either characteristically associated with the decaying wood and bark of conifers or appear to have distributions centered in montane regions. For example, at least five of the species encountered in this study (*Cribraria macrocarpa, C. rufa, Lepidoderma tigrinum, Licea minima,* and *L. kleistobolus*) are

Table 1. Occurrence of Myxomycetes in the Three Study Areas

Taxa	*Blister Run*	*Mount Rogers*	*Great Smoky Mtns.*
Arcyria cinerea	X	X	X
Arcyria denudata		X	
Arcyria ferruginea	X		
Arcyria incarnata		X	
Arcyria nutans		X	
Barbeyella minutissima			X
Clastoderma debaryanum			X
Ceratiomyxa fruticulosa		X	
Comatricha fimbriata	X		
Comatricha nigra	X	X	
Cribraria macrocarpa		X	
Cribraria rufa	X		
Didymium nigripes		X	
Echinostelium minutum	X	X	X
Enerthenema papillatum	X		X
Fuligo septica	X		
Hemitrichia calyculata	X		
Hemitrichia serpula	X		
Lamproderma arcyrionema	X		
Lepidoderma tigrinum			X
Licea kleistobolus	X		
Licea minima		X	X
Lycogala epidendrum	X		
Metatrichia vesparium			X
Physarum nutans	X	X	
Physarum viride	X	X	
Stemonitis axifera	X	X	
Stemonitis nigrescens			X
Trichia botrytis			X
Trichia decipiens			X
Trichia erecta	X		
Trichia favoginea	X		
Trichia subfusca			X
Tubifera ferruginosa	X	X	X
Totals	19	14	13

known to display a distinct preference for coniferous substrates (Martin and Alexopoulos 1969). Since most of the potential microhabitats available for myxomycete growth and fruiting (e.g., fallen logs) are derived from conifers (i.e., either spruce or fir), the presence of these species is certainly not surprising. At least three other species (*Barbeyella minutissima*, *Trichia erecta*, and *T. subfusca*) are Myxomycetes that appear to have distributions centered in montane regions (Hagelstein 1944, Martin

Table 2. Myxomycetes Obtained from Moist Chamber Cultures

Taxa	*No. of collections*
Echinostelium minutum	58
Comatricha nigra	13
Enerthenema papillatum	10
Arcyria cinerea	10
Licea kleistobolus	5
Licea minima	2
Clastoderma debaryanum	2
Comatricha fimbriata	1
Physarum nutans	1
Physarum viride	1
Stemonitis nigrescens	1

and Alexopoulos 1969). The collection of *Barbeyella minutissima* is particularly noteworthy, inasmuch as this is apparently the first record of this predominantly alpine species from eastern North America (Kowalski and Hinchee 1970).

Myxomycete fruiting bodies and/or plasmodia developed in 62% of the moist-chamber cultures prepared in the present study (Table 3). This figure is somewhat higher than those reported in the literature for bark samples from coniferous trees. Harkonen (1977) obtained a yield of 48% in a study conducted in southern Finland, and Peterson (1952) reported 46% for a study carried out in Michigan. However, Harkonen also noted that samples taken from trees in areas with a moist oceanic climate were the most productive. Since spruce-fir forests occur in areas of the southern Appalachians which have annual precipitation rates often exceeding 150 cm, the results of the present study are probably not unexpected.

Echinostelium minutum was the single most abundant species obtained from moist-chamber cultures, appearing in almost half (47%) of the cultures prepared in this study. The only other species represented by at least five collections are *Comatricha nigra, Enerthenema papillatum, Arcyria cinerea,* and *Licea kleistobolus*. The first four species listed (all of which are represented by at least 10 collections) were also the four most common species developing on bark samples from coniferous trees in the study by Harkonen (1977). *Comatricha nigra* (92% of all collections) and *Enerthenema papillatum* (80%) were much more common on spruce than on fir, *Licea kleistobolus* (80%) was more abundant on fir, and *Echinostelium minutum* and *Arcyria cinerea* did not seem to display an affinity for either type of bark.

Bark samples of fir yielded more different species (9) than did those of spruce (6). Both spruce and fir are trees with relatively smooth bark surfaces. The bark of spruce tends to flake off in thin roundish or polygonal plates, whereas that of fir generally remains intact, although the bark of older trees may become roughened and somewhat fissured. It should be

Table 3. Distribution of Myxomycetes by Tree Species

Tree	No. of cultures prepared	No. of cultures fruiting*	Percent fruiting	No. of species	pH	
					Range	Mean value
Abies fraseri	37	16	43	6	3.8-4.8	4.2
Abies balsamea	18	17	94	5	3.7-4.8	4.2
Subtotals for fir	55	33	60	9		
Picea rubens	62	39	63	6	3.0-4.0	3.6
Sorbus americana	5	4	80	2	4.0-5.1	4.5
Betula lutea	2	1	50	1	5.0-5.1	5.1
Totals for all species	124	77	62	11	3.0-5.1	3.9

*Includes all cultures in which myxomycete plasmodia and/or fruiting bodies developed.

noted that the two species of fir (*Abies balsamea* and *A. fraseri*) can not be distinguished on the basis of bark characteristics. In fact, they may represent nothing more than varieties of a single species (Thor and Barnett 1974). Since trees with smooth bark are generally regarded as less favorable habitats for Myxomycetes than trees with rough bark (Brooks et al. 1977), neither species would be expected to support a large myxomycete flora. Moreover, the relatively low pH of the bark (3.6 for spruce and 4.2 for fir) would undoubtedly exclude those species of Myxomycetes which prefer less acidic substrates. Several other studies (Harkonen 1977, 1978) have shown that the presence of epiphytic lichens and bryophytes on bark surfaces tends to increase the number of species of Myxomycetes present, presumably because they "trap" myxomycete spores (which are largely wind-disseminated) from the air. If such is the case, this could account for the apparent difference in the productivity of spruce and fir, since the total cover of bryophytes and lichens is higher for the latter species (Table 4). As shown in Table 4, appreciable differences in the relative abundance of the various types of epiphytes exist among the three study areas. For example, epiphytic algae cover a significant portion of the bark surface of both spruce and fir at Blister Run but are not evident at either of the other sites. However, these differences appear to be directly related to the wide range of environmental conditions already noted in the descriptions of the three study sites.

In summary, the results of the present study suggest that the Myxomycetes associated with southern Appalachian spruce-fir forests do seem to constitute a distinctive group which apparently includes a number of species that are rarely encountered in forests at lower elevations in the region. The data available are rather limited because of the paucity of collections made in the areas where the spruce-fir forest type exists. However, the investigation reported in this paper is continuing, and it is anticipated that additional research will provide a better understanding of the distribution and ecology of Myxomycetes in the forests of these high mountain areas of southeastern North America.

Table 4. Estimates of Percent Cover of Epiphytes on Bark Samples Collected from Spruce and Fir Trees in the Three Study Areas

Tree	*Blister Run*	*Mount Rogers*	*Great Smoky Mtns.*
		LICHENS	
Fir	25	17	31
Spruce	6	30	22
		BRYOPHYTES	
Fir	8	20	17
Spruce	0	0	4
		ALGAE	
Fir	14	<1	<1
Spruce	23	<1	<1

Acknowledgments

The author wishes to acknowledge the assistance of Dr. Marie L. Farr, who helped with the identification of several of the species reported in this paper, and also Zane E. Branson, Robert D. Myak, and my wife, Barbara, all of whom helped with the field work. This study was supported in part by funds provided by a Fairmont State Foundation Faculty Development Grant.

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Relationships Between Legal Game Harvests and Environmental Variables in West Virginia

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Abstract

Regression analyses were performed between certain environmental variables and the legal game harvests of deer (*Odocoileus virginianus*), turkey (*Castor canadensis*), bobcat (*Lynx rufus*), and beaver (*Meleggns gallopavo*) for the counties of West Virginia. Strong positive associations were observed between the percentage of the counties underlain by several types of limestone and the numbers of legal game harvests.

Introduction

Geographically extensive studies concerning the associations among legal game harvests and environmental variables have not been conducted in West Virginia. Previous studies have been concerned with relatively small geographic areas and/or specific habitats, or the cataloging of species and habitats such as the project Run Wild East and the Breeding Birds Survey of the Brooks Bird Club (1,2). The objective of this study is to examine the associations among a broad range of environmental variables and the legal game harvests for deer (*Odocoileus virginianus*), turkey (*Castor canadensis*), bobcat (*Lynx rufus*), and beaver (*Meleggns gallopavo*) for those West Virginia counties that have data on these harvests.

Methods and Materials

Wildlife data used in this study were obtained from game harvest reports published by the WV Department of Natural Resources (DNR) (3). The animal harvests selected for study were deer, turkey, bobcat, and beaver. These were the only species whose harvests met the criterion of having reasonably complete data available for a large number of counties (22 to 55 counties) for at least two consecutive years. The years and number of counties included in this study were: deer, 54 counties and eight years (1972-1980); turkey, 55 counties and seven years (1973-1980); bobcat, 37 counties and two years (1978-1980); and beaver, 22 counties and four years (1976-1980). Species having fewer than 55 counties in their data base are the result of counties having no legal season for that species. All counties having a regular season but reporting no harvest were included in the data base (as zero harvest). The geographical distribution of harvest data for the various counties within the state was checked for each species to avoid making regionally biased inferences.* Only the data distribution or beaver harvests was notably regionally biased, with most data coming from the southern and eastern counties.

From the within species preliminary linear correlation analyses of animals harvested among years, the data proved to be highly consistent for all years studied, i.e., those counties reporting high harvests in one year consistently reported large harvests in other years. For this reason the total game harvests for the respective species across all years were used instead of the harvest counts for each year. In addition, a small but generally increasing trend of wildlife harvests was noted for all four species over the time span of the study (1972-1980).

The environmental variables analyzed along with the game harvests were taken from the following data sets: EPA-NEDS air quality data (National Emissions Data System)**; EPA STORET water data network***; the WV Geological Survey, the WV DNR Wildlife Harvest Reports, and the US Soil Conservation Service. A total of 52 independent variables under the general groupings of geological, air quality, and natural water quality**** were used in the construction of the environmental data base.

Initially, stepwise regression was used to scan the data for significant associations among the wildlife harvest data and the environmental variables. Subsequently, multiple linear regressions were completed using the dependent and the four most highly associated independent environmental variables as identified using the stepwise procedure (Table 1). The Statistical Analysis System (SAS) (4) of the WV Computing Network for Educational Telecomputing was used for all of the statistical analyses.

Table 1 gives the number of counties (N) for which complete data are available. The number of counties available for analysis decreases as the number of independent variables increases. This is due to the incomplete nature of the two data bases. The stepwise regression procedure of SAS deletes the entire data record of any county in which any one (or more) data element is missing.

Results

Deer Harvests

Legal deer harvests show a strong association with the percentage of the county underlain by Mississippian aged limestone ($R^2 = 0.24$, Table 1). When combined with the percentage of the county underlain by

*Regional bias is the clustering of data in one or more parts of the state.

**These data were obtained directly from EPA-NEDS data tapes for 1977.

***These data were obtained directly from EPA STORET Printed Outputs, averaged by county, and essentially cover the years 1971-1976.

****By natural water we refer to the water in the streams, ponds, reservoirs, and rivers of West Virginia.

Silurian aged limestone, some 53% of the observed variation in deer harvest is accounted for. The addition of two variables to the regression equation (minimum value of zinc in natural waters of the counties and the percentage of the county underlain by rock salt) increased the accountable variation to 77%.

Turkey Harvest

Percentage of the county underlain by Silurian aged limestone and legal harvest for turkey were also found to be strongly associated (R^2 = 0.30, Table 1). The combination of the percentage of the county underlain by Mississippian and Silurian aged limestones increased the accountable variation to 54%. The subsequent inclusion of the average level of zinc and the average minimum values of zinc in natural waters increased the accountable variation to 70%.

Bobcat Harvest

Percentage of the county underlain by Mississippian aged limestone showed a significant association of $R^2 = 0.25$ with legal county bobcat harvests (Table 1). When this type of limestone is combined with the average percentage of dissolved oxygen in the natural waters of the counties, R^2 increases to 0.40. The addition of number of carbon monoxide emitters per county (the only air quality variable to have a significant association with the wildlife harvests) increased R^2 to 0.45. By adding average minimum dissolved oxygen in the natural water of the county to the equation, R^2 was increased to 0.53 (Table 1).

Beaver Harvest

The association among beaver harvests and percentage of the county underlain by Mississippian aged limestone was found to be highly significant ($R^2 = 0.65$, Table 1). The addition of the variable "number of quarries producing sand" raised the accountable variation to only 0.66. The addition of two natural water quality variables to the model (average maximum value of zinc and average minimum value of magnanese in natural waters) raised R^2 to .70.

General Summary

The most significant independent environmental variables associated with harvests of the four game species were found to be the percentages of the county underlain by Mississippian and/or Silurian aged limestone(s). In three of the four species, the limestone variable(s) accounted for over half of the variation. Other important variables in the equations were number of sand quarries, average levels of dissolved oxygen in natural waters, amount of zinc in natural waters, percentage of rock salt underlying the county, low levels of manganese, and the amount of carbon monoxide emitted in the county.

The stepwise regression procedure utilizes a large number of comparisons in the scanning phase of the analysis and for this reason, only those comparisons with low probability values were used (P less than

Table 1. Regression Models for Deer, Turkey, Beaver, and Bobcat Harvests in West Virginia

Dependent Variable: Type of Harvest	*Number of Variables in the Regression Model*			
	1-variable model	*2-variable model*	*3-variable model*	*4-variable model*
Total Deer Harvest	Miss. Limestone	Miss. Limestone Silurian Limestone	Miss. Limestone Silurian Limestone Min. Zinc	Miss. Limestone Silurian Limestone Min. Zinc Rock Salt
	$R^2 = 0.24$ N = 53 PR = 0.0051	$R^2 = 0.53$ N = 53 PR = 0.0001	$R^2 = 0.68$ N = 43 PR = 0.0001	$R^2 = 0.77$ N = 43 PR = 0.0001
Total Turkey Harvest	Silurian Limestone	Silurian Limestone Miss. Limestone	Silurian Limestone Miss. Limestone Min. Zinc	Silurian Limestone Miss. Limestone Min. Zinc Mean Zinc
	$R^2 = 0.30$ N = 33 PR = 0.0007	$R^2 = 0.54$ N = 33 PR = 0.0001	$R^2 = 0.58$ N = 27 PR = 0.0001	$R^2 = 0.70$ N = 27 PR = 0.001
Total Bobcat Harvest	Miss. Limestone	Miss. Limestone Avg. Dissolved O_2	Miss. Limestone Avg. Dissolved O_2 CO emissions	Miss. Limestone Avg. Dissolved O_2 CO emissions Min. Dissolved O_2
	$R^2 = 0.25$ N = 35 PR = 0.0017	$R^2 = 0.40$ N = 29 PR = 0.0010	$R^2= 0.45$ N = 29 PR = 0.0013	$R^2 = 0.53$ N = 29 PR = 0.0006

Total Beaver Harvest	Miss. Limestone	Miss. Limestone Sand Mines	Miss. Limestone Sand Mines Max. Zinc	Miss. Limestone Sand Mines Max. Zinc Min. Manganese
	$R^2 = 0.65$ $N = 21$ $PR = 0.0001$	$R^2 = 0.66$ $N = 21$ $PR = 0.0001$	$R^2 = 0.68$ $N = 19$ $PR = 0.0003$	$R^2 = 0.70$ $N = 19$ $PR = 0.0007$

Definitions:

Miss. Limestone—percentage of the county underlain by Mississippian aged limestone.
Silurian Limestone—percentage of the county underlain by Silurian aged limestone.
Min. Zinc—average minimum zinc value found in the natural waters of the county.
Rock Salt—percentage of the county underlain by rock salt.
Mean Zinc—mean value of zinc found in the natural waters of the county.
Avg. Dissolved O_2—average value of dissolved oxygen found in natural waters of the county.
Sand mines—number of sand mining operations in the county.
Min. Dissolved O_2—average minimum value of dissolved oxygen found in the natural waters of the county.
Max. Zinc—average maximum value of zinc in the natural waters of the county.
Min. Manganese—average minimum value of manganese found in natural waters of the county.
R^2—coefficient of determination.
N—number of counties with data for the specific analysis.
PR—probability of $R^2 = 0$.
CO emissions—average value for carbon monoxide emitted in the county.

0.01). Additional evidence to support the general conclusions is added as a result of the fact that the independent analyses on the four species identified similar groupings of independent environmental variables.

Discussion

The significance of the presence of limestone with respect to game harvests is probably the result of the integration of several geological, ecological, and socioeconomic factors. Geologically, the counties with both high harvests and large percentages of underlying limestone are those found within the Appalachian Plateau, with its dendritic non-parallel drainage patterns. Also, ridge and valley regions of West Virginia are characterized by lattice drainage areas with parallel ridges separated by relatively flat broad valleys often having meadows, with stunted and widely spaced vegetation and intermediate stage succession vegetation. Both of these areas are at elevations of between 2500 and 4500 feet. These latter areas possess exposed limestone which affects local fauna and flora by providing many springs, a higher soil and water pH, and often natural pastures with transitional vegetation. Socioeconomically, much of the land in this region lies within the Monongahela National Forest and is subject to many economic development restrictions. Economic activity within National Forest boundaries is limited largely to selective lumbering and/or livestock grazing. Because of federal restrictions imposed upon commercial growth, human population increases have remained low and the region is generally sparsely populated. Counties without federal lands, such as Hardy, Mineral, and Hampshire, are highly agricultural and have relatively broad fertile valleys with many acres of tilled crops. The combination of abundance of water, suitable food sources, shelter, and low stress from human habitation has undoubtedly resulted in good habitats for the four species studied.

The limestone variables used in the study are undoubtedly surrogates for other more ecological factors which would be necessary to describe good habitats for the species examined (such as the positive dissolved oxygen association, which near the higher end of its range can be used as one indicator of good water quality).

The ecological/distributional significance of the secondary variables (viz., high and low levels of zinc, underlying rock salt, dissolved oxygen, and number of sand quarries), or those components of the habitat that they might relate to, is not evident at this time. Clearly, the dominant relationship with game harvests is with the presence of limestones and their associated ecological communities with between 25 and 65% of the variation in wildlife harvests accounted for in the areas of these limestones.

Conclusions

Very strong associations were observed among the percentage of the county underlain by Mississippian and/or Silurian aged limestones and legal game harvests for deer, turkey, bobcat, and beaver. Also, there is a secondary association among the amount of beaver harvests and the number of sand quarries in the counties studied. A modest secondary association between bobcat harvests and the average levels of dissolved oxygen in the natural waters of the various counties was also observed.

Acknowledgments

We wish to thank Drs. Roland Guthrie and Steven Tonsor for their comments on the paper.

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Low pH Tolerance Under Continuous-Flow Bioassay Conditions of Hellgrammite Larvae, *Corydalus cornutus* L. (Megaloptera: Corydalidae)

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Abstract

Hellgrammite larvae, *Corydalus cornutus* L., were experimentally tested under continuous-flow bioassay conditions to determine their tolerance to low pH. The straight-line graphical interpolation method was employed to determine the pH value at which 50 percent of the hellgrammites survived after 96 hours. The $TL_m{}^{96}$ pH value was 1.76. This investigation was compared with other low pH tolerance studies of larval megalopterans.

Introduction

The mining of bituminous coal has come to play a major role in the economy of several states, including West Virginia. West Virginia coal fields have supplied more than 7.5 billion tons of bituminous coal (Minerals Yearbook, 1969). Numerous mines, both active and inactive, are found throughout the state. But this mining produces an acid drainage effluent that is generally recognized as the most widespread pollution problem in the Ohio River Basin.

Aquatic insect populations have been found to be eliminated or greatly reduced following the addition of acid drainage effluent (Parsons, 1968; Roback and Richardson, 1969; Nichols and Bulow, 1973; Tomkiewicz and Dunson, 1977). This experiment was designed to determine the effects of low pH on hellgrammite larvae, *Corydalus cornutus* L., under continuous-flow bioassay conditions.

Materials and Methods

One-hundred hellgrammite larvae of similar sizes (45-50 mm) were collected from the New River, Raleigh County, West Virginia. They were returned to the laboratory for observation and acclimation over a 48-hour period. Following acclimation, the hellgrammites were added to five duplicate 10-gallon glass aquaria (10 per aquarium) under continuous-flow bioassay conditions. The system consists of a water pump, two 20-liter Marriott bottles, two manifold boxes (each with five spigots), connecting funnels and hoses, splitter boxes atop each pair of aquaria, and standpipes and drains throughout to carry off water. Carbon-filtered tap water was pumped to the upper manifold box through PVC tubing. By combining relative amounts of H_2SO_4 (2N) and NaOH (5N), the following pH values were established in the aquaria: 6.6, 4.1, 3.0, 2.1 and 1.6. An Orion Research Model 601A/digital ionalyzer was used to check the pH readings. The water temperature was maintained at 22 C ($\pm$ 1.0). Each aquarium contained an air stone and a large flat rock. Hellgrammites were not fed during the experiment.

The 96-hour TL_m (median tolerance limit) test was employed as the measure of acute toxicity to low pH (APHA, 1971). The straight-line graphical interpolation method was used to determine the pH value at which 50 percent of the hellgrammites survived after 96 hours. Tests were duplicated and the mean was plotted as the final TL_m value.

Results and Discussion

Hellgrammite larvae showed a 96-hour TL_m pH value of 1.76 (Figure 1). One-hundred percent of the larvae survived in all pH levels after 24 hours (Table 1). After 48 hours, 95 percent survived in pH 6.6, 4.1, and 3.0, while 90 percent survived in pH 2.1 and 1.6. After 72 hours, either 90 or 95 percent survived in pH 6.6, 4.1, and 3.0, while 85 percent (pH = 2.1) and 75 percent (pH = 1.6) survived at the lower pH levels. At the end of the experiment (96 hours), either 90 or 95 percent survived in pH 6.6, 4.1 and 3.0, while 75 percent (pH = 2.1) and 35 percent (pH = 1.6) survived at the lower pH levels.

Aquatic insects differ drastically in pH tolerance. Generally, trichopterans and megalopterans are the most tolerant aquatic insects followed by odonates and plecopterans, with ephemeropterans the least tolerant (Bell and Nebeker, 1969; Bell, 1971; Kimmel and Hales, 1973). Bell and Nebeker (1969) have shown that aquatic insects are tolerant of acidic conditions for short periods of time. The $TL_m{}^{96}$ pH value ranged from 1.5

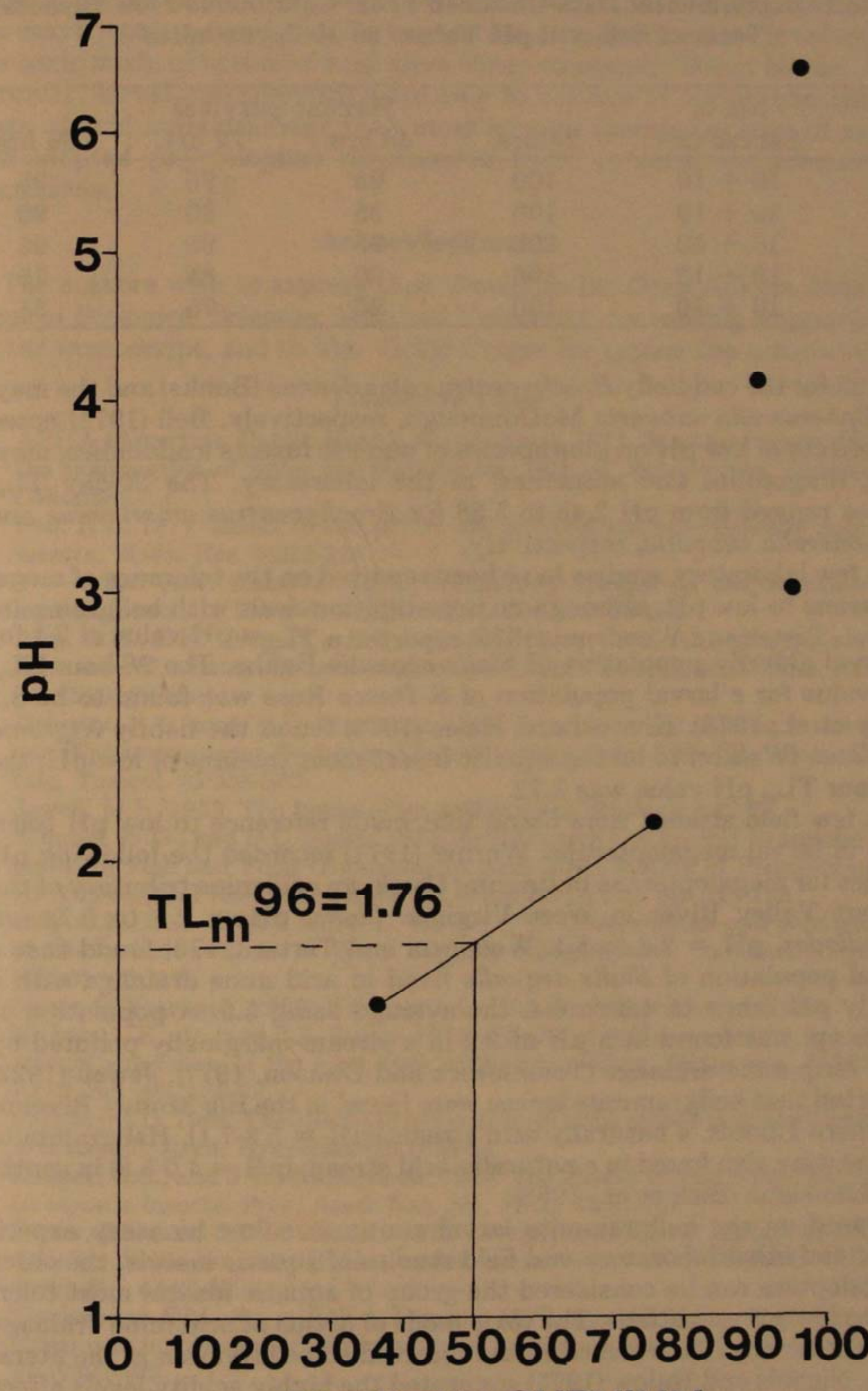

FIGURE 1. Estimation of the median tolerance limit of pH on hellgrammite larvae, *Corydalus cornutus*, by straight-line graphical interpolation.

Table 1. Experimental Data Obtained From Continuous-Flow Bioassay Tests of Selected pH Values on Hellgrammites

pH	No. of Larvae (20)	Percent Survival 24 hrs.	48 hrs.	72 hrs.	96 hrs.
6.6	10 + 10	100	95	95	95
4.1	10 + 10	100	95	90	90
3.0	10 + 10	100	95	95	95
2.1	10 + 10	100	90	85	75
1.6	10 + 10	100	90	75	35

to 4.65 for the caddisfly *Brachycentrus americanus* (Banks) and the mayfly *Ephemerella subvaria* McDunnough, respectively. Bell (1971) noted the effects of low pH on nine species of aquatic insects (caddisflies, mayflies, dragonflies and stoneflies) in the laboratory. The 30-day TL_{50} values ranged from pH 2.45 to 5.38 for *Brachycentrus americanus* and *Ephemerella subvaria*, respectively.

A few laboratory studies have been reported on the tolerance of megalopterans to low pH, although no investigation dealt with hellgrammite larvae. Tarter and Woodrum (1972) reported a TL_m96 pH value of 2.1 for a larval alderfly population of *Sialis aequalis* Banks. The 96-hour TL_m pH value for a larval population of *S. itasca* Ross was found to be 3.1 (Lilly et al., 1978). Kimmel and Hales (1973) found the fishfly *Nigronia fasciatus* (Walker) to be the aquatic insect most tolerant of low pH; the 96-hour TL_m pH value was 1.72.

A few field studies were found that made reference to low pH tolerance of larval megalopterans. Warner (1971) recorded the following pH ranges for megalopterans in Roaring Creek, an acid mine tributary of the Tygart Valley River in West Virginia: *Sialis*, pH = 2.8 to 5.7; and *Chauliodes*, pH = 2.8 to 5.1. Woodrum and Tarter (1973) found that a larval population of *Sialis aequalis* lived in acid mine drainage with a yearly pH range of 4.3 to 6.4, the average being 5.0. A population of *Sialis* sp. was found at a pH of 3.2 in a stream marginally polluted by acid strip mine drainage (Tomkiewicz and Dunson, 1977). Jewell (1922) reported that hellgrammite larvae were found in the Big Muddy River of southern Illinois, a naturally acid stream (pH = 5.8-7.1). Hellgrammite larvae were also found in a naturally acid stream (pH = 4.0-5.8) in southern Louisiana (Bick et al., 1953).

Based on the hellgrammite larval continuous-flow bioassay experiment and other laboratory and field studies of aquatic insects, the order Megaloptera can be considered the group of aquatic insects most tolerant to low pH conditions. The toxic mode of action of acid mine drainage on benthic macroinvertebrates has received some attention in the literature. Nichols and Bulow (1973) suggested the highly acidity levels affect the organisms directly through attack on the gills of benthos, which eventually succumb to anoxia. However, Doherty and Hummon (1980) reported that acid mine water did not consistently alter the respiratory rates of the stonefly *Eccoptura xanthenes* (Newman) and two species of the mayfly genus *Ameletus*. Perhaps several mechanisms are involved in the toxic mode of action of acid mine water on aquatic insect larvae. Apparently, larval megalopterans are able to survive in higher concentrations of acid mine drainage than most aquatic insects because of some well-adapted physiological response to these extreme environmental conditions.

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Engineering Section

Studying the Effects of Ultrasonics on the Processing of Materials with a Kinetic Model

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Abstract

In general, the effect of adding sonic radiation into the processing of materials appears to be catalytic. That is, sonic radiation increases the rate for a given process to reach equilibrium.

The influence of this catalytic effect by sonic radiation is usually quite significant when the normal rate toward equilibrium for the process is very slow. The mechanism by which the sonic radiation produces the catalytic effect appears to differ with the various process systems and conditions used. Processes which have been studied at West Virginia University for the effect of ultrasonic radiation include: solidification, recrystallization, heat treating of metals, heat conduction, drying, filtration, oil flow through porous sandstone, molding of polymers, mechanical drilling, and the adherence of molten glass to heated metal.

A mechanical model was built to simulate the motion of the units within a system when irradiated with sonic energy. Both the effect of frequency change and intensity change was investigated. A motion picture of the results was recorded.

Sonic assist in heat and fluid flow

Figure 1 shows the results obtained when ultrasound was introduced in metal during heat flow. The system was in the unsteady state. Different rates of temperature increase were obtained by applying ultrasound of different intensities. It appears that there was an optimum ultrasonic intensity which produced a maximum temperature rate of increase.

Figure 2 shows the results obtained when ultrasound was introduced into a system where oil was flowing through porous sandstone. Here it can be seen that an initial amount of sonic energy (intensity) was needed

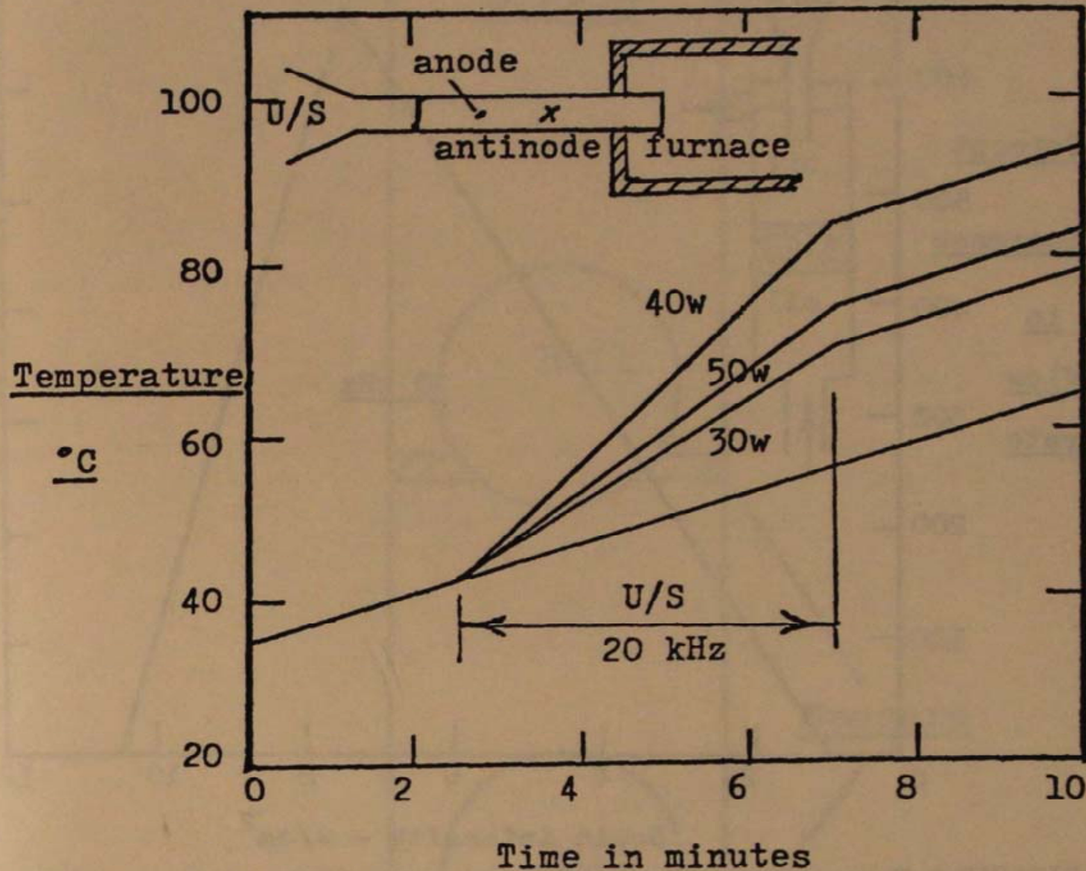

FIGURE 1. Curves showing the effect of adding ultrasound of different intensity on the unsteady heat flow rate in a metal.

before ultrasound stimulated the oil flow rate. Increased sonic intensity produced increased oil flow until a phase change occurred, producing an oil vapor due to cavitation. This vapor impeded the passage of the oil flow through the channels in the sandstone causing a "vapor lock."

Hypothesis

Simply expressed, the hypothesis is as follows: the influence of ultrasound causes a shifting of the units within a material away from their normal equilibrium vibrational positions. (Albeit a relatively small shift with a very small amount of kinetic energy added.) The introduction of sonic energy produces three types of motion: (1) translation, (2) rotation, and (3) vibration. The translation or linear motion being the predominant motion induced by the ultrasound.

Mechanical Model

Figure 3 shows a schematic sketch of the model which was built. It consists of three vertical guide rods and spacer plates having large center holes. A metal striking pin was located at the bottom, and a restraining knob at the top. Ping-pong balls were used as the units in motion.

Both the rate and intensity of the striking pin could be varied. Table 1

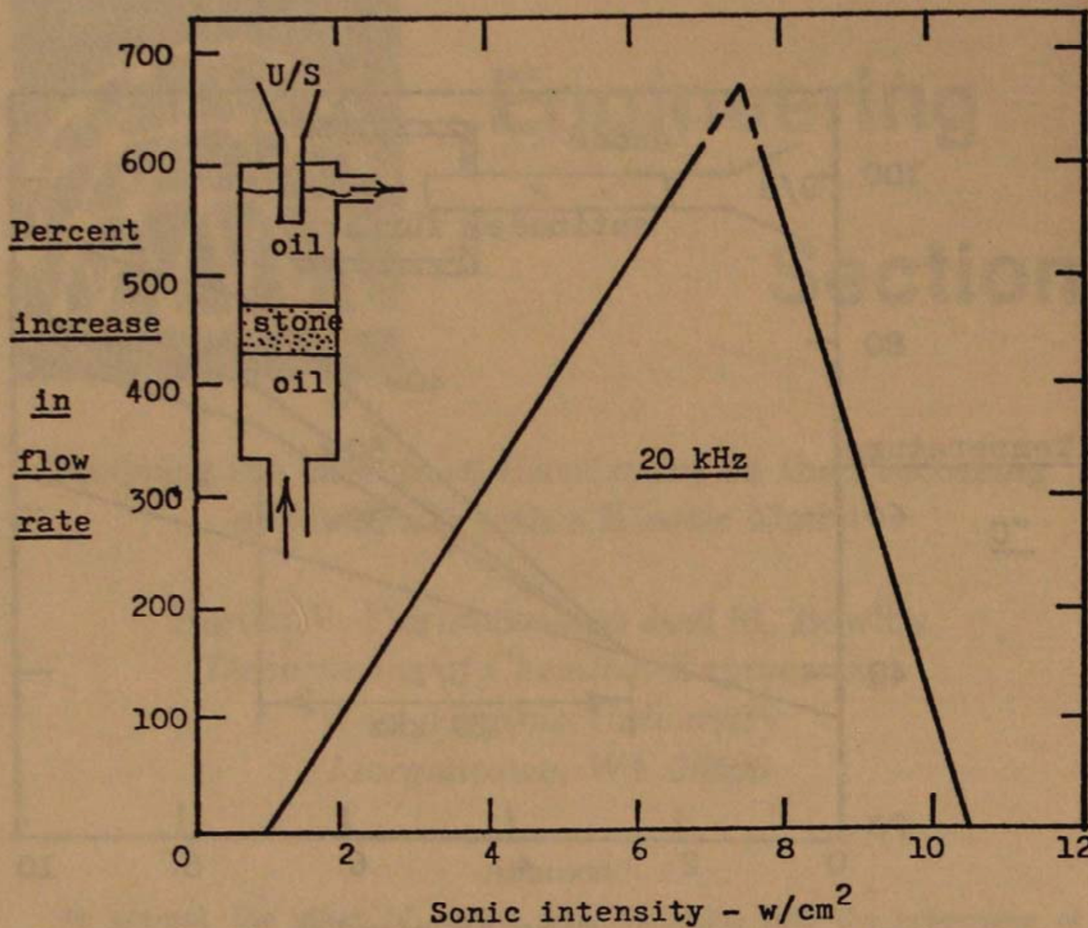

FIGURE 2. Curve showing effect on flow rate upon addition of ultrasound during the flow of oil through porous sandstone.

gives the design of experiments. The spacer plates were adjustable as was the clearance for the side movements of the balls contained by the vertical guides. An interface section was also made that could be attached to a side of the main unit. Gravity was used as the restraining force on the balls along with the knob at the top of the unit.

Table 1. Experimental Design

Variables	*Conditions*
1. Strokes per minute:	150, 250, 350
2. Force in grams:	50, 100, 150

Results and Discussion

It should be mentioned that the processes investigated and the mechanical model used were small finite systems fairly well-insulated from the environment surrounding them. This means that the introduction of ultrasound was fairly well confined to the system.

The model demonstrated the following results:

1. An initial amount of energy was required to affect the whole system.

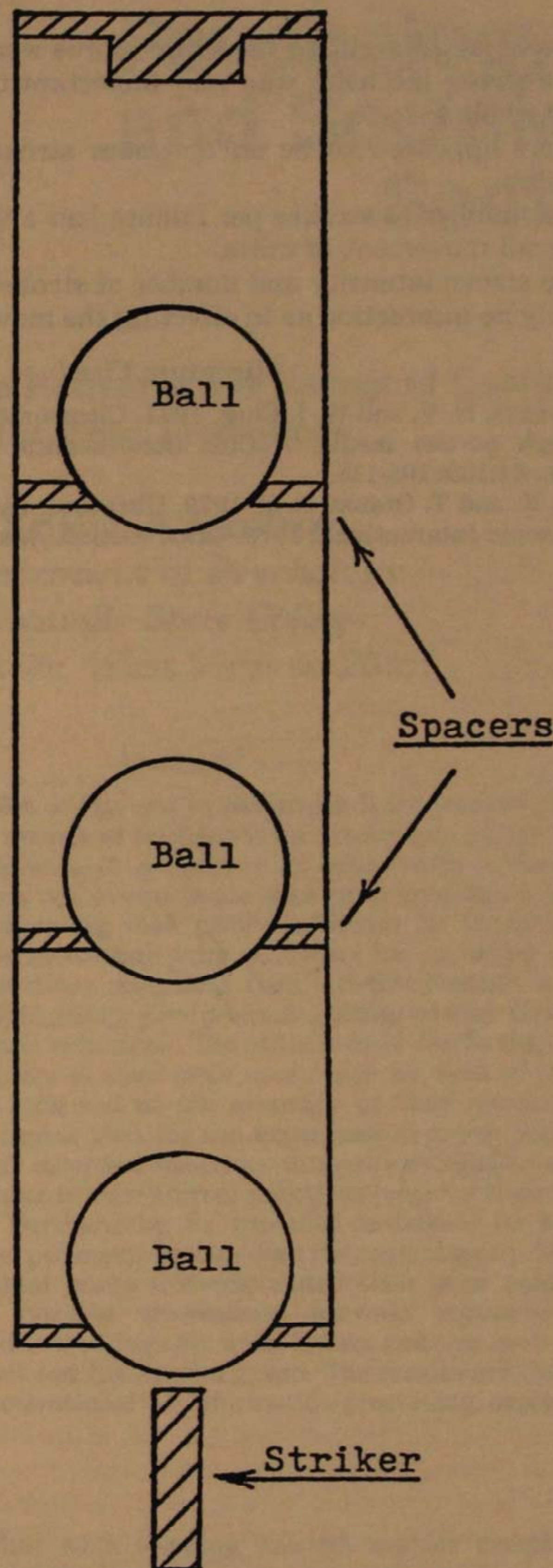

FIGURE 3. Schematic sketch of model.

2. The units adjacent to the sonic source were most activated.
3. The stroke intensity was very important to the movement within the whole system.
4. There appeared to be an optimum stroke intensity for a given system.
5. The number of strokes per minute had a very minor effect on the overall movement of units.
6. The stroke intensity and number of strokes per minute had essentially no interaction as to effecting the movement within a system.

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Psychology and Sociology Section

Distortions in the Retrospective Rating of Confidence for Prior Predictions

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Abstract

The purpose of this pilot study was to determine if systematic distortions occur in the retrospective ratings of confidence for predictions known to be correct or incorrect. Previous research suggests that subjects Ss informed of the outcome of their predictions will overestimate their prior confidence for correct predictions while underestimating their prior confidence for incorrect predictions. Thirty Ss each made 10 football team selections for upcoming games. In addition, Ss answered questions regarding their ego-involvement in football games. Half of the Ss (control group) gave pregame ratings of their confidence in being correct in each of their selections. The other half of the Ss (experimental group) gave postgame ratings of their prior confidence for each of their selections, after having been informed of the accuracy of their predictions. An analysis of the results indicates that for the experimental group only, the Ss' reported confidence in their incorrect selections (losses) was significantly lower than their reported confidence in their correct selections (wins) or their selections that ended in a tie (ties). Furthermore, Ss' reported confidence for losses was significantly lower for the experimental group than the control group. It was concluded that the experimental group underestimated their prior confidence in their losses. Significant positive correlations between measures of ego-involvement and Ss' confidence ratings for wins, losses, and ties were found for the experimental group, but not the control group. The results are discussed in terms of supporting a motivational or information-processing explanation of distorted hindsight.

Research indicates that with varying subject matter people have a tendency in making hindsight judgments to overestimate how well they would have performed prior to receiving outcome knowledge. Subjects (Ss), after being informed of which choices were correct, were asked to hypothesize on how they would have answered if they had not been so informed. The Ss were asked to hypothesize on what probabilities would they have assigned to alternative solutions to historical dilemmas (Fischhoff, 1975a), on answers to questions of fact (Fischhoff, 1977; Wood, 1978), and on outcomes of political and sporting events (Fischhoff & Beyth, 1975; Leary, 1981, 1982). In each of the studies, Ss apparently were unable to ignore the information and tended to distort their responses to conform more with what they were led to believe were the correct choices.

Fischhoff (1975a, 1975b, 1977) has attempted to explain this "knew-it-all-along" effect simply in terms of perceptual and cognitive activities by which people process information and make decisions. He feels that it is possible that when people are provided outcome knowledge they immediately assimilate it with what they already know to form an understanding of the event that includes all the relevant information as a coherent whole. People are unaware that they have reinterpreted what they knew to make the outcome appear more likely. Also, according to Fischhoff, if people are biased to view an event as relatively inevitable, they may in reasoning backwards alter other information that is already known so that it is perceived as more consistent with the outcome. Thus, distortions in thinking and memory can be interpreted as a result of the way information is processed, in that certain cognitive representations become emphasized or deemphasized, reassociated or disassociated, changed or forgotten, etc. This view is supported by evidence that a S's memory of an event is susceptible to distortion by relevant information that is later suggested to him (Loftus & Loftus, 1980).

A different explanation for the knew-it-all-along effect is that it is the result of motivational factors, such as the need to protect or enhance one's self-esteem, to feel competent, to have a sense of control over the environment, or to appear well to others. Attempts have been unsuccessful, however, to find evidence that the knew-it-all-along effect is influenced by a tendency of Ss to give a positive self-presentation or to enhance their self-esteem (Leary, 1981, 1982).

This is not the case with research on the attribution of causality. There is evidence that both informational and motivational processes mediate Ss' tendency to take credit for their successes but blame their failures on external factors for which they are not responsible (Bradley, 1978; Miller & Ross, 1975; Zuckerman, 1979). In the previous hindsight studies it is difficult to know whether prefeedback or hypothesized probability estimates free of hindsight distortion would be perceived by Ss as successes or failures. Thus, it is not known whether the knew-it-all-along effect results in Ss feeling that they were less wrong, more right, or some relative combination of both.

It is proposed that two forms a knew-it-all-along effect may take regarding predictions for which the outcomes are known are for Ss to report that they were more confident than they actually were for their successes and/or less confident than they actually were for their failures. It is the purpose of this pilot study to see whether a knew-it-all-along effect occurs for known correct and/or incorrect predictions and to help determine whether informational or motivational processes best explain the knew-it-all-along effect.

Method

Five student experimenters were instructed, using a double-blind procedure, to recruit and obtain data from a total of 30 Ss. The Ss were 19 males and 11 females with a mean age of 22.6 years. After the Ss agreed to participate in an experiment ostensively on "how good people are in predicting the scores of football games," they were randomly assigned to either an experimental or control group.

At the first meeting all Ss answered a questionnaire with four items designed to measure their degree of ego-involvement in the experimental task. The Ss were asked to give estimates about their interest in professional football games and their skill in predicting the scores of games. Ss were told to select 10 teams from 13 upcoming professional football games they thought would beat the point spreads that were shown to them. They were told that they could use outside resources to help them but that they had to make the final decisions. They also were told to do the best that they could and that there would be a cash prize for the person who got the most right.

The Ss were allowed several days to make their selections, with the deadline for submission being the day before the games were to be played. After the Ss in the experimental group returned the selections, an appointment was made to meet with them the following week. When the Ss in the control group submitted their team selections, they were asked to make pregame ratings of their degree of confidence in each prediction. The ratings were made on a scale from 1 to 7, with 1 being not confident at all and 7 being extremely confident.

When the Ss in the experimental group returned for their final appointment, they were shown which of their selections were correct (wins), incorrect (losses), or exactly matched the point spread (ties). Next, using the same scale as the control group, the experimental Ss were asked to rate the degree of confidence they felt when they first made each prediction. Their postgame ratings were written next to where their team selections had been scored.

Results

The experimental and control groups were very similar in the accuracy of their predictions. For the experimental Ss the mean number of wins, losses, and ties were 3.93, 4.0, and 2.07, respectively. The corresponding means for the control group were 3.67, 4.0, and 2.33. In addition, the mean number of wins was not found to be significantly ($p > .05$) correlated with any of the ego-involvement measures for either group.

As shown in Figure 1, however, there were apparent differences in confidence ratings between groups. A 2x3 mixed ANOVA of the confidence ratings revealed a significant, $F(2,56)=6.99$, $p < .01$, interaction effect for groups (experimental or control) x prediction outcomes (wins, losses, or ties).

An analysis of simple effects of each variable indicated only two sig-

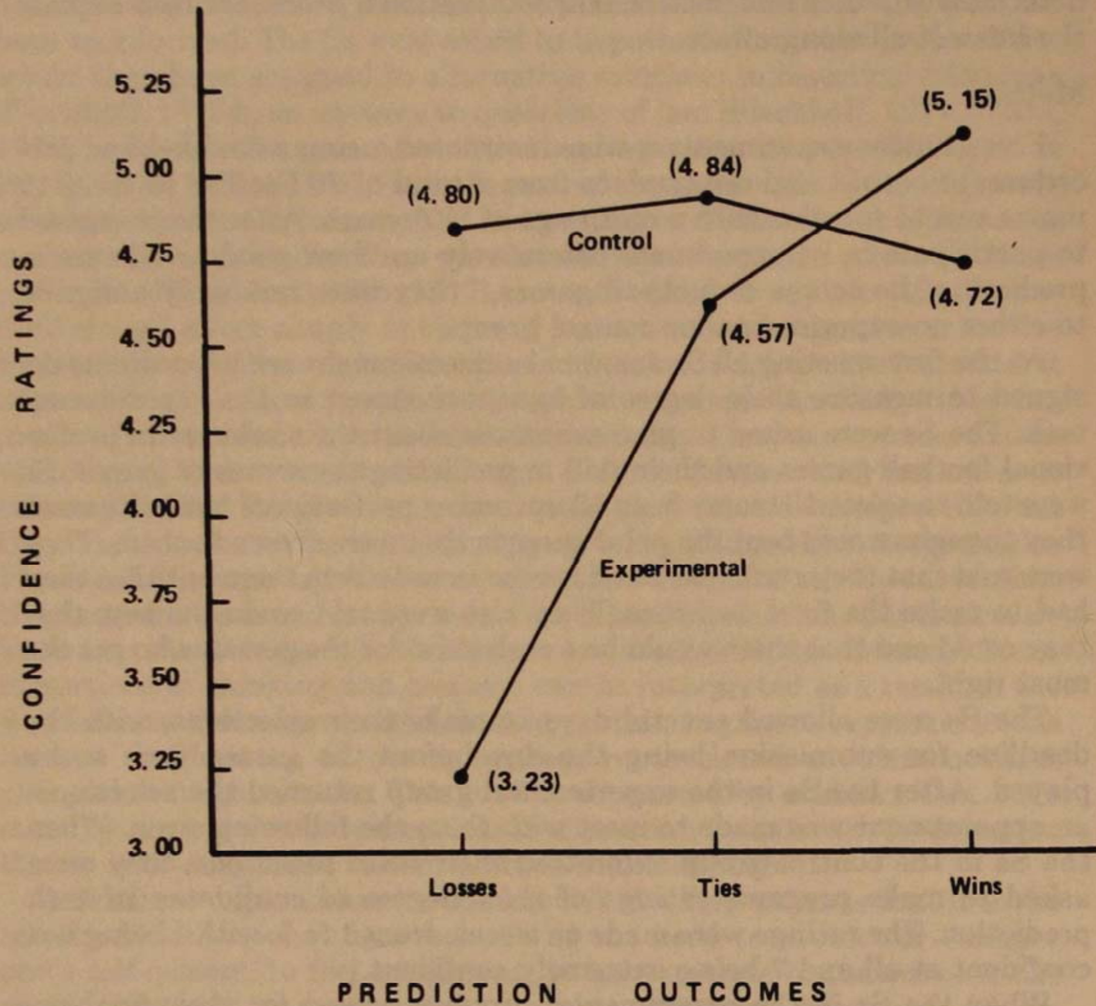

FIGURE 1. Mean confidence ratings of experimental and control groups for prediction outcomes.

nificant ($p < .01$) differences in confidence ratings. First, the confidence ratings of losses for the experimental group were significantly, $F(1,84) = 11.92$, $p < .01$, lower than those for the control group. Second, there were significant differences, $F(2,56) = 13.16$, $p < .01$, in reported confidence among prediction outcomes only for the experimental group. Subsequent Newman-Keuls tests among the experimental group's mean confidence ratings for prediction outcomes revealed that the reported confidence for losses was significantly ($p < .01$) lower than for ties or wins, and the reported confidence for ties was significantly ($p < .05$) lower than for wins.

Pearson product-moment correlation coefficients were calculated among the four measures of ego-involvement T-tests of these correlations revealed significant ($p < .01$) positive intercorrelations among all the measures of ego-involvement. The scores for the four measures of ego-involvement were combined to form a single composite measure of ego-involvement.

The means and standard deviations of the composite ego-involvement scores were 10.13 and 4.11 for the experimental group and 12.47 and 2.92, respectively, for the control group. The difference between the means for the two groups was not significant, $t(28) = 1.73, p > .05$. Significant ($p < .05$) positive correlations were found between the composite ego-involvement measure and the confidence ratings for wins, $r(15) = .62, p < .05$; ties, $r(15) = .58, p < .05$; and losses, $r(15) = .84, p < .01$, of the experimental group but only for losses, $r(15) = .55, p < .05$, of the control group.

Discussion

The results indicate that the experimental group Ss underestimated their prior confidence in their losses but did not exhibit a hindsight distortion in reported confidence for wins or ties. This provides evidence that the knew-it-all-along effect occurs in situations in which the outcomes of a person's forced-choice predictions are known to be incorrect. The knew-it-all-along effect thus appears to be best described as a tendency for Ss to report that their expectations were less in error than they actually were or would have been.

These results do not appear to support a simple information-processing explanation. According to the view presented by Fischhoff, a distortion in the retrospective rating of confidence should have occurred for both correct and incorrect predictions as soon as the outcome knowledge had been assimilated. However, a hindsight distortion in reported confidence for losses only is completely in line with an ego-protective motive interpretation of the knew-it-all-along effect. This is because only the Ss' predictions that are known to have been incorrect are potentially dissonant with attributions that Ss may have about themselves being knowledgeable, intelligent, competent, winners, etc. Thus, if Ss have a self-serving motive to protect their egos from dissonant information about themselves it need occur only for incorrect predictions.

Another explanation for these results is that the base confidence ratings of the control group may have made it more difficult to find a significant increase than a decrease in reported confidence for the experimental group. Since Ss were rating their confidence in teams that they predicted would beat the point spread it is more likely that confidence ratings of the control group for all prediction outcomes were closer to the psychological upper limits than the lower limits of the rating scale. An experiment in which experimental and control groups are assigned team selections by chance is proposed to help determine whether such a ceiling effect for wins may have occurred.

A finding that appears difficult to explain according to a self-serving motivational tendency is that the ego-involvement scores for the experimental group were positively correlated with confidence ratings for losses, as well as for wins and ties. As suggested by Leary (1981, 1982), if distorted hindsight is a product of motivational processes, the effect should be greater among Ss whose self-esteem most depends on making correct predictions about a given event. Therefore, it was expected that there would be a negative correlation between confidence ratings for losses and ego-involvement scores for the experimental group. But, as found in previous studies (Leary, 1981, 1982) there was no evidence that

Ss with the most ego-involvement had a greater tendency for the knew-it-all-along effect.

There are, however, several interpretations of the results that do not preclude the existence of motivational processes. First, it is possible that as ego-involvement becomes greater a general tendency for confidence in all predictions to increase may be relatively stronger than the competing tendency for the knew-it-all-along effect to increase for losses. If the confidence ratings were approaching a psychological upper limit then a general tendency for confidence to increase with greater ego-involvement would be even more evident in the lower confidence ratings associated with losses for the experimental group. Although a proposed general tendency for confidence ratings to increase with greater ego-involvement was observed only for losses in the control group, it is possible that the smaller variability among their composite ego-involvement scores made it more difficult to obtain significant correlations than for the experimental group. Second, the responses to the questionnaire items may have provided an inadequate measure of actual ego-involvement. Third, the degree of ego-involvement in the target activity may be, in itself, poorly related to the motive to be ego-protective. In fact, general personality variables may be more predictive of a need to be ego-protective in a situation than is the degree of ego-involvement in the situational activity. Recent evidence of one such variable is the finding (Muneno & Dembo, 1982) that differences in cognitive complexity are related to the tendency to make ego-defensive attributions. Interestingly, the degree of influence of an ego-protective motive on the knew-it-all-along effect may be mediated by individual differences in cognitive styles.

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The Revolution in Juvenile Justice in West Virginia: 1977 - 1982

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The revolution in juvenile justice which occurred in West Virginia between 1977 and 1982 was not independent of larger political and social forces. Most important among those forces was a change in thinking, nationally, as to what was best for juveniles who had violated the law. In 1967 the President's Commission on Law Enforcement and the Administration of Justice recommended a series of reforms which came to be known as the 4 Ds: due process, diversion, deinstitutionalization, and decriminalization (Empey, 1982: 409). Due process was gained with the Supreme Court ruling, *in re Gault,* in 1967. This required that children brought before the juvenile court must be granted essentially the same constitutional rights as adults facing criminal charges.

Congress led the way for the other 3 Ds with passage of the Juvenile Justice and Delinquency Prevention Act (JJDP) of 1974. The Act provided federal funds for innovative juvenile programs to each state which acted to comply with the JJDP guidelines. Most important among the guidelines were these five: the removal of all status offenders (children whose juvenile offense would not be a crime if committed by an adult: truancy, running away, disobedience, etc.) from secure incarceration-type facilities; the provision that all juveniles be placed in the "least restrictive alternative" constant with the best interests of the child and society; the separation of juveniles from adult offenders in those places where children are incarcerated; the monitoring of all jails and correctional facilities in order to ensure radical deinstitutionalization within the state; and the development of numerous community-based alternatives to incarceration (Sect. 223 (a)).

Efforts to to bring the State of West Virginia into compliance with JJDP began as early as 1974, although in 1976 the Legislature rejected a bill which would have initiated the flow of those federal dollars.[1] It was not until 1977 that the State took the necessary steps to meet JJDP compliance. Once begun, however, the results have been dramatic: the number of children held in county jails was reduced by 86%; the number of status offenders held in West Virginia correctional facilities was reduced by 100%; and the number of juveniles appearing before the juvenile courts was reduced by 57%. This paper traces the history of this revolution in juvenile justice.

West Virginia Supreme Court of Appeals. The revolution began with the Supreme Court of Appeals ruling in the case of Harris V. Calendine (March 22, 1977). The ruling stated that all status offenders must be removed from correctional facilities and cannot be held in secure facilities at all unless their behavior is so "unmanageable, ungovernable, and antisocial that he or she is amenable to no treatment or restraint short of in-

[1]New juvenile justice legislation similar to SB 200 was proposed by Welfare Commissioner Thomas Tinder and Rosella Archer, Director of Family and Children's Services, as early as 1974. A juvenile justice bill was rejected by the West Virginia State Legislature in 1976. That bill would have brought the State into compliance with JJDP guidelines a year earlier. Several of the people who worked to achieve compliance prior to 1977 are Frank Shumaker, Director of Youth Services, Department of Welfare; Karen Maimon, President of the Charleston Section of the National Council of Jewish Women (later appointed Youth Services Program Supervisor, Department of Welfare); Jean Loewenstein, Legislative Chairperson, Charleston Section of the National Council of Jewish Women; Karen Hill, Youth Services Program Supervisor, Department of Welfare; Dan Hedges, Director, Appalachian Research and Defense Fund; and Beth Bauserman, State Chairperson of Juvenile Services, West Virginia League of Women Voters.

The importance of non-governmental agencies in laying the groundwork for the revolution may be seen in the work of the League of Women Voters document, *Juvenile Services: Alternatives to Jail*, prepared in 1974. There the League made, among others, the following recommendations for improving juvenile services in West Virginia: reorganization of the fragmented juvenile justice system; the creation of a new youth authority to guide the total system; the removal of the term "delinquent" from all non-criminal type offenders (the League recommended that "status offenders" be called "unruly children"); the development of a state plan for juvenile services; the publication of a resource book listing all available juvenile services; a focus on prevention and diversion; opposition to "warehousing"; the expansion of group home and juvenile detention centers; improved aftercare for juveniles released from the juvenile justice system; the development of "positive behavioral programs" in all correctional facilities; and continued evaluation and research (LWVWV, 1974).

carceration. . . ." The most dramatic result of this ruling was the release of 61 of the 70 girls housed at the Industrial Home for Girls at Salem.

Other Supreme Court rulings had the following effects: terminated all forms of physical punishment in correctional facilities (K.W. and C.W. v. Werner, 1977); required that the State seek all "reasonable prospects for rehabilitating [the] child" prior to transferring a case to criminal court (E.D. v. Aldredge, 1978); required the court and all counsel to "explore and become knowledgeable of all possible community resources available to the juvenile court in an effort to find the least restrictive dispositional alternative having reasonable prospects for successful rehabilitation" (C.A.H. v. Strickler, 1979); charged the State with the constitutionally imposed burden of proving the juvenile's guilt beyond a reasonable doubt (West Virginia v. Peterman, 1979); required that a child be detained in county jail only under court order and for no more than 96 hours and that the child be separated from adult prisoners (R.C.F. v. Wilt, 1979); required that the lower court set forth a finding that "no less restrictive alternative would accomplish the requisite rehabilitation of the child" before sentencing a juvenile to a correctional facility (S.J.S. v. Fox, 1980); required that evidence admitted into juvenile court must be governed by the same rules as those governing criminal trials (D.D.H. v. Dostert, 1980); and affirmed the right of the superintendent of a juvenile correctional facility to return a child to the court when that superintendent is convinced that the child will not benefit from the programs provided by that correctional facility (R.S. v. Trent, 1982).

Legislation. Prior to the new legislation of 1977, Chapter 49 of the West Virginia Code defined a "delinquent child" as any child who is incorrigible, ungovernable, habitually disobedient, habitually truant, runs away from home without just cause, associates with immoral or vicious persons, or "frequents a place the existence of which is in violation of law." Such children might be taken into custody by the state and held in a secure facility. The law did not protect children from incarceration in the county jail.

Senate Bill 200, passed on April 5, 1977, revolutionized the juvenile code. The definition of delinquent child was limited to only those children who violate criminal law, are ungovernable, or habitually truant. No longer was a child guilty by association, occupation, location, or dangerous deportment. SB 200 requires the constitutional rights and protections set forth in the Gault ruling, significantly proscribes the use of county jails for the detention of children, requires the application of the "least restrictive alternative" principles when a child is taken into custody, separates status offenders from criminal-type offenders, defines an "improvement period" which the juvenile may request prior to disposition, and requires the Supreme Court of Appeals to appoint and maintain a five-member panel of attorneys whose task it is to visit and inspect all places where juveniles are involuntarily being held, to interview juveniles therein, and to report their findings to the Court. SB 200 defines the rights and protections of juveniles being held in custody by the state and requires the commissioner to publish annually a directory of alternatives to incarceration. SB 200 and the Harris ruling provided the necessary evidence that the state was seeking compliance with the 1974 JJDP Act.

Between 1978 and 1982 the Legislature passed three more acts, which significantly altered Chapter 49 of the State Code. SB 364 (March 11, 1978) "fine tunes" the legislative reforms begun in SB 200. From the point of view of JJDP guidelines, however, SB 364 was in some ways a step backward. The definition of delinquency was expanded to include a child who violated probation or who stands in contempt of any court (thus a status offender who refuses to cooperate with a court order becomes "delinquent"). Also, grounds for custody were expanded to include runaway children. SB 364 lowered from 16 to 14 the age at which a child might be held in a county jail, and allowed certain repeat-offender juvenile cases to be transferred to the criminal court.

House Bill 1484 (March 9, 1979), the "West Virginia Juvenile Offender Rehabilitation Act," was innovative in that for the first time the term "status offender" was written into the state code. The Act defines a "status offender" as

> a juvenile who has been charged with delinquency or adjudicated a delinquent for conduct which would not be a crime if committed by an adult.

Thus, a "status offender" is distinguished from a "criminal-type offender." HB 1484 empowers the Department of Welfare to establish prevention and diversion programs and community-based alternatives to incarceration, including a youth services bureau, advocacy programs, and "a statewide program designed to reduce the number of commitments of juveniles to any form of juvenile facility, to increase the use of non-secure incarceration and detention, and to discourage the use of secure incarceration and detention." The Department of Welfare is also instructed to create and maintain one or two small status-offender rehabilitation facilities wherein individualized treatment plans will be developed for each resident.

House Bill 1010 (March 13, 1982) again took some steps backward by JJDP standards. It lowered from 16 to 14 the age at which certain "extra-judicial statements" might be used in court and allowed children who were fugitives from the law to be taken into custody, as well as those who have a record of willful failure to appear at juvenile proceedings.

HB 1010, however, was also innovative in that it recommended several alternatives to incarceration, including small fines, restitution or reparation, and restrictions upon the privilege of driving a motor vehicle. The Act authorized the commissioner of welfare to "develop a comprehensive plan to establish a unified state system of predispositional detention," which would include youth services coordinators in each judicial district. Also, it required the use of emergency home shelters and foster homes for temporary detention. Finally, 1010 established a permanent legislative commission on juvenile law whose task it is to review continually the juvenile code and make recommendations for revision.

The State Advisory Group. With the 1977 Court ruling and SB 200, West Virginia became eligible for federal JJDP monies. As required by JJDP, the funds were administered by a State Advisory Group (SAG) for Juvenile Justice and Delinquency Prevention. Governor John D.

Rockefeller IV appointed 33 citizens to serve on that group, and the first meeting was held on November 10, 1977. On December 31, 1977, West Virginia submitted its first state plan for JJDP support, requesting 1978 fiscal funds. Since that time federal funds have been awarded to the state in the following amounts:

1978	$605,065
1979	513,000
1980	525,000
1981	525,000
1982	350,000
1983	355,000

These funds have been administered by the SAG for the following projects: a prehearing care survey; an information and referral clearinghouse for alternative placements, awarded to the West Virginia Child Care Association; jail monitoring programs; an independent living facility at the Methodist Children's Home at Burlington, and one at Samaritan House in Wheeling; juvenile advocacy; four treatment foster home programs for hard-to-place court referrals; ten alternative schools; seventeen community education and training programs; four emergency shelters; three community-based crisis centers; three restitution programs; and a home detention program.

Alternatives to Incarceration. The JJDP Act requires that "in order to receive formula grants" a state must submit a "plan for carrying out" the purposes of the Act. One key element of that plan is "to provide community-based alternatives to juvenile detention and correction" (Sect. 223 (a)(10)).

The Department of Welfare has attempted to achieve a full "spectrum and continuum" (Mayer, 1977) of services to children and youth. The full range of those services is made visible in *Alternatives: Directory of Youth Serving Agencies in West Virginia*, published annually by the Department of Welfare, as authorized by SB 200.

Services to the juvenile court are provided by the larger child-caring institutions as well as the newer community-based group homes. In 1979 41% of the children living in the larger institutions were status or criminal-type offenders; 74% of those living in group homes were juvenile offenders (Ulm, 1979).

Recognizing certain weaknesses in the state system, Welfare Commissioner Leon Ginsberg (1980) listed five program recommendations for improving services to children: expansion of pre-hearing care resources; residential treatment for emotionally disturbed youth; more alternative schools; increased family services; and improved community mental health services.

The Youth Services Major at West Virginia Wesleyan College. Recognizing the new growth in youth-serving agencies in the USA and that few youth-services workers have been adequately educated for their careers, a new academic major was created at West Virginia Wesleyan College in 1974. Students majoring in youth services take an interdisciplinary classroom program, spend an "urban semester" in Columbus, Ohio, and work for one semester as interns in youth-serving agencies. Since 1976 more than 50 students have graduated with degrees in that program and many are working in related agencies in West Virginia and elsewhere.

The Juvenile Justice Committee. Senate Bill 200, passed in 1977, required the creation of a Juvenile Justice Committee (responsible to the West Virginia Supreme Court of Appeals) which would monitor the jails of the state to determine whether the intent of the new juvenile law was being implemented. The Supreme Court took little action in that direction, however, until Michael Jeffery, a 17-year-old youth, hanged himself in a cell in the Kanawha County jail on September 20, 1979. Supreme Court Justice Darrell McGraw was physically prevented from inspecting the jail a few days later, whereupon the Court activated the Juvenile Justice Committee (Assault, 1980).

That committee has been vigilant in its inspection of all 53 of West Virginia jails since 1980, and by its efforts those jails have been encouraged to reduce drastically the number of children being held therein. The results of these efforts are evident in Table 1.

Juvenile Advocates, Inc. In 1980 the State Advisory Group for JJDP funded Juvenile Advocates, Inc., of Morgantown, to develop "a state-wide legal advocacy and legal education program for juveniles and those professionals who work as their advocates" (Juvenile Advocates, 1981). The major objectives were to establish detention criteria to be adopted state-wide; to assist and train lawyers who represent juveniles; and to reduce the number of juveniles inappropriately detained through "the development of detention criteria and advocacy for juveniles in jails and institutions" (Juvenile Advocates, 1980). Attorney Paul Mones was hired as director of the agency. Juvenile Advocates has successfully argued several *habeas corpus* cases before the West Virginia Supreme Court of Appeals, and has effectively altered juvenile law through Mones' advocacy. Mones has gained access to the state correctional facilities and has inspected many of the jails in the state. Juvenile Advocates has been a most effective agent in reducing the number of juveniles incarcerated within the state. Mr. Mones has also taught a course on juvenile advocacy at the West Virginia University Law School.

Results: Decriminalization, deinstitutionalization, and diversion. The results of these efforts are impressive. Through legislative action the status offenders have been "decriminalized" (SB 200 and HB 1484). Status offenders were deinstitutionalized through the action of the Supreme Court in Harris v. Calendine and other rulings. As Table 1 indicates, the number of children held in county jails and state correctional facilities has been drastically reduced. Furthermore, the successful diversion of children from the wide net of juvenile justice can be illustrated by the fact that in 1981 there were only 43% as many cases before the juvenile courts in West Virginia as in 1978 (see Table 1). The data presented in Table 1 summarize the progress that has been made.

The (near) future of juvenile justice in West Virginia. Much of the work of deinstitutionalization and decriminalization has been completed.

Table 1

	1976	*1977*	*1978*	*1979*	*1980*	*1981*	*1982*
1. Cases before Juvenile Courts in West Virginia[a]	4200	4026	4435	4355	3062	1890	
2. Juveniles in custody in state institutions[a]	326	279	262	218	136	106	
3. Accused status offenders and non-offenders detained in jails or detention centers more than 24 hours[b]	544	225	74	182	113		
4. Adjudicated status offenders held more than 24 hours[b]	83	44	14	0	0		
5. Juveniles not properly separated from adult offenders while detained[b]	940	785	430	240	138		
6. Juveniles in WV jails[c]					638	276	88
7. Status offenders in WV jails[c]					94	33	15

[a]Source: West Virginia Department of Welfare, Juvenile Delinquency Division. Disposition of Case by Reason for Referral. Report No. WE003P4. Table 8. 1976, 1977, 1978, 1979, 1980, 1981. Charleston, WV.

[b]Source: State Advisory Group Jail Monitoring Reports, 1976, 1977, 1978, 1979, 1980. The State Advisory Group was not required to monitor all facilities in 1981, but only those in violation in 1980. For this reason only 19 facilities were inspected in 1981, compared to 66 in 1980. Thus, 1981 figures were not presented in Table 1. Table 1 figures for 1981 were, for item 3: 6; for item 4: 2; and for item 5: 131.

[c]Source: West Virginia Supreme Court of Appeals. Juvenile Justice Committee, 1980, 1981, 1982. Survey of Juvenile Incarceration in West Virginia. (Six semi-annual jail monitoring surveys, all 53 county jails included.)

On January 18, 1983, the Department of Corrections closed the Industrial School for Boys at Pruntytown, moving the few boys who remained to the Industrial Home for Youth (formerly "for girls") at Salem. This reduced the number of youth correctional facilities remaining in the state to two (in 1977 there were five).

In West Virginia as in other states the next few years will witness a struggle to hold onto the gains made in the past five years. Federal JJDP funds have been reduced from $605,000 in 1978 to $355,000 in 1983. A recent memo from A.L. Carlisle of the National Advisory Council for the Office of JJDP calls attention to "a hasty and short-sighted turn of policy" at JJDP, resulting in a new focus on "apprehension and prosecution" of juvenile offenders (Feb. 3, 1983).

In 1982 the State Legislature mandated the development of a "comprehensive plan to establish a unified state system of predispositional detention" and establishment of youth services coordinators in each judicial district (HB 1010). Senate Bill 131 now before the State Legislature would provide guidelines for those youth services coordinators. But, as of this writing, passage of SB 131 seems doubtful and no action has yet been taken to implement such a plan.

The state must now address the issue of emotionally-disturbed delinquent children, as suggested by Ginsberg (1980). The Supreme Court of Appeals dealt with this in 1982 (R.S. v. Trent), and is dealing with it again in a case now before the court, E.H. v. Martin. The issue is institutionalized or deinstitutionalized care for such children.

Restitution programs have just now been formally established in the state (winter 1982-83). The State Advisory Group has provided money for three new restitution programs in 1983. Such plans seem appropriate to future programming in the state.

Alternative school programs are another current issue. Results of these programs have been encouraging. Figures provided by the WV Board of Education (Feb. 1983) indicate that the dropout rate for those eight counties in which alternative schools were established prior to 1981 fell more rapidly than for the state as a whole.

Acknowledgment

Several people have helped me with this paper. They include Frank Shumaker, Dennis Pease, Beth Bauserman, Jean Loewenstein, Robert Weis, Lauren Young, Mike Arbogast, Les Ulm, W. Joseph McCoy, and Sandra Ianuzi. My thanks to them.

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Minutes of the Annual Business Meeting
West Virginia Academy of Science
The Verona Mapel Room
Glenville State College
Glenville, West Virginia

April 16, 1983

Welcome to the campus by Dr. William K. Simmons, President of Glenville State College.

The meeting was called to order at 9:15 a.m. by President Blaydes. Minutes of the April 3, 1982, business meeting were distributed and approved. The treasurer's report was presented by Dr. Pauley and approved.

Action was taken to include a page of "Necrology" in the Proceedings.

The nominating committee, chaired by Dr. Keller, presented nominations for:

President Elect—Dr. Tom Pauley
Treasurer—Dr. Roy Clarkson

There were no nominations from the floor. Both candidates were elected by unanimous vote.

An invitation to hold the 1984 Annual Meeting was extended by West Virginia Wesleyan College. The invitation was accepted.

On a motion by Dr. Glencoe, seconded by Dr. Keller, the Academy committed a minimum of $750.00, and as much more as the treasury could afford, to the West Virginia Junior Academy of Science.

Dr. Glencoe requested financial support from the Academy for the Science Talent Search Project. There were three winners this year.

Items considered by the Academy:

1. Joint meeting with West Virginia Sociological Associates. No action taken.

2. To promote science in West Virginia and particularly to seek involvement of State Government, Industries, and Institutions.

3. President Blaydes will provide Certificates of Membership which will be given to life members of the Academy and sold to others.

4. Editor's report was presented on the status of the "Proceedings."

5. Possible affiliation with the "West Virginia Committee of Correspondence" was discussed.

6. Recognition of charter members of the Academy was made: Nelle Ammons and Virgil Lilly.

7. Necrology: Bob Urban
   Henry Hurlbutt
   Mr. Hanlon

John A. Chisler
Secretary

WEST VIRGINIA ACADEMY OF SCIENCE
ANNUAL TREASURER'S REPORT
FISCAL YEAR 1982-1983

April 1983
WVAS Annual Meeting
Glenville State College
Glenville, West Virginia

January 1, 1982 to December 31, 1982

CASH RECEIPTS

Balance on hand January 1, 1982		$ 7,252.04
Dues	$1,950.00	
Institutional Memberships	1,403.00	
Proceedings	1,345.50	
Contributions	280.00	
Annual Meeting	533.50	
Page Charges	201.00	
Interest on Savings	428.38	
TOTAL RECEIPTS FOR YEAR	$6,141.38	
TOTAL RECEIPTS & BALANCE ON HAND		$13,393.42

CASH DISBURSEMENTS

Printing (McClain)	$3,440.13	
Printing (Printech)	17.15	
Duplicating	24.85	
Annual Meeting	713.10	
Postage	111.89	
National Assoc. of Academy of Science (dues)	30.00	
Secretarial Help	60.75	
Miscellaneous	150.31	
Telephone	31.66	
TOTAL DISBURSEMENTS	$4,579.84	
RECEIPTS LESS DISBURSEMENTS	$1,561.54	
CASH ON HAND December 31, 1982		$ 8,813.58

(Savings—$864.09)
(Checking—$3,949.49)
(Certificates of Deposit—$4,000.00)

Respectfully submitted,

Th K. Pauley

Thomas K. Pauley, Treasurer, WVAS

We the undersigned members of the audit committee, have examined the records of the treasurer of the WVAS from January 1, 1982 to December 31, 1982, and find them to be correct.

W. E. Keder, April 14, 1983
Kate Pickens, April 15, 1983
Richard F. Melka, April 15, 1983