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October Executive Committee Meeting Minutes
October 24, 1996

Members Present:

Dr. Marcia Harrison, President, WVAS
Dr. Ron Preston, President-Elect, WVAS
Dr. James Arnold, Treasurer, WVAS
Dr. Michael Panigot, Acting Secretary, WVAS
Dr. Bonnie Dean, Chair, Dept. of Biology, WV State College
Dr. Tim Ruhnke, Dept. of Biology, WV State College
Dr. Sundar Naga, Dept. of Chemistry, WV State College

Acceptance of minutes of the last meeting.

The minutes were accepted as presented.

Treasurer's report/update.

Dr. James Arnold, Treasurer, presented the treasurer's report. The opening balance of WVAS at the start of Dr. Arnold's term was $11,418.29. Two audits were performed, one before 1993 and one after 1993. State tax filing for the years 1993 through 1996 is currently being done by WVAS. Since September 15, 1996 the following transactions have occurred: Income of $515 and Expenditures of $134. The current balance of WVAS treasury is $11,799. A certificate of deposit in the amount of $5,000 exists due to money left to WVAS by a former member; interest from this CD will be used to fund the teacher of the year award.

Discussion of meeting preparation

-Symposium topic and keynote speaker. Ron Preston suggested a symposium on mine restoration and reclamation of mining lands; the suggestion was approved by the members present at the meeting.

-Review of abstract submission procedure. Abstracts will be submitted to Dr. Ralph Taylor (editor of WVAS proceedings) at Marshall University. Once collected and compiled, the abstracts will be forwarded to West Virginia State College to handle programs, announcements, room assignments, etc.

-Set dates for abstract submission, meeting preprogram, and Proceedings vol. 1 publication. Currently, the Call for Abstracts will be sent out sometime in mid-November, 1996. The cutoff date for a paper to be presented as an oral presentation will be February 7, 1997. The cutoff date for a paper to be presented as a poster presentation will be February 21, 1997. The preprogram will be mailed around March 14, 1997.

-Teacher of the year award. The teacher of the year award will be selected from Kanawha, Putnam, and surrounding counties near WV State College. A nominating committee will be selected to select the teacher of the year.

-Student awards. Two judges per category will be involved in the selection of the student to receive student awards. One award per category will be given.

-Vendors. It was decided that Dr. Tom Weaks would contact vendors for their participation as he is involved in Academy of Science and has contacts with many vendors. A fee of $100 will be charged to vendors.

-Registration procedures. The procedure for abstract submission and meeting registration was discussed. WV State College will take care of nametags and handle dues and registration fees. Preregistration and on-site registration were discussed.

-The flyer to be sent with the Call for Abstracts will include possible field trips and symposium topics that have been determined by the time of the mailing. This flyer is to be sent out by WV State College around the second week in November 1996.

Date for membership renewal, ballot for secretary position, call-for-papers mailing.

The dates for membership renewal, call for papers, and ballot for the secretary position will be sent out in mid-November.

Discussion of duties for institutional representatives.

Institutional representatives to have contact with other faculty and students and inform new faculty of WVAS are to be selected.

Recruitment for new members.

The president should welcome all new math and science faculty in the state and provide them meeting and membership information.

Editor's report

Efforts to get the 1993 proceedings published are still underway. There have been requests for the 1993 proceedings; most notably by the University of Iowa, that if they are not received soon they will request a refund of their money paid for them. It was decided that in the future a one-year turnaround on publication of the proceedings would be the maximum amount of time between submission and publication.

Junior WVAS report: State Science Fair will be April 5, 1997.

The flyer will be sent out soon.

Appoint nominations committee for president-elect.

Names discussed for the nominating committee included:

Ben Stout (Wheeling College)

Ron Preston or Linda Butler (WVU)

Steven Stevenson (Fairmont State)

Marcia Harrison (Marshall)
These names are not necessarily those of the final nominating committee.

Organize April meeting for executive committee.
The April executive committee meeting is to be held the night before the annual meeting on April 11, 1997.

Submitted by: Dr. Mike Panigot, Acting Secretary of WVAS
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Children's Worries and Parents' Perceptions of Those Worries

Jessica D. Talley and John H. Hull, Bethany College,
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Abstract

This study examined the nature and intensity of children's worries and the extent to which parents are aware of those worries. Children from three class ranges - third and forth graders, seventh and eighth graders, eleventh and twelfth graders - and their parents filled out questionnaires designed to measure children's self-reported levels of worries, and parents' estimates of their individual child's worries, in three broad areas: Physical Harm (e.g., being a crime victim, AIDS), Daily Life Matters (e.g., not being liked, divorce), and Global Issues (e.g., world hunger, destruction of rainforests). Analyses of variance and t-tests showed that: Overall, girls and boys reported about equal levels of worry, although boys reported significantly more worry on four items in the Global Issues area; there was no consistent relationship between age of child and overall level of worry; overall, children worried significantly more about Physical Harm than they did about either Global Issues or Daily Life Matters; parents significantly underestimated their children's levels of worry on most items across the three areas.

Introduction

Virtually all children experience worries and fears, yet until recently relatively little research had been done in this area. One focus of recent research has been the content of children's worries and fears. Silverman, La Greca, and Wasserstein (1995) reported that second through sixth graders most commonly worried about school, health, and personal harm, and that one of the most intense worries was concern about being physically attacked or harmed. Gottlieb and Bronstein (1996) found that, in general terms, sixth-grade children worried most about global issues (e.g., pollution, starvation) and physical harm (e.g., family member dying, own death), and least about daily life matters (e.g., not being liked, divorce of parents). Henker, Whalen, and O'Neil (1995), examining the worries of fourth through eighth graders, found that most children mentioned at least one self-worry, while almost half had global-societal concerns, and almost one third indicated at least one worry related to family.

A second focus of recent research has been on amount of worry, and differences in worries, of girls and boys (e.g., Davidson, White, Smith, & Poppen, 1989; Doctor, Goldenring, & Powell, 1987; Gottlieb & Bronstein, 1996). Most studies show that girls report more worries, and a higher intensity of worry generally, than do boys. However, most studies also report a decline in worrying with age for boys and girls.

A third focus of recent research has been on parents' perceptions of their children's worries. Most studies show that parents often underestimate the amount or extent of worry of their children. As examples, Doctor, et al. (1987) found that parents of highly worried children perceived their children as being less concerned about nuclear war than they actually were. Jones and Borgers (1988) reported children have more fears in general than their parents think they have. Gottlieb and Bronstein (1996) found that parents were fairly accurate in perceiving how much their children worried about daily life matters, but parents underestimated the degree to which their children worried about physical harm and global issues.

The present study examined the worries of children across a wider age span than did comparable prior studies, comparing the reported levels of worry with those predicted by the children's parents. On the basis of past research, we investigated four hypotheses: 1 - Girls would report higher levels of worry than boys; 2 - younger children would report higher levels of worry than older children; 3 - children's levels of worry about global issues would be greater than or equal to their levels of worry about physical harm or daily life matters; 4 - parents would underestimate the levels of worry of their children.

Materials and Methods

Participants

Participants were 174 school-age children (66 males and 108 females) and 255 of their parents (88 males and 167 females) from West Virginia. All children had at least one "parent" participate in the study. Of the children, 78 (30 males, 49 females, ages eight or nine) were third or fourth graders, 50 (18 males and 32 females, ages 12 or 13) were seventh or eighth graders, and 46 (19 males and 27 females, ages 17 or 18) were eleventh or twelfth graders. "Parents" included not only biological mothers and fathers, but also stepparents, and others serving as legal guardians. All participants lived in small towns or rural areas at the time of the study, and were predominantly from middle or lower middle class socioeconomic groups.

Instrument

All participants completed a Children's Worry Scale, adapted from a scale developed and factor-analyzed by Gottlieb and Bronstein (1996). The scale had a total of 20 items concentrated in three areas: Daily Life Matters, Global Issues, and Physical Harm. Items included: Daily Life Matters - getting bad grades, having no money, moving, looking ugly, not being liked, divorce; Global Issues - world hunger, pollution, nuclear war, overpopulation, global warming, destruction of the rainforests; Physical Harm - a family member dying, your own death, AIDS, getting sick/crippled, cancer, being a crime victim, drugs/alcohol, an earthquake. One Global Issues item (nuclear leak) was removed from Gottlieb and Bronstein's original scale, and two Global Issues items - global warming, destruction of the rainforests - were added. Each item was rated on a four-point scale from 1 - not at all worried, to 4 - very worried. Children were asked to rate their actual levels of worry, while parents filled out the Worry Scale based on what they thought their children's worry ratings were. Each child who wished to participate was given an explanatory letter, a permission slip, and two parent Worry Scales which were taken home in a sealed envelope. If parents chose to participate, they filled out their Worry Scales and returned them to school in a sealed envelope, along with their child's permission slip. The children of participating parents then filled out their Worry Scales at school. Of the 174 participating children, 162 (93%) had forms filled out by one or both biological parents, nine (5%) had forms filled out by one biological, and one nonbiological, parent, two had forms filled out by biologically-related guardians, and one had a form filled out by a stepparent only.

Results

Note: Unless otherwise indicated, statistical significance is at the .05 level. A 2 (gender) by 3 (age) by 3 (type of worry: the repeated measure) repeated measures ANOVA showed no significant difference in boys' and girls' mean levels of worry overall (female mean=2.32, male mean=2.39, $F(1,168) < 1$). Thus, Hypothesis 1: Girls would report higher levels of worry than would boys, was not supported. In fact, independent-groups t-tests showed only four of the 20 items on the Children's Worry Scale had significant male-female differences. All items were from the Global Issues area, and all showed boys reporting significantly <u>more</u> worry than did girls. Those items are summarized in Table 1.

Table 1. Children's Worry Scale items showing significant male-female differences

item	male mean	female mean	t	p<
Pollution	2.79	2.40	2.31	.05
Overpopulation	1.97	1.53	3.29	.001
Global warming	2.20	1.69	3.20	.01
Destruction of the rainforests	2.79	2.40	2.17	.05

Hypothesis 2: Younger children would report higher levels of worry than older children, received partial support. One-way ANOVAs with children's ages as the independent variable showed the following significant age differences:

Table 2. Children's Worry Scale items showing significant age differences

item	grades 3-4	grades 7-8	grades 11-12	F	p<
1. Getting bad grades	2.61	2.81	3.24	5.90	.01
2. Having no money	2.00	2.43	2.55	4.46	.05
3. Looking ugly	1.95	2.34	2.37	3.25	.05
4. Pollution	2.86	2.33	2.24	6.44	.01
5. Nuclear war	2.39	2.66	1.98	3.79	.05
6. Overpopulation	1.49	2.02	1.70	5.67	.01
7. Global warming	1.75	2.26	1.74	4.35	.05
8. Destruction of rainforests	2.78	2.80	1.87	11.96	.001
9. Your own death	2.94	2.82	2.26	4.16	.05
10. Being a crime victim	2.20	2.59	1.98	3.24	.05
11. An earthquake	1.77	1.90	1.30	4.31	.05

Items 4, 5, 8, 9, and 11 showed significant decreases in worry as a function of age. However, items 1, 2, and 3 showed significant increases in worry as a function of age, while the remaining three items showed significant peaks of worry for the intermediate age level.

Hypothesis 3: Children's levels of worry about Global Issues would be greater than or equal to their levels of worry about Physical Harm or Daily Life Matters, received partial support. A repeated-measures ANOVA was conducted on mean scores for children's worries averaged within the three broad areas. Between-groups variables included child age and gender. The only statistically significant main effect was the repeated measure; Daily Life Matters and Global Issues means (2.26 and 2.28, respectively) did not differ significantly from one another, but the Physical Harm mean of 2.52 was significantly higher ($p<.001$) than either of the others. Means from a significant age by type of worry interaction are presented in Table 3. Newman-Keuls posttests

Table 3. Mean worry scores across age for the three main areas on the Children's Worry Scale

	grade		
area	3-4	7-8	11-12
Daily Living	2.18	2.29	2.30
Global Issues	2.35	2.49	2.08
Physical Harm	2.48	2.77	2.29

showed that the overall Physical Harm mean peaked significantly in the seventh and eighth grade sample, when it was also significantly higher than the Daily Life Matters mean. Global Issues and Physical Harm means dropped significantly from the seventh and eighth grade sample to the eleventh and twelfth grade sample. Finally, among eleventh and twelfth graders, there were no significant differences among means for the three broad categories of worry.

Hypothesis 4: Parents would underestimate the levels of worry of their children, received substantial support. Separate related-means t-tests, run on mean scores for children's worries, and their parents' estimates of those worries, for each of the 20 items on the Children's Worries Scale, and for the three broad area totals, are summarized below. Parents' estimates of their children's worries did not differ significantly from their children's self-reported worries on only one broad area - Daily Life Matters - and two other

Table 4. Children's Worry Scale items showing significant parent-child differences

item	child mean	parent mean	t	$p<$
Getting bad grades	2.83	2.81	0.21	N.S.
Having no money	2.27	2.34	-.79	N.S.
Moving	1.95	1.61	3.55	.001
Looking ugly	2.17	2.38	-2.07	.05
Not being liked	2.20	2.41	-2.05	.05
Divorce	2.07	1.55	5.40	.001
World hunger	2.67	1.64	4.09	.001
Pollution	2.55	1.86	6.95	.001
Nuclear war	2.35	1.58	7.49	.001
Overpopulation	1.70	1.26	5.83	.001
Global warming	1.89	1.41	5.70	.001

Destruction of the rainforests	2.55	1.64	10.01	.001
A family member dying	3.46	2.75	6.64	.001
Your own death	2.72	2.38	2.95	.01
AIDS	2.65	1.87	7.49	.001
Getting sick/crippled	2.40	1.87	5.20	.001
Cancer	2.64	1.86	7.33	.001
Being a crime victim	2.25	1.70	5.31	.001
Drugs/alcohol	2.31	1.84	4.19	.001
An earthquake	1.68	1.39	3.16	.01

items - getting bad grades, and having no money. In both other broad areas and on 16 individual items, parents significantly underestimated their children's reported levels of worry. On only two items - looking ugly, and not being liked - did parents significantly overestimate the degree of their children's worry.

Discussion

Why do some previous studies show that girls report higher levels of worry than do boys, yet our study shows that, for the few items on the Children's Worry Scale that have significant gender differences, boys report more worry than do girls? Perhaps part of the reason is methodological. Children in our study were asked to rate levels of worry for a wide variety of specific items. Had we used a more restricted variety of items, or asked children to list their individualized fears, then rate the intensities of those fears, our participants might have produced gender differences others previously reported.

Why did only some worries decline across age, while others actually increased across age? First, our study used a wider range of children's ages than previous studies did, allowing more subtle age effects to emerge. Second, it is obvious that the type of worry measured is important in understanding changes in worry across age. The three worries which increased significantly across age - getting bad grades, looking ugly, and having no money - are all Daily Life Matters items. On the other hand, the five worries which decreased significantly across age - earthquake, nuclear war, own death, pollution, and destruction of the rainforests - as well as the three worries which peaked in intensity for seventh and eighth graders - being a crime victim, global warming, and overpopulation - are from the Global Issues or Physical Harm categories. It seems obvious in retrospect that as children reach late high school age their worries about self increase, while other worries decrease. Part of this change might simply indicate that as children age, they become more aware of the probabilities associated with particular worries, and change their worry patterns accordingly. Another possibility is that, as developmental psychologists have hinted in similar lines of research, worries about self-image and self-experience often increase during the teen years (e.g., Elkind, 1978). Perhaps these generalized concerns are reflected in some of the specific worries contained in the Daily Life Matters area. Future research could focus on clarifying and extending this finding.

The use of a wide age range of participants in our study also seems to explain why children's overall levels of worry were not greater for Global Issues than for Daily Life Matters, as in Gottlieb and Bronstein's (1996) study involving sixth-grade participants. As summarized in the results section, the repeated-measures ANOVA which showed the Physical Harm category with the highest mean worry level also contained a significant age by worry category interaction. For our two younger age groups (closest in age to Gottlieb and Bronstein's sixth graders) combined, mean worry for Global Issues was higher, although not significantly higher, than for Daily Life Matters. However, for our oldest age group, mean worry about Global Issues was lower, although not significantly lower, than for Daily Life Matters.

One possible limitation on generalizing the results of this study is the relatively limited range of socioeconomic and cultural backgrounds of the study's participants. Although demographic data were not systematically gathered, virtually all the participants in this study were rural or small-town Caucasians from middle- or lower-middle-class socioeconomic groups. Future research should expand the scope of this research to include a wider variety of participants, and to expand the range of ages studied. Nonetheless, this study should provide valuable information for parents, educators, and counselors as they deal with children and their fears.

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Liverworts of a wooded ravine in Wayne Vounty, West Virginia

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Abstract

Twenty-seven species of liverworts have been identified from a 0.8 ha ravine located near East Lynn Lake in Wayne county, West Virginia. The ravine is unique in that it is colonized by a considerably higher number of species of liverworts than has been reported from any other morphologically similar area within the state. This number represents twenty-four percent of the total species reported for the entire state of West Virginia. Twenty-four foliose and three thallose species were collected from the study area. Species richness was highest on upper surfaces of sandstone outcrops. Species richness was lowest for wooded areas between an ephemeral stream and rock outcrops. *Jubula pennsylvanica* (Steph.) Evans had the highest occurrence of all liverworts of the study area. This species also had the highest total percent cover of all species. *J. Pennsylvanica and Scapania nemorosa* (L.) Dum., by their "weedy" character in five or more habitat types, demonstrated the highest diversity of environ preference of all species in the study area. Species richness and total percent cover were highest on upper surfaces of sandstone outcrops. Factors contributing to the relatively large number of species within the area were probably related to water availability, high diversity of suitable substrates for colonization, and disturbance.

Introduction

Wayne County is located in the south-western part of West Virginia. Woodland vegetation is predominant throughout most of this rural county. Rocky forest floors, decaying logs, rock outcrops, cool rock-walled ravines, small streams and many other situations are commonplace. The high diversity of natural habitat types plus moderate disturbance associated with logging, farming and mining generate substrates highly favorable to the growth and distribution of liverworts (Weaks and Creekmore, 1981; Engelmann and Weaks , 1985).

Several studies of liverworts have been conducted in West Virginia and surrounding states. In one of these, Ammons (1940) studied the liverworts of the entire state of West Virginia. She made a considerable contribution to West Virginia hepaticology and probably collected more species of Hepaticae from the state than any researcher before her time. The major part of her work was conducted in the eastern part of the state, with only scant records from the western counties. She recorded 112 species for the state , twelve of which were from Wayne County. Wayne County is one of eight counties in West Virginia that border the Ohio River. Several other researchers have studied liverworts in counties along the Ohio River and in states that border on West Virginia.

Hall (1958) conducted a study of the Hepatic flora of southeastern Ohio. Fifty-eight species, supported by specimens, were recorded for Athens, Meigs and eastern Vinton Counties. Miller (1964) reported 122 species of liverworts for the entire state of Ohio. Six of these species were recorded for Lawrence County, Ohio which adjoins Wayne County, West Virginia to the south. Patterson (1953) reported on a study of Bryophytes from all physiographic provinces of Virginia; however, the majority was from the southeastern Coastal Plains. Of the 130 species collected, 17 were hepatics. In a more recent study, Breil (1996) presented a checklist of 64 Virginia Piedmont liverworts and hornworts.

In the present study, the liverworts of a deep wooded ravine were examined. The purposes of the study were: (1) to catalog the species of liverworts within the study area and (2) to establish their distribution within habitat types present. While some casual collecting of liverworts has occurred in the ravine for several years, this paper represents the first effort at cataloging the liverwort flora.

Description of the Study Area

The study area (82 degrees 22' 33" W, 38 degrees 15' 21" N) lies within the maturely dissected Kanawha section of the Appalachian Plateau physiographic province. The terrain is rugged with narrow, steep-walled valleys and high hills. Elevations in the vicinity of the study area range from 172 to 288 m above sea level. The study area is located in the Low Hills Belt of the Cumberland and Allegheny Plateau region of the mixed mesophytic forest (Weaks & Creekmore, 1981). The greatest part of the area is covered with second-growth upland hardwoods. A distinct oak-hickory-beech type of woods is prevalent. Generally the woods are open. Conifers (red cedar, eastern hemlock, mountain laurel, and Virginia pine) are scattered throughout the area.

The study site is located near East Lynn Lake in Wayne County, West Virginia. The area is a 12.1 ha cove containing a 0.8 ha ravine along the mid-length of the ephemeral drainage. The northern exposure, along with the climax growth, makes the site dry mesic to mesic within the cove and mesic to hydric within the contained ravine area. Overburden on the valley slopes is composed of detritus derived from weathered indurated clay, siltstone, and sandstone (United States Army Corps of Engineers, 1974).

Soil series of the lower elevations of the study area are predominantly of the Dekalb-Gilpin complex (U.S. Department of Agriculture, 1988). Runoff of water from this complex is very rapid, and natural fertility is low to moderate. These soils are not suited to cultivated crops. The hazard of erosion is very severe in unvegetated area and is a major management concern.

Soil series of the upper elevations of the ravine studied are of the Dormont-Latham complex. The available water capacity of the Dormont soil is high while it is moderate for the Latham soil. Runoff is very rapid, and natural fertility is moderate for the Dormont-Latham complex.

Season variations in temperature range from an average of 2.2 C in January to 23.9 C in July. The growing season averages approximately 6 months and usually falls between mid-April and mid-October. Precipitation and potential evapotranspiration average 108 and 79 cm per year, respectively (U.S. Army Corps of Engineers 1974).

Methods

All sampling sites were determined by the use of the dot-grid matrix method applied to a quad map. Three to six 25 m transects were randomly established for each habitat type sampled . A total of twenty-four 25 m transects was randomly established in the study area. Centered on each transect line, 10 x 10 cm quadrats were sampled at 1 m intervals. Percent cover of each hepatic species within the quadrat was determined by measurement and calculation of area. Those hepatics having a percent cover less than 1% were referred to as infrequent species.

Tree bole communities were also sampled. The nearest tree, within 1.5 m of the closest meter mark, having a breast height diameter (DBH) of 10 cm or greater was sampled. Twelve quadrats were sampled on each tree (four at the base, 1 m and 2 m heights at cardinal points).

Nomenclature conformed to Stotler and Crandall-Stotler (1977). Voucher specimens were deposited in the Marshall University Herbarium, Huntington, West Virginia.

Habitat Types Sampled in Study Area.

Ephemeral Stream Channel (ESC): North-south compass orientation. Characterized by a substrate of consolidated rock, loose gravel, and sand. Occasional, shallow pools of water remain several days following moderate to heavy rainfall. Ephemeral Stream Bank (ESB): Height of the stream bank ranged from approximately 0.5 m at the upper (northern) end of the ravine to 2 m at the lower (southern) end.

Upper Surfaces of Sandstone Outcrops (USSO): Rock outcrops were confined to the western aspect along the rim of the ravine. Exposed upper surfaces of the outcrop ranged up to 0.5 m in width. Undercuts of Rock Outcrops (URO): Undercuts lay below a USSO and the cove proper. Undercut surfaces averaged approximately 60 degrees, ranged up to 2.0 m in width, and were mesic. Soils on slope above ephemeral stream (SSES): Substrates included litter and sandstone, Rocks ranged from gravel to boulder-size. Trees present included *Quercus sp., Fraxinus sp., Fagus sp.* and *Linden sp.)* Drains into Ephemeral Stream (DES): Some associated with rock outcrops while others were not. Evidence of only slight erosion appeared along banks of drains. Trees on slope above ephemeral stream (TSES): Trees (*Quercus sp., Fraxinus sp., Fagus sp., Linden sp., and Tsuga sp.)* were present and ranged up to 75 cm in diameter.

Results and Discussion

Twenty-seven species of liverworts were collected from the study area (See Table). *Jubula pennsylvanica* (Steph.) Evans had the highest occurrence of all liverworts of the study area . This species also had the highest total percent cover (36.59%) of all species. Cover of a second dominant species, *Calypogeja trichomanis* (L.) Corda was 15.9 percent. This latter species was reported by Engelmann and Weaks (1985) to be a dominant liverwort of recovering mine lands in West Virginia. *J. pennsylvanica* and *Scapania nemorosa* (L.) Dum., by their "weedy" character in five or more habitat types, demonstrated the highest diversity of environ preference of all species in the study area. However, the majority of liverworts occurred in only one or two habitat types suggesting a narrow range of ecological tolerance for these species.

Species richness and total percent cover were highest for upper surfaces of sandstone outcrops (USSO) (Table). Species richness was lowest for a wooded area between an ephemeral stream and rock outcrops (SSES) and along drains that discharged into the main ephemeral stream (DES). Lowest percent cover was lowest for SSES. Both USSO and DES showed evidence of disturbance associated with weathering and periodic flooding, respectively.

USSO, SSES, and TSES liverworts occupied the most distal habitats in relation to the ephemeral stream channel. Because of their location well above elevations where flooding occurs within the ravine, these species were not subjected to periodic inundation. The presence of similar but sparsely colonized substrates (i.e ESC) located within the periodic flood zone suggested that flooding was a factor affecting both liverwort species richness and cover. It is speculated that low cover and species richness for TSES and SSES habitats were related in major part to the absence of suitable substrates for colonization by liverworts.These habitats, characterized by a heavy ground cover of fallen leaves plus trees (i.e. *Quercus, Fraxinus sp., Fagus sp., Linden sp., and Tsuga sp.)* that were normally poorly colonized by liverworts supported only patchy populations with low cover.

The removal of competing vegetation during flooding, coupled with the exposure of a nutrient poor substrate, would appear to make stream banks suitable substrates for colonization by liverworts (i.e. *Pellia epiphylla)*. Downing (1992) reported that soils and limestone rocks supported more thallose liverworts than leafy forms. In the present study, coverage was high for ESB and when compared with the other habitat types, species diversity was moderately high. However, the spatial distribution of populations of these species on the bank of the ephemeral stream suggested selective pressure and restriction to microhabitats protected from flood associated processes. The complete absence of liverworts on areas showing evidence of scouring, sedimentation or erosion indicated that these important factors restricted colonization by liverworts. In addition, an effect by water itself could not be ruled out. In studies of corticolous lichens, Beckelhimer and Weaks (1984, 1986) concluded that lichen species that are able to colonize and compete effectively on streamside trees subjected to periodic inundation must have physiological and/or morphological adaptations to sediment accumulation, at the heights at which they grow. These adaptations include the capacity to colonize a modified substrate. In the present study, the high cover of *J. pennsylvanica* along the stream channel suggested that this species, is better adapted physiologically and/or morphologically than the other species of the study area.

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TABLE . Liverwort species distribution type, percent of coverage per habitat, area and percent of total overage. Comon ≥ 15% coverage, frequent (freq.) 4-15% coverage, occasional (occ.) 0.1-4% coverage, rare < 0.1% coverage or not found in quantitative sampling.

(**DES**=Drains into Ephemeral Streams; **ESB**=Ephemeral Stream Bank; **ESC**=Ephemeral Stream Channel; **SSES**=Soils on Slope above Ephemeral Stream;**TSES**=Trees on Slope above Ephemeral Stream;
URO=Undercuts of Rock Outcrops; **USSO**=Upper Surfaces of Sandstone Outcrops)

SPECIES	DISTRIBUTION TYPE	DES	ESB	ESC	SSES	TSES	URO	USSO	AREA 2 CM	TOTAL % COVER
Anastrophyllum helleranum (Nees) Schust.	occ.			5.1			1.5	0.7	34	1.10
Bazzania trilobata (L.) S. Gray	occ.						6.6	65	2.11	
Blepharostoma trichophyllum (L.) Dum.	occ.						8.1	3.7	111	3.61
Calypogja neesiana (Mass. & Carest.) K. Mull	occ.			15.3					9	0.29
Calypogeja sullivantii Aust.	occ.							2.2	22	0.71
Calypogeja trichomanis (L.) Corda	common		1.5	13.6			16.9	28.8	490	15.94
Blepharostoma trichophyllum (L.) Dum.	occ.						8.1	3.7	111	3.61
Calypogja neesiana (Mass. & Carest.) K. Mull	occ.			15.3					9	0.29
Calypogeja sullivantii Aust.	occ.							2.2	22	0.71
Calypogeja trichomanis (L.) Corda	common		1.5	13.6			16.9	28.8	490	15.94
Cephalozia catenulata (Hub.) Lindb.	rare									
Cololejeunea biddlecomiae (Aust.) Evans	occ.		3.8	3.3		15.8			44	1.43
Conocephalum conicum (L.) Lindb.	rare									
Diplophyllum apiculatum (Evans) Steph.	freq.						9.1	10.4	186	6.05
Frullania brittonia Evans	rare									

SPECIES	DISTRIBUTION	DES	ESB	ESC	SSES	TSES	URO	USSO	AREA 2 CM	TOTAL % COVER
Frullania inflata Gott.	occ.		1.5	8.5					17	0.55
Jubula pennsylvanica (Steph.) Evans	common	69.1	58.4	6.8	14.3		26.4	29.9	1125	36.59
Jungermannia crenuliformis Aust.	rare							0.1	1	0.01
Lejeunea laetivirens Nees & Mont.	freq.		3.8				25.4		265	8.62
Lophocolea heterophylla (Schrad.) Dum.	freq.		11.0	37.3		15.8	8.1		196	6.37
Lophocolea minor Nees	occ.		1.5			46.0			47	1.52
Metzgeria conjugata Lindb.	freq.		8.9		51.4		4.3	0.7	135	4.39
Nowellia *curvifolia (Dicks.) Mitt.*	occ.			34.3					12	0.39
Pellia epiphylla (L.) Corda	occ.		1.5	6.8				0.5	21	0.68
Porella platyphylloidea (Schwein.) Lindb.	rare									
Radula complanata (L.) Dum.	rare	3.1							5	0.16
Radula tenax Lindb.	rare									
Scapania nemorosa (L.) Dum.	freq.		6.5	3.3		22.4	0.2	7.7	147	4.78
Scapania undulata (L.) Dum.	occ.							8.7	85	2.76
Trichocolea tomentella (Ehrh.) Dum.	occ.		1.5						12	0.39

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Fish surveys of the upper Meadow River drainage, Greenbrier County, West Virginia

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Abstract

Fish surveys were conducted in November, 1994 on the upper Meadow River watershed (Gauley River, Kanawha River drainage) in an area designated as the Meadow River Wetlands. This complex in Greenbrier County encompasses approximately 2,024 hectares and is West Virginia's second largest wetland. A total of 1,03 1 specimens representing six families, 16 genera, and 21 species were taken from the Meadow River drainage at 17 locations. Distribution, relative abundance, and percent occurrence of all fishes is presented. Briefly, the most abundant species were *Semotilus atromaculatus* (29.9%), *Pimephales notatus* (1 S.9'/0), *Notemigonus crysoleucas* (12.2%), and *Lepomis cyanelks* (6.8%). The fishes most often encountered were: *Pimephales notatus* (88%), *Semotilus atromaculatus* (77%), *Lepomis cyanellus* (77%), *Notemigonus crysoleucas* (65%), and *Catostomus commersoni* (53%). Collections of *Cyprinus carpio, Notemigonus crysoleucas, Ameiurus melas, Gambusia affinis, Micropterus salmoides,* and *Pomoxis nigromaculatus* are first time records for the Meadow River drainage. The *A. melas* record is the first verified occurrence of this species in the upper Kanawha River (i.e., above Kanawha Falls) in West Virginia, while the *Gambusia* information represents the second record for the state and the first for the Kanawha River system. Fauna1 differences from the lower and upper Meadow River drainage are documented, and species composition changes that have occurred since the 1940's are noted.

Introduction

The Meadow River is a major tributary of the Gauley River in the upper Kanawha River system. It initiates in Summers County at approximately 1,200 m elevation and flows north to northwest to its confluence with the Gauley River at Carnifex Ferry. The river is 80.5 km long and drains 932 km*; its gradient averages 10.4 m/km and increases from the headwaters to its mouth (Hocutt et al. 1979). The headwaters slowly meander through a broad flat section of the Appalachian Plateau, but near Rainelle the river descends (with only a few interruptions) into a rigorous gorge for the last 48 km (Reed

1995). The low gradient upper reach from approximately Rupert creates an extensive wetland complex known as the Meadow River Wetlands. It is estimated that this unique upper drainage area, composed mostly of wet meadows and shrub swamps, encompasses 20,235 km* (ca. 5,000 ac.) and represents 5 percent of all wetland habitats in West Virginia (Tiner, 1987). The ichthyofauna of the Meadow River drainage are generally known, but records in the upper drainage are uncommon. The lack of fish data in the low gradient headwaters is attributed to inaccessible marshlands and the difficulties encountered in sampling such habitat. Unpublished historical information for the Meadow River drainage is presented in Addair (1944), who performed three surveys and collected 12 species of fish. Hocutt et al. (1979) greatly expanded the faunal knowledge of the watershed by sampling 16 stations (7 above Rupert) and increasing the total number of species to 29. In addition, since 1963, the West Virginia Division of Natural Resources (WVDNR) has performed 30 stream surveys in the drainage and reported 30 species of fishes; their surveys are documented in annual Federal-Aid Dingell-Johnson reports but have never been published or collectively summarized. The primary purpose of this study was to establish a fish database for the area known as the Meadow River Wetlands. This was accomplished by systematically collecting relative abundance and percent occurrence fish data and reviewing historic information. Because of the history of anthropogenic impacts and the distinct differences in habitat between the lower and upper Meadow River (Reed, 1994), a secondary objective was to compare historic with recent data so that the faunal changes and/or species composition variations would be documented for the entire drainage.

Methods and Materials

A total of 17 sampling sites were sampled in the Meadow River wetland complex above Rupert, West Virginia (Figure 1). The field work was conducted in November of 1994. Fishes were qualitatively collected primarily by using a 115 AC backpack electrofishing unit; occasionally a 1.5 x 3.09 m nylon seine with a 3.2 mm mesh was employed (i.e., at Stations 2,6,13,16). Stations were chosen based on accessibility to existing roads and trails and the presence of a variety of habitats. All stream and marsh habitats were sampled until a biologist determined that no further sampling would yield significant numbers of additional species (Hocutt et al. 1974). Large specimens were identified to species in the field, noted and released. As no fishes were determined to be rare or endangered, most specimens were preserved in 10% formaldehyde and returned to the laboratory for examination; a representative sample was preserved in 40% isopropanol and deposited in the U. S. Fish and Wildlife Service's

National Training Center fish museum at Shepherdstown, West Virginia. Common and scientific names follow Robins et al. (1991). The station localities in the upper Meadow River, Greenbrier County were as follows (Figure 1; detailed site descriptions available from WVDNR upon request).

1-4 Meadow River
5 Patterson Creek
6-7 Morris Fork
8-9 Buffalo Creek of Morris Fork
10 Eagle Branch
11 Callahan Branch
12 Otter Creek
13 Smoot Branch of Otter Creek
14 Methodist Branch of Otter Creek
15 Beaver Creek
16- 17 Little Clear Creek

Results and Discussion

A total of 1,031 specimens representing six families, 16 genera, and 2 1 species were taken from 17 collection sites in the upper Meadow River study area (Table 1). No species was common to all sampling locations. The most frequently encountered species were *Pimephales notatus* (88%), *Semotilus atromaculatus* (77%), *Lepomis cyanellus* (77%), *Notemigonus crysoleucas* (65%), *Catostomus commersoni* (53%), and *Micropterous salmoides* (41%). Although the standing crop of species by station was not calculated due to the difficulties in sampling (i.e. turbidity and unstable stream bottoms), the number of specimens at most localities was noticeably low; this was attributed to the naturally sterile water quality (i.e., low alkalinities) which is typical of Appalachian Plateau headwater streams. The most common species as expressed by relative abundance summed over all sites were *Semotilus atromaculatus* (29.9%), *Pimephales notatus* (18.9O/), *Notemigonus crysoleucas* (12.2%), *Notropis buccatus* (S.9%), *Lepomis cyanellus* (6.9%), and *Catostomus commersoni* (3.9%). The collection of *Cyprinus carpio, Notemigonus crysoleucas, Micropterous salmoides, Pomoxis nigromaculatus, Ameiurus melas*, and *Gambusia affinis* here represent the first published records from the Meadow River drainage (Hocutt et al. 1979, Stauffer et al. 1995). Moreover, the *Pomoxis* occurrence is the first from the Gauley River basin; *A. melas* the first from the West Virginia portion of the upper Kanawha drainage; and, *G. affinis* the first from the entire Kanawha River system. All records are regarded as introductions to the upper Kanawha River system (Jenkins and B&head 1994, Stauffer et al. 1995). The collection of *Ameiurus* *melas* and *Gambusia affinis* warrants further discussion. *A. melas* is known from the upper Kanawha or New drainage from only one verified 1939 account in Virginia (Burkhead et al. 1980, Jenkins and Burkhead 1994). The West Virginia records reported herein for this bullhead are important because at least two year classes were taken. Hence, this is the only known reproducing or extant population of *A. melas* from the entire upper Kanawha drainage. The occurrence of *G. afinis* is only the second record in West Virginia. It was captured for the first time in the state during a 1991 survey in the Potomac River drainage, where reproduction was not documented (Cincotta et al. in review). In April 1995, the authors verified that the Meadow River population is reproducing at Station 4. The source of both these species is attributed directly and/or indirectly to a bait distributor in Crawley (immediately south of Little Clear Creek). This contention is substantiated by the fact that the owner (D. Schoolcraft, pers. comm.) purchases his fishes from central Tennessee, where these common southern species could easily have been mixed with his baitfish stocks of Notemigonus crysoleucas and *Pimephales promelas*. Moreover, the owner's son revealed he had released into nearby streams "catfish" (i.e., probably *A. melas*), which were included with their minnow shipments. The addition of *Gambusia* and *Notemigonus* to this area may have also been by the dealer (deliberately or by escape), but could just as likely have been the result of a fisherman release of unused bait originating from this distributor. Records of the WVDNR indicate that several gamefishes have been stocked (historically and currently) in the upper Meadow River drainage (i.e., defined as 48 km above confluence with Gauley River). These species are *Salvelinus fontinalis, Salmo trutta, Oncorhynchus mykiss*, and *Esox masquinongy*. The former three species are regarded as introductions to the Meadow drainage and are all stocked in Big and Little Clear creeks on a put-and-take basis; they are expected in the study area, especially during the spring and fall stocking seasons. *Esox musquinongy* has been stocked in the upper drainage since 1963 and is regularly released at Station 4 (Rupert area); its absence in our surveys is attributed to the difficulty in sampling the deepest pools in November with hand-held electrofishing equipment. Other species not taken in this study that are known from the upper Meadow River drainage are: *Cyprinella spiloptera, Notropis stramineus, N. rubellus, N. photogenis, N. volucellus, Nocomis platyrhynchus, Hypentelium nigricans, Ameiurus nebulosus, Micropterus punctulatus, and Etheostoma blennioides.* Addair (1944), Hocutt et al. (1979) and WVDNR (unpubl. data) all document the local occurrence of *H. nigricans* and *E. blennioides,* and the latter two sources have also verified records of *N. rubellus, N. platyrhynchus,* and *M.punctulatus* in the upper drainage; with the exception of *M: punctulatus*, the absence of these species here was attributed to the lack of suitable habitat in the low gradient wetlands. *M. punctulatus*, an introduced species, apparently is rare to the upper drainage. Interestingly, C. *spiloptera*, *N. stramineus, N. photogenis* and *N. volucellus* are all indigenous and known from the upper watershed from the records of Addair (1944) only, while *A. nebulosus* is documented by only Hocutt et al. (1979). Jenkins and B&head (1994) consider *A. nebulosus* introduced to the upper Kanawha River drainage as the Hocutt et al. account is the only record of it above Kanawha Falls. The absence of C. *spiloptera*, N. *stramineus*, N. *photogenis* and N. *volucellus* (Addair 1944) is somewhat perplexing. Of his three Meadow River stations sampled, Addair found them all near Rainelle in the upper drainage and all except *N. volucellus* in the Russelville area in the lower drainage. However, Stauffer et al. (1995) Hocutt et al. (1979), and WVDNR have not collected these species anywhere in the Meadow River drainage. Although *N. volucellus, N. stramineus*, and *N. photogenis* are apparently locally common elsewhere in Gauley River waters, *C. spiloptera* has apparently disappeared from the entire drainage (Hocutt et al. 1979, WVDNR unpubl. data). The loss of these species may be the cumulative result of years of poor land use practices from logging, mining and agricultural interests in the Meadow River drainage (Reed 1995). The above summary documents 35 species of fishes from the upper Meadow River drainage. Only five additional species of fishes are restricted to the lower drainage and have apparently not been able to negotiate the rigorous gradient of the gorge. These species are Rhinichthys caturactae, Pylodictis olivaris, Etheostoma nigrum, Percina oxyrhnychus, and *Stizostedion vitreum*; all are considered native except the *S. vitreum*, which was historically introduced by WVDNR for sportfishing. The addition of these five fishes brings the total for the entire Meadow River drainage to 40 species (22 native, 18 introduced).

Acknowledgments

This study is part of a larger inventory of the Meadow River Wetland Complex conducted cooperatively with the West Virginia Office of Water Resources, Division of Environmental Protection. Thanks is extended to Dr. Thomas Pauley of Marshall University who provided us 21 October 1994 data for *Gambusia affinis* and *Ameiurus melas*, which were collected during the herpetology field work for the project. Allan Temple of the FWS accepted and catalogued arepresentative sample of our fishes into the National Training Center's fish museum. We particularly wish to express our gratitude to WVDNR employees Randy Tucker, Rob Silvester, Eugene Holland, and Mark Scott for their assistance in the field surveys. Walter Kordek, Assistant Chief of the WVDNR Technical Support

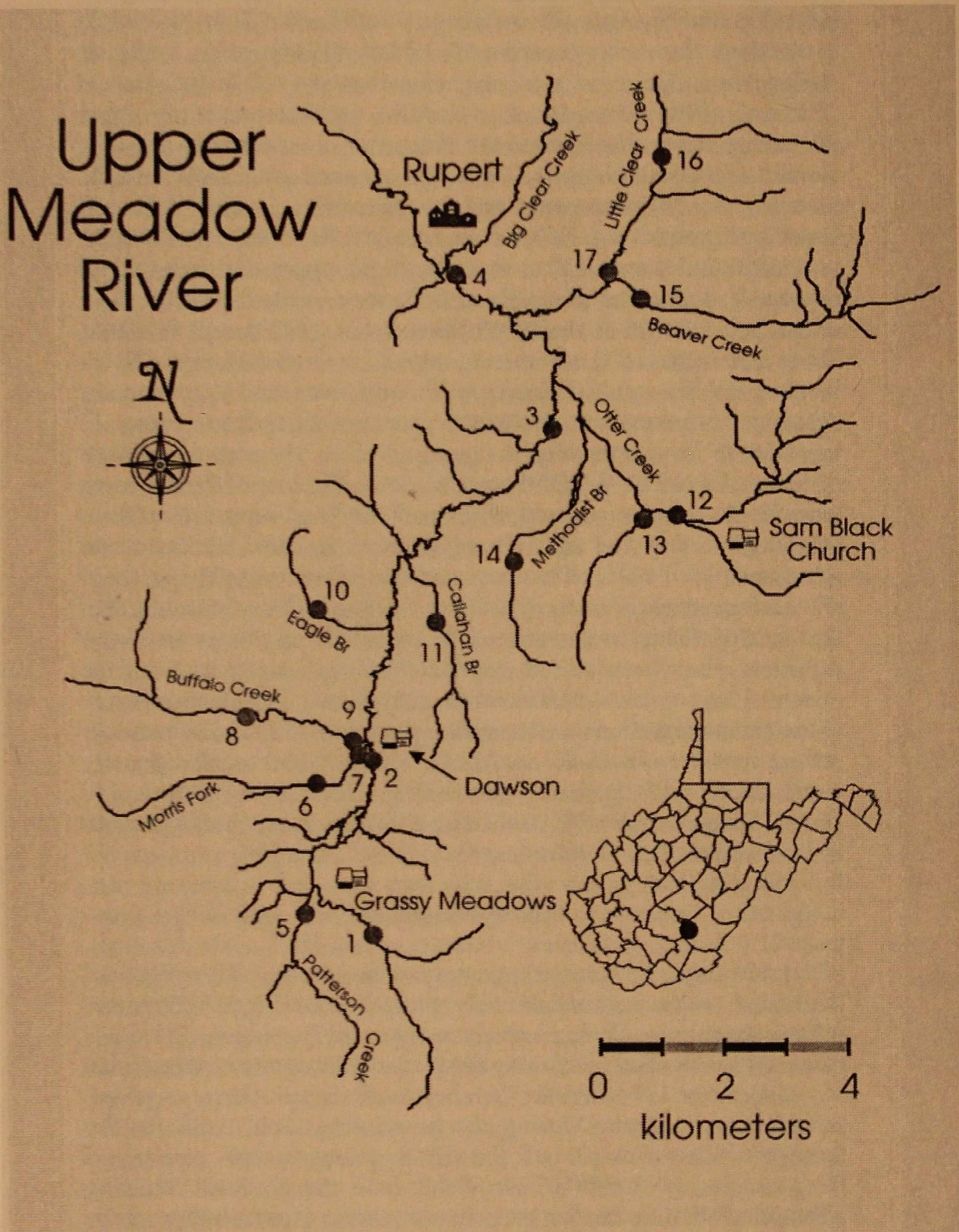
Upper Meadow River
Rupert
Big Clear Creek
Little Clear Creek
16
17
4
15
Beaver Creek
3
Otter Creek
12
13
Sam Black Church
14
Methodist Br
10
Eagle Br
Callahan Br
11
Buffalo Creek
9
8
2
7
6
Dawson
Morris Fork
Grassy Meadows
5
1
Patterson Creek
0
2
4
kilometers

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Figure 1. Map of upper meadow River, Which epicts the fish survey stations (1-17) and four towns in the collection area.

REDUCED ETHYLENE BIOSYNTHESIS IN SEEDLINGS GROWN IN SMALL CLOSED CANISTERS

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Abstract

In environmental chambers and other enclosed plant-growth systems, ethylene has greater opportunity to accumulate and have physiological effects. In this investigation, measurements of ACC, ACC conjugation, ACC oxidation, and ethylene production in plants grown in loosely closed canisters were compared with plants grown in open canisters. Our objective was to assess subtle changes in ethylene biosynthesis and plant stress in pea plants grown in a limited but not gas-tight space. The plant growth systems were modeled after the small plant growth canisters (Biological Research in Canisters; BRIC) used for plant studies aboard the Space Shuttle's mid-deck locker facility These canisters allow reduced passive gas diffusion with the research area. After five days of seedling growth, samples from closed canisters showed accumulation of ethylene. These seedlings had somewhat inhibited ethylene production and ACC oxidation ability but exhibited increased ACC conjugation in the roots compared with seedlings grown in open canisters. Increasing the ethylene level by 1 $\mu l\ l^{-1}$ within the canister, significantly decreased the ACC level in both the stems and roots. These results indicate that slight accumulation of ethylene within a closed plant growth system causes inhibition of ethylene biosynthesis. ACC conjugation appears to play a role in this inhibition process. Thus, these findings suggest that closed environmental chambers designed for plant growth alter ethylene biosynthesis even when the growth period is for a relatively short duration.

Introduction

An important element in plant physiology is the adaptation of plants to stressful environmental conditions that deviate from what would be considered optimal. One result of plant stress is increased ethylene biosynthesis which in turn affects cellular growth and developmental processes. In environmental chambers and enclosed plant growth systems, accumulated ethylene has greater opportunity to have physiological effects. This is of concern when designing specialized hardware to provide the environmental conditions for plant growth in space. Small plant growth canisters (Biological

Research in Canisters; BRIC) are used for plant studies aboard the Space Shuttle's mid-deck locker facility (Dreschel et al. 1991, NASA Research Announcement: Ground based and small payload research in space life sciences, NRA95-omls-01). The Small growth canisters are closed systems, but allow limited passive gas exchange with the research area. This reduced gas exchange may cause ethylene accumulation and altered O_2 and CO_2 levels within those closed chambers.

A change in the overall rate of ethylene production is often due to altered levels of the ethylene precursor, 1-aminocyclopropane-1-carboxylic acid (ACC). ACC production is regulated by ACC synthase, and its conversion to ethylene is regulated by ACC oxidase. The reaction catalyzed by ACC oxidase is oxygen-dependant. In situations such as hypoxia due to flooding of root tissue, lack of available oxygen reduces ACC oxidase activity, causing ACC to accumulate in the anoxic root or stele (Brailsford et al. 1993). Extra ACC accrued this way may diffuse or be transported through the xylem sap into aerated cortical tissues. In the later case, the ACC is converted to ethylene, increasing ethylene production above that already synthesized by those tissues (Abeles et al. 1992). Ethylene biosynthesis has been reported to exhibit negative feedback when ethylene is applied (Abeles et al. 1992). However, Abeles et al. (1992) note that in most of the reported experiments "tissues were treated with levels of ethylene much higher than most plants would normally experience. The physiological significance of feedback control under normal conditions is not known."

Conjugation of ACC regulates ethylene biosynthesis by tying up excess ACC which could otherwise be converted to potentially toxic levels of ethylene (Liu et al. 1985; Tophof et al. 1989; Abeles et al. 1992). ACC can be conjugated to malonyl-ACC by malonyltransferase (Hoffman et al. 1982) or -glutamyl-ACC by -glutamyltranspeptidase (Martin et al. 1995). Martin and Saftner (1995) reported that exogenous ethylene treatment and endogenously produced ethylene were associated with increased malonyltransferase activity in tomato fruit. However, -glutamyltranspeptidase is not affected by ethylene treatment or endogenous levels (Martin et al. 1995).

For this study, small growth canisters were used to analyze changes in ethylene biosynthesis within partially enclosed systems. Measurements of ACC, ACC conjugation, ACC oxidation, and ethylene production in plants grown in closed canisters were compared with plants grown in open canisters.

Materials and Methods

Plant material and growth conditions. Experiments were carried out on 5 day-old pea (*Pisum sativum* L. cv. Alaska) seedlings. Seeds were surface sterilized with 10% NaOCl for 10 min, thoroughly rinsed under running tap water, and placed between moist Kimwipes in 15 ml plastic test tubes. Test tubes were positioned vertically in 1 liter Nalgene polycarbonate bottles with the top 1 cm removed (to approximate the dimensions of the BRIC canisters). The canisters were fitted with a port for gas addition or analysis. Closed canisters were topped with a glass Petri dish lid to limit (but not prevent) gas exchange. This system was designed to mimic the passive gas exchange in the Small growth canisters. All canisters were placed in a dark environmental chamber at 23°C. The final capacity of each canister without plants was approximately 850 ml. During manipulations, seedlings were exposed to a dim safelight (0.4 μmol m^{-2} s^{-1} irradiance) which did not transmit wavelengths absorbed by the photosynthetic pigments or the regulatory pigment, phytochrome, (520-555 nm transmittance) (Steed and Harrison, 1993).

Ethylene measurement. For tissue ethylene measurements, 2 cm subapical stem segments were cut under water (to reduce the wounding response) from peas grown in open or closed canisters. Segments were placed in a 2 ml glass vial covered with a rubber septum, and incubated for 15 min at room temperature. A 1 ml sample of headspace was injected into an alumina F column (2 m x 3 mm) in a Varian 3700 gas chromatograph (Varian Instrument Division, Palo Alto, CA, USA) equipped with a flame ionization detector. This procedure measures the basal level of ethylene production before the occurrence of wound-stimulated ethylene, which begins 26 min after excision in etiolated pea stems (Saltveit and Dilley 1978; Harrison 1991).

ACC Level and ACC Conjugation Measurements. For ACC and conjugated ACC extraction, whole shoots or roots were homogenized twice with a mortar and pestle in 1 ml boiling 80% ethanol. Homogenates were centrifuged at 10,000 g. The supernate was equally divided between two vials, and lyophilized to dryness (Riov and Yang 1982a and 1982b). Free ACC was analyzed in one of the paired samples by reacting rehydrated material with NaOCl in the presence of Hg to liberate ethylene (Lizada and Yang 1979). ACC quantitation was based on ethylene formed from standard amounts of ACC (Sigma, St. Louis, MO, USA). The second sample of each pair was hydrolyzed in 0.4 ml 6 N HCl for 1 h to release bound ACC (Vangronsveld et al. 1988; Martin et al. 1995). After neutralization with NaOH, the total ACC content (free ACC and ACC released from conjugated ACC) was measured as above. The free ACC quantity was subtracted from the total ACC to obtain the final conjugated ACC (total malonyl- and glutamyl-ACC) value. Also, in a separate experiment, 1 μl l^{-1} ethylene was added to closed canisters on the second and fourth day to simulate additional ethylene accumulation.

ACC oxidation assays. *In vivo* ACC oxidation to ethylene was determined by the rate of conversion of 1 mM ACC (140 nmol per vial) to ethylene by subapical stem segments placed in 2 ml glass vials according to the procedure of Riov and Yang (1982b). Segments were incubated in ACC for 10 min, after which the vials were capped. Ethylene production was measured by gas chromatography of 1 ml headspace gas collected after an additional 15 min incubation. In a separate experiment, an equivalent to atmospheric oxygen was added to closed canisters on the third and fourth days after germination to offset possible O_2 depletion within the canisters.

Gravistimulation measurements. Since exogenous ethylene treatment has been reported to affect growth rate in upright and horizontally-oriented seedlings (gravitstimulated) (Wheeler et al. 1986; Clifford and Oxlade 1989; Abeles et al. 1992), gravitropic curvature was compared in pea seedlings grown in open canisters, closed canisters, or closed canisters with exogenous 1 $\mu l\ l^{-1}$ ethylene treatment. After a 5-day growth period, plants were placed horizontally. Curvature angles were measured from photocopies before and at intervals after gravistimulation.

Statistical Analysis. All data represent means of 5-15 replicate experiments. Significance was determined by t-test. Both t-test and P values were obtained using SigmaStat™ (Jandel Scientific, San Rafael, CA).

Results

After five days of seedling growth, headspace samples from seedlings grown in loosely closed canisters showed ethylene accumulation compared with those from open canisters ($P = 0.0021$) (Table 1). Endogenous ethylene production and ACC oxidation both decreased in peas grown in closed canisters compared to control canisters (Table 1). However, these trends were not significant ($P = 0.145$ for ethylene and $P = 0.316$ for ACC oxidation). The addition of oxygen did not restore the ACC oxidation rate of seedlings grown in closed canisters to the control level. Also, the additional exogenous ethylene, did not further inhibit ACC oxidation. These results indicated that the slight reduction in ACC oxidation was not due to ethylene accumulation or oxygen depletion within the canister. However, cumulatively, all plants grown in closed canisters exhibited depressed ACC oxidation.

Table 1. Ethylene accumulation within closed canisters after five days of seedling growth. Analysis of tissue ethylene production and ACC oxidase activity from 5-day-old pea stem segments. ACC oxidation was defined as the rate of ethylene of conversion of 1 mM ACC to ethylene by subapical pea stem segments. Means ± SE; n.d. = no data.

	Ethylene accumulation (pl g^{-1} min^{-1})	Tissue ethylene level (pl g^{-1} min^{-1})	ACC oxidase activity, ethylene (pl g^{1} min^{1})
Open canisters	15.7 ± 1.0	7.61 ± 0.57	81.7 ± 18.1
Closed canisters	21.9 ± 1.3	5.54 ± 1.16	59.1 ± 12.8
Closed canisters +1 µl l^{-1} ethylene	n.d.	n.d.	61.5 ± 8.1
Closed canisters +oxygen	n.d.	n.d.	55.36 ± 4.6

There was no significant change in stem or root ACC level in open or closed chambers. The root ACC level was somewhat higher than the stem level in seedlings grown within open canisters (P = 0.122) (Fig. 1). This ACC distribution pattern was not observed in seedlings grown in closed canisters. Exogenous ethylene treatment caused a significant decrease in ACC production in both stems (P = 0.05) and roots (P = 0.004) grown within closed canisters. There was a somewhat greater level of ACC conjugation in roots within closed canisters compared to open canisters (P = 0.058), whereas almost equal amounts of ACC conjugation occurred in stems of open and closed canisters (Fig. 2). Within closed canisters, ACC conjugation in the roots was greater than in shoots (P= 0.034). This pattern did not occur in seedlings grown in open canisters. The addition of ethylene did not significantly alter ACC conjugation. Stem gravitropic curvature was not affected by the slight ethylene accumulation or by ethylene treatment in closed chambers (Fig. 3). However, increased ethylene within closed canisters appeared to slightly inhibit the initial rate (at 30 min gravistimulation) of curvature in etiolated pea stems, but not at a significant level (P = 0.28) (Fig. 3).

Overall these results indicate that accumulation of ethylene within closed canisters may decrease endogenous ethylene biosynthesis. The trends reported here suggest plants grown within closed canisters have reduced ACC level accompanied by active ACC conjugation within the roots and reduced ACC oxidation in stems. Experiments using ethylene treatment support the idea of ethylene inhibition by reducing ACC levels within the seedling. However, the effect of ethylene on ACC conjugation is inconclusive in this study.

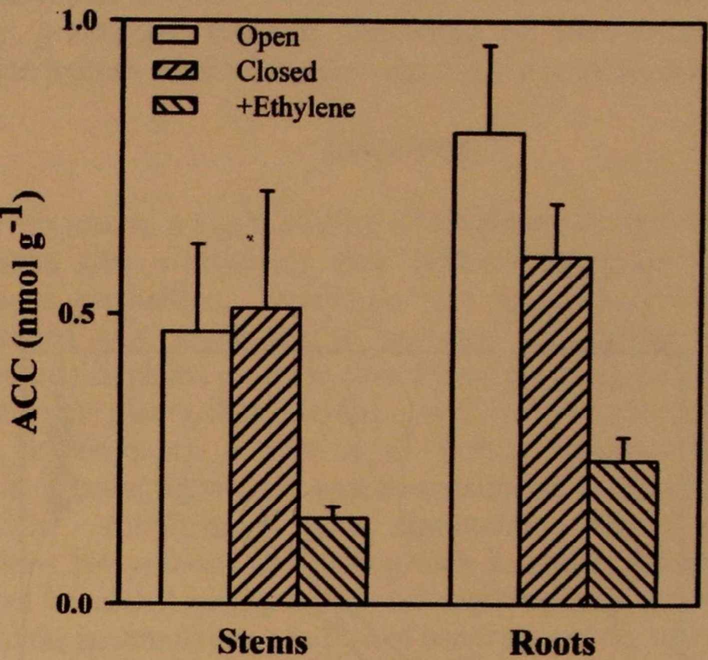

Figure 1. Average amount of ACC produced in stems and roots of dark grown peas in open and closed canisters. In a separate experiment, 1 µl l^{-1} ethylene was added to closed canisters and stems were evaluated for ACC level. Mean ± SE.

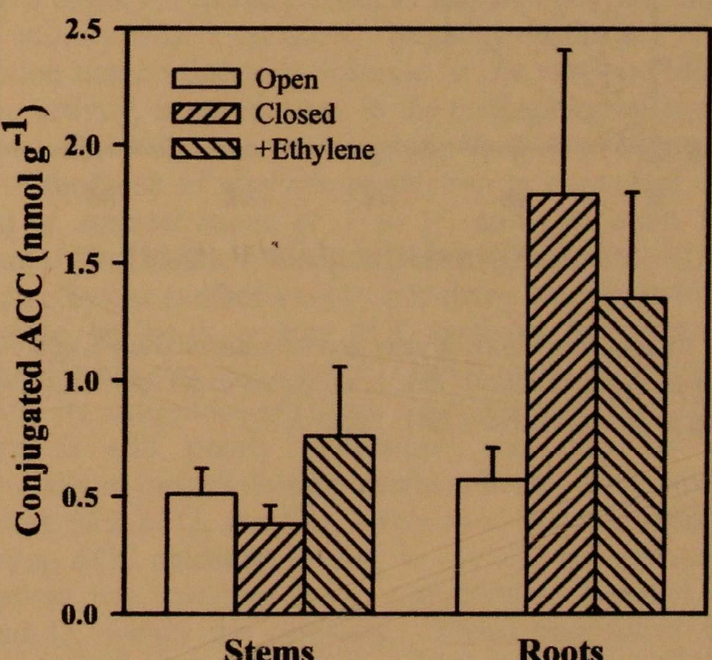

Figure 2. Average amount of conjugated ACC produced in stems and roots of dark grown peas in open and closed canisters. In a separate experiment, 1 µl l^{-1} ethylene was added to closed canisters and stems were evaluated for conjugated ACC level. Mean ± SE.

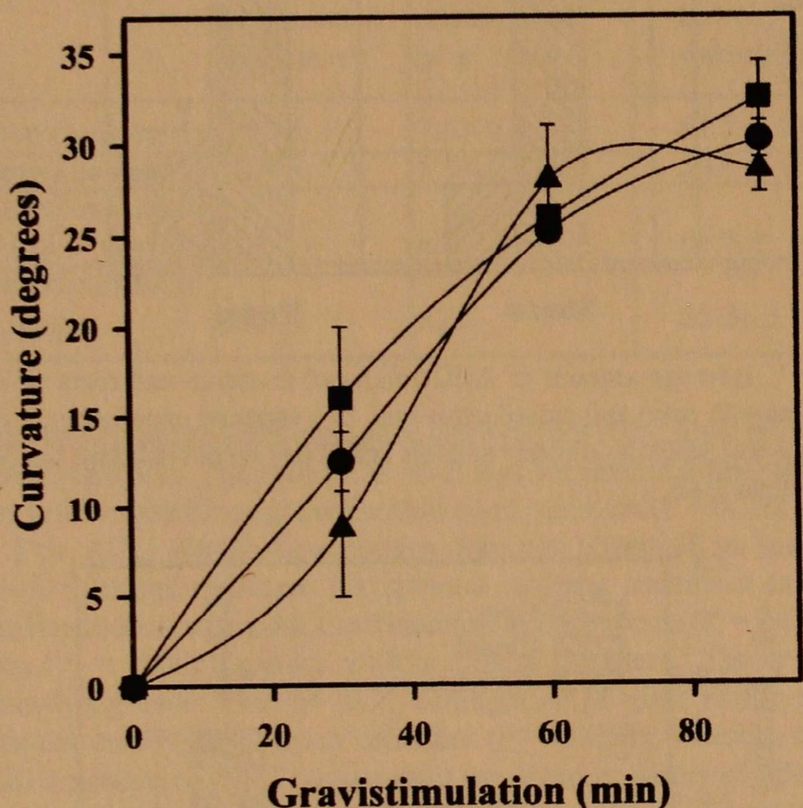

Figure 3. Average curvature in peas gravistimulated 30, 60, and 90 min in open (●) or closed canisters (■). In a separate experiment, 1 $\mu l\ l^{-1}$ ethylene was added to closed canisters (▶). Mean ± SE.

Accumulated ethylene within closed chambers was not enough to affect gravitropic bending, indicating no substantial change in growth pattern within the stem after the 5-day incubation period.

Discussion

In this study, a slight amount of ethylene accumulated in closed canisters after a relatively short period causing an inhibition of ethylene production. Inhibition was most likely the result of decreased ACC levels due to increased conjugation. It has been proposed that plants grown in closed plant growth systems may cause stress to the plants, thus interfering with the interpretation of results from experiments. Brown et al. (1995) reported accumulated ethylene in canisters from space experiments compared to ground controls. Additionally, other confounding factors may affect ethylene biosynthesis in plants grown in space. Porterfield et al. (1994) found that roots grown in microgravity may become hypoxic due to the accumulation of a film of water around the roots compared to ground controls especially when agar growth media were used. The hypoxia may reduce ACC oxidation in roots in space flight.

Under experimental conditions, applied ethylene can either increase or decrease ethylene production via regulation of either ACC synthase or ACC oxidase (Abeles et al. 1992). Our results support a negative feedback effect in etiolated pea seedlings grown within loosely closed canisters. Negative feedback of ethylene production can be due to a decrease in the ethylene biosynthetic enzyme activity, or an increase in the conjugation of excess ACC (Abeles et al. 1992). In an earlier study by Riov and Yang (1982a), negative feedback of ethylene production in citrus leaf disks was evident at concentrations of 1 $\mu l\ l^{-1}$, and maximum inhibition occurred at 10 $\mu l\ l^{-1}$. They concluded that ethylene exerts an inhibitory effect on ethylene synthesis not by impairing the conversion of ACC to ethylene, but by decreasing ACC synthase. In contrast to these findings, Dominguez and Vendrell (1994) found activation of ACC oxidation by exogenous ethylene. Regulation of ACC oxidase by ethylene is still poorly understood and may be regulated differentially in various developmental systems. Also, environmental factors such as O_2 and CO_2 levels need to be considered when evaluating ACC oxidation levels. In our study, respiration within dark-grown pea seedlings may contribute to elevated CO_2 and depleted O_2 within the canisters. These parameters were not measured in this study although the addition of O_2 in closed canisters did not affect ACC oxidation. Although ethylene accumulation occurred within the canisters, the overall ethylene production of the stem tissue was at an expected basal level for etiolated pea stems (Harrison, 1991). Thus, inhibition of ACC oxidase by increased ethylene or depleted oxygen levels within closed canisters is not a significant problem in the short-term studies used here (Table 1). However, according to Poneleit et al. (1993), without supplemental CO_2, ACC oxidase activity is low. In dark-grown seedlings, CO_2 is not likely to be limiting. Chavez-Franco and Kader (1993) found that ACC oxidase activity is differentially affected by CO_2 being stimulated at low CO_2 levels and inhibited at high levels. Dark-grown pea seedlings used in this experiment undoubtedly actively respire and could cause increased CO_2 accumulation within the canisters. However, conflicting reports of CO_2 involvement in ethylene production and its known inhibition of ethylene action make this factor difficult to evaluate (Abeles et al. 1992).

Although there was no significant change in ACC level in seedlings grown in closed canisters, the inhibitory effect of increased exogenous ethylene on tissue ACC level was pronounced in both root and stem tissue (Fig. 1). However, exogenous ethylene did not affect ACC conjugation in either stems or roots of closed canisters (Fig. 2). These results are consistent with the suppression in ACC formation via ethylene-inhibited ACC synthase activity in grapefruit discs (Riov and Yang 1982a). Liu et al. (1985) found that ethylene promoted the capability to conjugate ACC in tomato fruit tissue due to an increase in ACC malonyltransferase activity. Martin et al. (1995) also reported ethylene regulation of malonyltransferase but not -glutamyltranspeptidase. Thus, the observed decrease in overall ACC production in both stems and roots after addition of exogenous ethylene may be due to changes in ACC synthase activity or ACC conjugation.

Under some experimental conditions especially dark-grown seedlings, even small levels of ethylene inhibit growth and may be an environmental regulator of growth-dependent processes such as gravitropism (Abeles et al. 1992; Pickard 1985). In peas, ethylene prevents lateral auxin transport and a normal response to gravity (Burg and Burg 1966). However, in light-grown tomato seedlings, hypocotyls and roots exhibit little response to ethylene (Harrison and Pickard 1986; Lee et al. 1991). Our data suggests exogenous ethylene inhibition of the initial rate of gravitropic curvature on etiolated pea stems although the final curvature angle was not significantly affected (Fig. 3). Conditions within the closed canisters did not alter the initial rate of gravitropic curvature, thus, the slight ethylene accumulation there was not enough to affect overall growth rate along the stem during the study period.

Our results suggest that the observed negative feedback of ethylene biosynthesis was most likely the result of decreased ACC levels due to increased conjugation to malonyl-ACC. However, addition of exogenous ethylene to canisters did not significantly affect ACC conjugation. There was no significant difference in the average degree of curvature in closed canisters or ethylene treated plants. We suggest that within environmental chambers or enclosed systems some problems in plant growth analyses due to ethylene accumulation along with changes in O_2 and CO_2 levels may occur. Therefore, subtle changes in ethylene biosynthesis due to growth conditions should be considered in the interpretation and comparison of physiological studies of plant growth processes such as gravitropism, cellular growth, and fruit ripening. Since ACC and conjugated ACC analyses can be taken from ethanol extracts, this system is well suited for sampling at remote sites where excised tissue can be fixed in ethanol. Tissues fixed for microscopic analysis can also be used for these assays (Harrison 1997). Thus, some monitoring of ethylene biosynthesis can occur even when direct ethylene measurements are not possible such as in spaceflight experiments.

Acknowledgments

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Diet and growth of larval and juvenile grass pickerel, *Esox americanus vermiculatus,* and centralmudminnow, *Umbra limi,* in the Green Bottom Wildlife Management Area, Cabell County, West Virginia

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Abstract

The grass pickerel, *Esox americanus vermiculatus,* is listed as Undetermined on the Vertebrate Species List of Concern in West Virginia. The central mudminnow, *Umbra limi,* is a disjunct population in Green Bottom Swamp. The lentic, vegetated areas required for spawning by the grass pickerel and the central mudminnow have been reduced by residential, agricultural, and industrial developments. Green Bottom Swamp, a naturally occurring wetland of 58 ha, and a nearby mitigated wetland of 29 ha, provide spawning habitat for the grass pickerel and the mudminnow. Fishes were collected in beds of *Potamogetan crispus* and *Ceratophyllum demursum* in the old swamp. In December 1994, 15 pickerel were collected from beds of *Polygonum* sp. in the mitigated wetland. Between April 1995 and July 1996, 65 pickerel (6.67101.45 mm total length) and 155 mudminnows (3.89-36.97 mm total length) were collected from the old swamp. Growth rates and diets of these fish were determined. Stomach contents of each fish were analyzed, assigned a point value ranging from 0 (empty gut) to 30 (full gut), and expressed as percent frequency of food items per stomach. Cladocerans and copepods were the most abundant items in larval pickerel and mudminnows. In juvenile mudminnows, items included larval chironomids, ostracods and cladocerans, while pickerel consumed naiadal stages of large aquatic insects (odonates and corixids) and small fish. Horn, Morisita, and percent similarity indices were used to determine whether a dietary overlap occurred between the phases of each fish. Yolk-sac larvae (YSL) and post yolk-sac larvae (PYSL) of pickerel (Horn = 0.797, Morisita = 0.750, percent similarity = 57.0) and mudminnows (Horn = 0.778, Morisita = 0.666, percent similarity = 56.0) were the most similar. A dietary overlap between fishes was also ascertained. Pickerel PYSL and mudminnow PYSL were similar with values of Horn = 0.900, Morisita = 0.872, and percent similarity = 70.0. Using back-calculated values from a linear regression (r = 0.9257), daily growth for the pickerel was determined to be 1. I 0 mm/day compared to only 0.35 mm/day for mudminno

Introduction

Green Bottom Wildlife Management Area (GBWMA) is a naturally occurring wetland that serves as a nursery for larval fishes including the grass pickerel *(Esox americanus vermiculatus)* and central mudminnow *(Umbra limi)*. Larvae of both species inhabit water with abundant submerged or emergent vegetation. These areas are often subject to hypoxia during the summer and fall months. Grass pickerel and the mudminnow are physostomous fishes that are able to utilize both atmospheric and dissolved oxygen.

While the diet of the adult pickerel and mudminnow has been studied extensively, little is known about the feeding habits and growth rates of the larval and juvenile fishes. The objective of this investigation was to determine the diet and growth rates of larval and juvenile grass pickerel and central mudminnow.

Description of the study site

Green Bottom Wildlife Management Area (GBWMA) is a naturally occurring wetland located on State Route 2, 26.7 km northeast of Huntington, West Virginia, along the Cabell and Mason County Line (Evans and Allen, 1995). The wetland is bordered on the north by the Ohio River and on the east and west by open, grassy farmlands. A Mitigation project (29 ha) has been in progress since 1990 to replace wetlands that were destroyed by the construction of the Gallipolis Locks and Dam.

Green Bottom Swamp is 58 ha in area, with water depth varying seasonally between 0.5 to 2.5 m (Furry, 1978). Hydrology and wetland acreage are influenced by terrestrial input and drainage controls, such as beaver dams and human construction (Evans and Allen, 1995). Four types of wetlands are present in GBWNLA: seasonally flooded flats, inland open freshwater, shrub swamp, and wooded swamp.

Distribution and Habitat

The grass pickerel occurs throughout the Mississippi drainage. It is found in Wisconsin and southern Michigan, east along the Ohio River to western Pennsylvania and New York. This fish also occurs in southern Ontario and Quebec, south through eastern Iowa, Missouri, and Oklahoma to the Brazos River of Texas and east through the gulf states to Georgia (Wallus et al., 1990). In West Virginia, it occurs in four counties along the Ohio River: Cabell, Wayne, Jackson, and Mason. Throughout its range, the grass pickerel is found in swamps and creeks with dense vegetation. It occurs in marshes, bogs, ponds, oxbows, and slow-moving streams in

Ohio (Trautman, 1981). Wallus et al., (1990) described the grass pickerel as a piscivorous predator that inhabits low-gradient, clear waters that are heavily vegetated with a bottom layer composed of organic debris. The grass pickerel can be found in areas with low oxygen levels (Cooper and Washburn, 1949).

The central mudminnow is restricted to central North America, west of the Appalachian Mountains from Quebec to western New York. It occurs in the glaciated portion of Ohio, south to Tennessee and eastern Arkansas, north through Missouri, Iowa, North and South Dakota, to southern Manitoba and Ontario (Scott and Crossman, 1973). A disjunct population is found in Green Bottom Wildlife Management Area in West Virginia. The nearest population of central mudminnows occurs approximately 50 kilometers away in Ohio (Tarter et al., 1990). Throughout its range, the central mudminnow is found in sloughs, marshes, mudbottom streams, and ponds where there is an abundance of emergent or submerged vegetation and organic debris (Wallus et al., 1990). Martin-Bergmann and Gee (1985) found that mudminnows are associated with shallow water and dense vegetation. Martin-Bergmann and Gee (1985) and Wallus et al. (1990) referred to the central mudminnow as a fish that is tolerant of hypoxic conditions that often occurs in swamps.

Materials and Methods

Field Collections

Larval and juvenile mudminnow and grass pickerel were collected from Green Bottom Wildlife Management Area during April and May of 1995 and 1996. Grass pickerel larvae were also collected in December 1994, June 1996, and July 1996. Dipnets and seines were used to collect larval and juvenile fish. Upon capture, all fish were placed in chlorotone to prevent regurgitation. In the laboratory, fish were transferred into 70 percent ethanol for preservation.

Water Quality and Temperature

At the beginning of each month, water quality and temperature (^{0}C) were determined. Temperature was measured using a Taylor minimum-maximum thermometer. The following water quality parameters were measured using a Hach chemical kit (Model 36-WR): dissolved oxygen (mg/L), alkalinity (mg/L $CaCO_3$), carbon dioxide (mg/L), hardness (mg/L), and pH.

Laboratory Studies

Grass pickerel and mudminnow were divided into the following early life phases: (1) yolk-sac larvae (YSL), (2) post yolk-sac larvae (PYSL), and (3) juveniles (J). The YSL phase is the phase of development from the moment of hatching to complete absorption of the yolk. The PYSL phase begins with complete absorption of the yolk and ends when a minimum adult complement of rays is present in all fins and the median finfold is completely absorbed. The J phase begins when an adult complement of rays is present in all fins and the median finfold is completely absorbed (Wallus et al., 1990). The following size ranges (total length) are associated with the early life phases of the grass pickerel: (1) YSL/6-11mm; (2) PYSL/12-22mm; (3) J/23-100mm. The size ranges (total length) differ somewhat for the central mudminnow: (1) YSL/5-8mm; (2) PYSL/9-19mm; (3) J/20-46mm.

Growth

The weight (0.001 g) of each fish was recorded on a top-loading analytical balance and total length (0.01 mm) was measured using Vernier calipers. Daily growth rates (mm/day) were back-calculated for the two larval fishes using linear regression analysis.

Food Habits

Microdissecting scissors were used to excise the digestive tract from the esophagus to the beginning of the small intestine. Stomachs were then placed in 70 percent ethanol. Volume of all food items in a stomach was estimated using a point method devised by Hynes (1950). In this point method, each stomach was allotted a specific number of points based on its fullness (distended - 30; full - 20; three-quarters full - 15; half full - 10; one-quarter full - 5; trace - 2; empty - 0). After the points were allotted, the stomach was opened and the food items were identified under a dissecting microscope using Merritt and Cummins (1984) and Needham and Needham (1962). The point values awarded to each type of food item were used to calculate (1) percent total volume = total number of points per given food item / total points awarded per study period, and (2) percent frequency of occurrence = number of stomachs in which an item appeared / total number of stomachs in a given study period. Diet overlap values were determined for each species and size classes using the indices of Horn (1966) and Morisita (1959).

Results and Discussion

Field Collections

In December of 1994, eight post yolk-sac and eight juvenile grass pickerel were collected in the south arm of the mitigated area. This collection represents a fall spawn of the grass pickerel based on the mean length (23.88 mm) of the 16 fish collected. The grass pickerel is a spring spawner, although fall spawns have been known to occur if the temperature threshold of 90°C has been met or exceeded. In

December, unusually high temperatures occurred (Fig. 1) in Green Bottom Swamp and may have initiated the fall spawn. Hubbs and Lagler (1943) collected a fall spawn of the grass pickerel in a tributary of Fleming Creek, Washtenaw County, Michigan. Twelve of the fall-spawned fish averaged only 27.7 mm in length in comparison, with springspawned fish that averaged 113.5 mm. The fall spawn was attributed to unusually warm weather in October.

From 3 April 1995 to 8 July 1996, three stages of the grass pickerel were collected. The larval and juvenile fish ranged from 6.67 to 101.45 mm in length. The central mudminnow was collected from 8 April 1995 to 6 June 1996. The smallest mudminnow collected was 3.89 mm in length, while the largest mudminnow collected was 36.97 mm. Mudminnows of all three stages were collected during these dates.

Water Quality and Temperature

Dissolved oxygen ranged from 3 mg/L in September 1995 to 10 mg/L in March and April 1995; the mean was 6.4 mg/L. Carbon dioxide levels in Green Bottom Swamp ranged from 10-25 mg/L; the mean was 15.9 mg/L. Alkalinity in the swamp was at its lowest point (51 mg/L) in April, May, August, September, and December of 1995. Values for alkalinity reached a high of 140 mg/L in June and July of 1995; mean value was 90.5 mg/L. Hardness values ranged from 85 mg/1- to 153 mg/L; the mean was 113.7 mg/I. The pH varied only slightly, 6.9-7.8, from March 1995 to July 1996. All water quality parameters were within normal ranges. Detailed water quality data and temperatures are available in Midkiff (1997).

Laboratory Studies

Of 77 pickerel collected, four were yolk-sac larvae, 12 were post yolk-sac larvae, and 61 were in the juvenile phase. Yolk-sac larvae lengths ranged from 6.67-7.43 mm, while the post yolk-sac larvae collected ranged from 12.69-21.99 mm. Juveniles had the largest range, 23.9-1101.45 mm, in length. Nineteen mudminnows that were captured in the yolk-sac larvae phase ranged from 3.89-8.96 mm. Forty-nine post yolk-sac stage mudminnows ranged from 9.14-19.92 mm in length. Fifty-two juveniles (20.02-36.97 mm) were also collected.

Growth

Weights for grass pickerel YSL phase varied from 0.001 to 0.002 g. The PYSL pickerel weighed considerably more (0.009 - 0.080 g). Juveniles had the largest range of 0.068 - 6.993 g. Mudminnow YSL weighed <0.001 - 0.002 g, while the PYSL mudminnows weighed 0.005 - 0.167 g. The juvenile phase had the largest weight range, 0.045 - 0.566 g.

Growth measurements were made for each fish after preservation. Lengths were plotted against Julian days to show a trend in growth throughout the collection period (Fig. 2). Using a linear regression analysis, lengths were also plotted against Julian days.

The grass pickerel grew at a calculated daily rate of 1.10 mm/day. There was a positive correlation (r = 0.9243) between total length and Julian day (Fig. 3). This correlation was statistically significant (0.05 confidence level). The linear regression equation for the growth of grass pickerel was Y = -92.82799 + 1.10948X. Although the daily growth rate was high when compared to the growth rates (0. 55 mm/day) of pickerel collected from an oxbow lake in West Virginia (Evans, 1972), it is still comparable to growth rates (0. 96 mm/day) of pickerel collected for a 30 day period in their first summer in Michigan (Wallus et al., 1990). In Oklahoma, the spring-spawned grass pickerel grew at a rate of 0.60 mm/day during the period from March to June. The winter spawned pickerel grew 0.25 mm/day during the winter months and 0.66 mm after March (Wallus et al., 1990).

The central mudminnow had a slower growth rate of 0.35 mm/day. A positive correlation (r = 0.9638) was found to exist between the length and Julian day of the mudminnows (Fig. 4). This value was statistically significant (0.05 confidence level). The linear regression equation for this graph was Y = -26.36742 + .356844X. No calculated daily growth rate of mudminnows was found in the literature.

Food Habits

Diet analyses were performed on all three stages of grass pickerel collected from 2 December 1994 - 9 December 1994 and 3 April 1995 to 8 July 1996. Pickerel consumed thirteen prey items (Table 1). The most frequently consumed items throughout all life phases were cladocerans (YSL - 25%; PYSL - 44%; J - 41%). Copepods, larval fish, amphipods, and larval chironomids were next in importance of prey items for PYSL and J stages (Fig. 5). Plant material and filamentous algae were ingested only in minor amounts in the PYSL (1%) and J (3%). Pickerel in the juvenile stages showed a more diverse diet than the previous two stages. Diet of the juveniles included such prey items as the following: corixids (12%), insect detritus (2%), ostracods (1%), odonates (6%), ephemeroptera (1%), and miscellaneous (2%). Empty stomachs were present throughout the collection dates. They dominated in the YSL phase (75%), but were seen less frequently in the PYSL (8%) and J (3%) phases.

The grass pickerel is a highly piscivorous fish that preys on the young of later-spawning species (Wallus et al., 1990). In Connecticut, Buss (1962) found that the diet of grass pickerel under

15 cm consisted of crustaceans, algae, insects, plants, and fish. In Oklahoma, grass pickerel from 12 - 49 mm in length fed on copepods, cladocerans, chironomids, and ephemeropterans (Ming, 1968). In the next size range (50 - 99 mm), the diet was composed mainly of fish along with amphipods, decapods, chironomids, and odonates. Ming (1968) found that aquatic vegetation, leaves, filamentous algae, and sand grains were ingested by accident. Kleinart and Mraz (1966) noted that the stomach contents of grass pickerel 9.0 - 15. 0 mm long contained cladocerans, copepods, and ostracods.

Diet was analyzed for three stages of central mudminnow collected from 4 April 1996 to 6 June 1996. Nine prey items were ingested during this period (Table 1). Cladocerans were the most frequently consumed items in the YSL (37%) and PYSL (38%), while J consumed ostracods (33%) more often than cladocerans (25%). Mudminnow (YSL) ingested a large amount of plant detritus (19%) and filamentous algae (17%). Copepods (5%) were only a small portion of the YSL diet. The PYSL consumed the following food items in order of importance: copepods (25%), ostracods (23%), chironomids (6%), plant detritus (3%), amphipod (2%), and algae (1%). The diet of J mudminnows was slightly more varied than that of PYSL (Fig. 6). The diet of juveniles included chironomids (15%), copepods (12%), plant detritus (4%), filamentous algae (3%), miscellaneous (2%), insect detritus (1%), and amphipods (1%). The miscellaneous category included prey such as isopods, unidentifiable coleopterans, and hydrachnidia. Empty stomachs predominated in the YSL phase of mudminnows (22%). In the PYSL phase, empty stomachs were present only two percent of the time, while in the J phase empty stomachs were seen in approximately four percent of individuals.

The diet of the central mudminnow is similar to that of the younger stages of the grass pickerel. The central mudminnow is considered a carnivorous species, although it does ingest plant material. According to Peckham and Dineen (1957), important food items of the young fish are small crustaceans (ostracods, cladocerans, and copepods). Aquatic invertebrates were the major food items along with mollusks, cladocerans, ostracods, and copepods for all age classes of the mudminnow (Martin-Bergmann and Gee, 1985; Scott and Crossman, 1973). Mudminnows (1 year old +) were shown to consume several species of fish (Chilton et al., 1984).

Overlap between the early life history phases of the grass pickerel and central mudminnow was calculated using Horn's Index of Community Similarity, Morisita's Index of Similarity, and Percent Similarity (Horn, 1966; Morisita, 1959). Percent frequency of occurrence, the number of stomachs a food item occurs in divided by the total number of stomachs for that study period, was determined for each phase. The overlap in diet of grass pickerel between the YSL and PYSL was the highest with values of 0.797 (Horn), 0.750 (Morisita), and 57.0 percent similarity (Table 2), The YSL and PYSL have diets that are more similar than the YSL vs. J or PYSL vs. J. This can be attributed to the number of prey items that were taken and also the percent consumed. The YSL vs. J was the least similar with values of 0.420 (Horn), 0.288 (Morisita), and 24.2 percent similarity. The mudminnow YSL and PYSL phases, 0.778 (Horn), 0.666 (Morisita), and 56.0 percent similarity, were also more alike than YSL vs. J or PYSL vs. J (Table 2). The overlap between phases of each species was most similar (70 % similarity) in the PYSL phase of the grass pickerel and central mudminnow. The J phase of the pickerel and the YSL of the mudminnow were least similar (21 % similarity). This may be credited to the different sizes of each stage (mouth size, total length, etc.) and the ability to seek out more prey items.

Summary and Conclusions

Grass pickerel and central mudminnow showed a calculated daily growth rate of 1.10 and 0.35 mm/day, respectively. Fall spawning of the grass pickerel occurred in December 1994. Spawning may be attributed to the unusually high temperatures during the end of November and beginning of December.

Food habits were described by early life history phases and by collection dates. The main prey items consumed by both fish were cladocerans. Due to the small amount of plant material in pickerel stomachs, it seems that pickerel ingested plant material and filamentous algae only by accident, whereas the mudminnow consumed plant material and filamentous algae more often. The mudminnow YSL phase consumed the largest amount of plant detritus (19%) and filamentous algae (17%). Fish became an important part of the diet in the pickerel in the PYSL and J phases. Dietary overlap between stages was determined. Pickerel and mudminnow YSL and PYSL were most alike with values of Horn = 0.778, Morisita = 0.666, percent similarity = 56.0 and Horn = 0.797, Morisita = 0.750, percent similarity = 57.0, respectively.

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