Volume 54, Number 2, 3, 4

Proceedings of the West Virginia Academy of Science

1983 82

Papers of the Fifty-Seventh Annual Session

GEARED TO LAST A LIFETIME

Slip Clutch, ADO (Advanced Design Optics), and Low Prices — Meet the NEW Micromaster™ E/EH Series

LONG-LASTING DESIGN. Protects your microscopes and slides from overzealous, inexperienced users with slip clutch, positive safety stop, and retractable 40X/100X objectives. Deters student tampering with locked-on eyepieces and stage clips. And with its durable metal construction, the Micromaster™ E/EH Series is an unbeatable value.

HIGH-QUALITY, LOW COST. Advanced Design Optics (ADO) ensure crisp, clear images. 360° rotatable head lets students share, stretching budget dollars to the edge of the micro-universe. From the economical EM mirror model for $250, to the EBHL illuminated model with 4-objective binocular viewing for only $595, your choice is clear, the NEW Micromaster™ E/EH Series.

micromaster

For Info:
Fisher Scientific Company
585 Alpha Drive
Pittsburgh, PA 15238
(412) 784-2600
OR
703 Rayon Drive
Parkersburg, WV 26103
(304) 485-1751

Fisher Scientific
An ALLIED Company

Or Call Us Toll Free
800-245-2230

Proceedings of the West Virginia Academy of Science 1982

Vol. 54—Nos. 2, 3, 4

PAPERS OF THE FIFTY-SEVENTH ANNUAL SESSION

Davis and Elkins College

Elkins, West Virginia

April 3, 1982

Printed by
McClain Printing Company
Parsons, West Virginia
September, 1983

Cover Design
Meredith Pearce
West Virginia University
Office of Publications
Morgantown

West Virginia Academy of Science, Inc.

The West Virginia Academy of Science was founded at Morgantown, November 28, 1924. The Academy was incorporated under the Code of West Virginia on May 9, 1959 as "a nonstock corporation, which is not organized for profit but for the advancement of learning and scientific knowledge."

Officers

1978-79

President . . . . . Karl D. Fezer, Concord
President-Elect . . . . . John R. Warner, Jr., Buckhannon
Past President . . . . . Edward S. Hanrahan, Huntington
Treasurer . . . . . Thomas K. Pauley, Salem
Assistant Treasurer . . . . . John R. Warner, Buckhannon
Archivist . . . . . Arthur S. Pavlovic, Morgantown
Secretaries . . . . . Elizabeth Bartholomew, Morgantown
Violet Philipps, Montgomery
Proceedings Editors:
Managing . . . . . E. C. Keller, Jr., Morgantown
Publications . . . . . Henry Hurlbutt, Morgantown
Associate . . . . . Anthony Becker, New Kensington, PA
Talent Search Chairman . . . . . Robert Urban, Elkins
Chairman of West Virginia
Junior Academy of Science . . . Zeke Wolfe, Buckhannon
Chairman of Annual Meeting
at Institute . . . . . S. Das Sarma

Dues Structure

Student	$ 5.00
Regular	10.00
Contributing	20.00
Sustaining	40.00
Life	100.00
Corporation	200.00 min.
Institutional	200.00 min.
Patron	1,000.00

Institutional Members

Salem College

West Virginia College of Graduate Studies

West Virginia Wesleyan College

West Virginia University

Proceedings of the West Virginia Academy of Science

Published by the West Virginia Academy of Science, Inc. Manuscripts for publication (which normally must have been read at an annual meeting of the Academy) should be sent to the Editor, E. C. Keller, Jr., Department of Biology, West Virginia University, Morgantown, W. Va. 26506. Proof, edited manuscripts, and all correspondence regarding papers for publication should be directed to the Editor.

Applications for membership in the Academy and dues should be sent to Roy Clarkson, Treasurer, WVAS, Biology Dept., Brooks Hall, West Virginia University, Morgantown, WV 26506. Changes of address should be sent to Roy Clarkson, at the address above. Correspondence concerning library exchanges should be directed to Director of Libraries, West Virginia University, Morgantown, W. Va. 26506.

This issue of the Proceedings is dedicated to Dr. Henry Hurlbutt, our papers editor for the past several years. Dr. Hurlbutt passed away on Dec. 10, 1982. Dr. Hurlbutt was an Acarologist by training and practiced his profession in an exemplary manner. He obtained his Ph.D. in Zoology at the University of Maryland. At WVU, Henry taught invertebrate zoology and ecology along with freshman biology for the past 19 years except for the three years he and his family spent in Africa with the University team who helped set up universities in Tanzania.

The Academy will miss his valuable advice and judgments in regard to its Proceedings which has been of extremely high quality during his tenure as our papers editor.

Contents

Biology Section

A List of Freshwater Mussels Suggested for Designation as Rare, Endangered or Threatened in West Virginia

Ralph W. Taylor and Karen J. Horn
Department of Biological Sciences
Marshall University
Huntington, West Virginia 25701

Most malacologists presently feel that all freshwater mussels are in danger of extinction. The reasons for this are many and include such things as impoundment, industrial and human pollution, dredging, lumbering and mining. Each of these human activities plays a role in habitat degradation and impacts adversely upon the animals living in streams and rivers of this area. If we wish to maintain the advantages of having a widely diverse natural fauna and flora within West Virginia, it is time to take steps toward conserving this valuable resource.

With the passage of the Federal Endangered Species Act in 1973, a commitment was made by the federal government to place rare plants and animals under protection. The federal government is concerned about species that are rare on a national basis. State governments are now becoming involved and many have demonstrated a concern for conservation of native wildlife within their respective political boundaries. A species may be rather abundant in other areas of the country, but moderately to extremely rare in a particular state. The extirpation of a plant or animal from our state should be a major concern to all of us.

Ohio has had a state list of rare, endangered or threatened plants and animals for some years. Kentucky, through the efforts of the Kentucky Academy of Sciences, now has a recommended list, though it does not carry the force of law. West Virginia currently has no rare and endangered list. The West Virginia Heritage Trust has been working for some time on the preparation of a list, but the major emphasis has been placed on the higher plants and animals.

It is the intent of this paper to designate several species of freshwater

mussels as rare, endangered or threatened within the political boundaries of West Virginia. Several criteria are used in making this determination.

1. The species was historically widespread in the state and is now restricted in occurrence to only one or two streams.
2. The state is peripheral to the range of distribution of a species and habitat may only be marginally acceptable at best.
3. The species has never been found in large numbers in any stream in the state.

We hope this paper will heighten the awareness of leaders in industry, academia and government of a very serious problem. Only through the combined effort of these groups in supporting additional research and subsequent conservation can this valuable natural resource be maintained.

Species Review

Lasmigona compressa—Primarily an Atlantic coastal species; early records report this mussel from the North Fork of the Hughes River and Reedy Creek. It has been recently found only in the Ohio River.

Pleurobema clava—This species was historically distributed throughout the Ohio River Basin. Range of distribution is rapidly declining, and throughout most of its range it is relatively rare. Early collections place it in the West Fork River, North Fork of the Hughes River and Little Kanawha River. Recently, it was found only in the Elk River and Middle Island Creek.

Plethobasus cyphyus—This species, once very common in the Ohio River and all of the larger Ohio River tributaries, is now absent. The only remaining population in West Virginia is in the Kanawha River. An occasional specimen may be seen in the area near Kanawha Falls.

Ligumia recta—This species has apparently never enjoyed widespread distribution in West Virginia. Early records indicate its presence in the Cheat River and Little Kanawha River. Presently, there is a large population in the Elk River and an occasional specimen may be found in the upper Kanawha River.

Cyprogenia stegaria—There are no historical records for this species. It is apparently rare throughout its entire range. The only current collections have come from a small population in the upper Kanawha River.

Elliptio fisheriana—This species is restricted to the Atlantic Coastal Plain. In West Virginia, *E. fisheriana* is found in fairly large numbers in the Potomac River near Shepherdstown.

Elliptio crassidens—No historical records for this species exist in West Virginia. Archeological evidence indicates that *E. crassidens* was very abundant in the Ohio River several hundred years ago. It is currently extinct in the Ohio River. Recently, several specimens have been collected from the Elk River, Twelvepole Creek and Monongahela River only.

Uniomerus tetralasmus—This species was never abundant in West Virginia. It is currently found in the Ohio River in very limited numbers.

Potamilus ohiensis—This species has never been found in West Virginia outside the Ohio River. Recent collections indicate a small number of individuals reside in the Ohio River along the West Virginia boundary.

Villosa fabalis—Historically known from the Monongahela River in West Virginia. Recent records indicate extremely small populations still exist in Twelvepole Creek, Middle Island Creek and West Fork River.

Table 1. Proposed Mussel Species and Their Current Standing on the Federal Rare, Endangered or Threatened List and the State Lists of Ohio and Kentucky

Species	Rare, Endangered or Threatened Species Lists		
	Federal	Kentucky	Ohio
Lasmigona compressa (Lea, 1829)		X	
Pleurobema clava (Lam., 1819)		X	X
Plethobasus cyphyus (Raf., 1820)		X	X
Ligumia recta (Lam., 1819)			
Cyprogenia stegaria (Raf., 1820)		X	X
Elliptio fisheriana (Lea, 1838)			
Elliptio crassidens (Lam., 1819)			
Uniomerus tetralasmus (Say, 1830)			
Potamilus ohiensis (Raf., 1820)			X
Villosa fabalis (Lea, 1831)		X	
Villosa lienosa (Conrad, 1834)		X	
Lampsilis abrupta (Say, 1831)	X		X
Lampsilis teres f. *teres* (Raf., 1820)			X
Epioblasma torulosa rangiana (Lea, 1839)		X	X
Epioblasma torulosa torulosa (Raf., 1820)	X	X	

Villosa lienosa—Normally considered to be a Midwestern species, it was not reported from West Virginia by Ortmann. This species has recently been collected in the Pocatalico River, Twelvepole Creek and Greenbrier River. *V. lienosa* may very well be expanding its range eastward. Having recently established a fragile residency in West Virginia, it should be closely monitored so that its continued survival may be assured.

Lampsilis abrupta—This species is very rare throughout its entire range. Small populations still exist in the Kanawha River and Elk River.

Lampsilis teres teres—This species is very abundant in streams of the lower Ohio and Mississippi Drainages. It is very rare this far east. No historical records can be found for West Virginia. An occasional individual may still be found in the Ohio River near Huntington, West Virginia.

Epioblasma torulosa rangiana—Historically known in West Virginia only from the West Fork River. An occasional specimen may still be found in the Greenbrier and Elk Rivers.

Epioblasma torulosa torulosa—No historical records exist for this species. Apparently, a small population still resides in the Kanawha River near Kanawha Falls.

Selected References

1. Johnson. R. I. 1970. The Systematics and Zoogeography of the Unionidae (Mollusca: Bivalvia) of the Southern Atlantic Slope Region. Bull. Mus. Comp. Zool. 140(6):263-449.
2. ———. 1980. Zoogeography of North American Unionacea (Mollusca: Bivalvia) North of the Maximum Pleistocene Glaciation. Bull. Mus. Comp. Zool. 149(2):77-189.

3. Morris, J. S., and R. W. Taylor. 1978. A Survey of the Freshwater Mussels (Bivalvia: Unionidae) of the Kanawha River of West Virginia. Nautilus 92(4):153-155.
4. Ortmann, A. E. 1921. A Monograph of the Naiads of Pennsylvania. Ann. Car. Mus. VIII:1-384.
5. Stansbery, D. H. 1971. Rare and Endangered Mollusks in the Eastern United States. *In* S. E. Jorgensen and R. W. Sharp (eds.), Proceedings of a Symposium on Rare and Endangered Mollusks (Naiads) of the U.S., U.S. Bureau of Sport Fisheries and Wildlife, Twin Cities, MN, p. 5-18.
6. Taylor, R. W. 1980. A Survey of the Freshwater Mussels of the Ohio River from Greenup Locks and Dam to Pittsburgh, PA. Huntington/ Pittsburgh Districts, U.S. Army Corps of Engineers, 71 p.
7. ———and R. C. Hughart. 1981. The Fresh-water Naiads of Elk River, West Virginia, USA, With a Comparison of Earlier Collections. Nautilus 95(1):21-25.

Glyphosate Residues in Strawberry Fruit Following Rope-Wick Application to Tall Weeds*

Oscar E. Schubert
Division of Plant and Soil Sciences
West Virginia University
Morgantown, West Virginia 26506
and
Terry D. Spittler and Rocco Marafioti
Northeast Regional Pesticide Laboratory, IR-4,
New York State Agricultural Experiment Station
Geneva, New York 14456

Abstract

Weeds taller than 'Catskill' and 'Surecrop' strawberry plants (*Fragaria* x *ananassa* Duch.) were treated with glyphosate (*N*-(phosphonomethyl)glycine) by making one, two, or three passes over them with a rope-wick applicator containing a glyphosate:water solution consisting of the isopropylamine salt of glyphosate (41% active) diluted with three parts water. Residues of glyphosate in the 'Catskill' fruit were <0.05, <0.05, 0.36, and 0.50 ppm for the untreated, one-pass, two-pass and three-pass treatments, respectively; similarly residues in 'Surecrop' fruit were <0.05, <0.05, 0.06, and 0.29 ppm, respectively. Residues of the metabolite, aminomethylphosphonic acid, were <0.05 ppm for all treatments of both strawberry cultivars.

*Published with the approval of the Director of the West Virginia Agricultural and Forestry Experiment Station as Scientific Article #1758. This research was supported in part with funds appropriated under the Hatch Act.

The rope-wick application of glyphosate gave good to excellent control of quackgrass (*Agropyron repens* (L.) Beauv.), acceptable control of curly dock (*Rumex crispus* L.) and no control of red sorrel (*R. acetosella* L.) that were taller than the strawberry plants. Common chickweed (*Stellaria media* (L.) Cyrillo) and mouseear chickweed (*Cerastium vulgatum* L.), which were below the tops of strawberries at the time of treatment, were not controlled.

Introduction

Strawberry growers often have many uncontrolled weeds in their fields just before strawberry harvest. These weeds decrease the yield of marketable fruit, lower the quality of berries through shading and competition, increase losses from insects and diseases, and interfere with harvesting. If these weeds are appreciably taller than the strawberry plants, it is possible to treat them with a rope-wick applicator containing glyphosate. In 1976, Dale (5) developed a rope-wick applicator to apply nonselective systematic herbicides to weeds that become taller than the crop. Dale (5, 6, 7) and others (1, 9, 10, 11, 12, 14) have reported success in the control of tall weeds in boxleaf holly (*Ilex crenata convexa* L.), cantaloupe (*Cucumis melo* L.), cotton (*Gossypium hirsutum* L.), cucumber (*Cucumis sativus* L.), pepper (*Capsicum* annuum L.), potato (*Solanum tuberosum* L.), soybean (*Glycine max* (L.) Merr.), strawberry (*Fragaria virginiana* Duch.), tomato (*Lycopersicon esculentum* Mill.); tree crops, and bermudagrass (*Cynodon dactylon* (L.) Pers.) pastures. Some investigators (3, 4, and 8) reported a reduction in growth or yields and/or injury to tomato, pepper, cucumber, cantaloupe, or bermudagrass pastures from rope-wick applications of glyphosate.

Bagley and Beste (3) suggested the following reasons for reduced tomato and pepper growth from wick-bar treatments with glyphosate in which sweet corn (*Zea mays* L.) was seeded between plants in the row as the "weed": "1) in-row competition from the sweet corn before wiping, 2) splashing by rain or irrigation of glyphosate from the treated corn leaf surface, 3) wick-bar contact of crop leaves, 4) contact of the treated corn leaf with the pepper or tomato leaf caused by wind movement of plants, 5) glyphosate vapor effects, and 6) root transfer of glyphosate from corn to tomato or pepper."

The objectives of the experiment reported here were: 1) to evaluate the rope-wick application of glyphosate to control certain weeds in strawberries grown in the matted-row and 2) to determine the residues that may occur in the fruit at harvest.

Materials and Methods

Experiments were conducted in fields with 'Catskill' and 'Surecrop' strawberry plants grown in matted-rows containing quackgrass, curly dock, and red sorrel that were taller than the strawberry foliage. Common and mouseear chickweeds also were present; however, they were below the tops of strawberry leaves. Glyphosate (as the isopropylamine salt) was diluted with three parts water and then applied May 28, 1980 to weeds taller than the strawberry plants with a rope-wick applicator. Treatments were made by one, two, or three passes over the treated

rows, each about 40 m (130 ft) long, to simulate one-, two-, and three-fold application rates. Treatments within each of the three replications of each of the two cultivars were assigned at random.

Samples of strawberry fruit were collected June 15, 1980 by harvesting random mature berries from plants in close proximity to dead or dying weeds in the herbicide-treated rows. This sampling location was selected to provide the greatest likelihood of collecting contaminated fruit. The samples were placed in polyethylene bags, and were then closed, labelled, and stored on dry ice in an insulated shipping container. The samples were then transferred to a cold storage at −29 C and held until the frozen samples were shipped with dry ice to the Northeast Regional Pesticide Laboratory, New York State Agricultural Experiment Station, Geneva, New York. The samples were received frozen and stored at −23 C, until they were subsampled. On September 20, 1980 samples were chopped in a Hobart food chopper and at which time 15g subsamples were taken and frozen.

Residues were determined using an adaptation of the manufacturer's procedure (2). Twenty-five g of berries were blended with 50 ml of chloroform and 90 ml of deionized water. Phases were separated by centrifugation and the aqueous phase was diluted to 1200 ml with water. A 2.2 by 30 cm A-101 (HCO_3) anion exchange resin column was prepared in water, and the 1200 ml aqueous phase was passed through it. The column was washed with 3 x 100 ml aliquots of deionized water (discarded) and residues collected in 4 x 25 ml fractions of 0.5 m ammonium bicarbonate. Two g of Darco charcoal were added to combined fractions which was then filtered and the filtrate evaporated to dryness at 50 C on a rotary film evaporator. A 1.2 by 20 cm column in water (H^+ form) of AG50W-X8 cation exchange resin was prepared. The dissolved residue (5 ml) was added to the column and eluted with dionized water, collecting the parent molecule in the 15 to 25 ml fraction, and the metabolite in the 35 to 65 ml fraction. The fractions were evaporated to dryness for derivatization.

After final dry nitrogen drying of the flask containing the parent compound or the metabolite, 2.5 ml of trifluoroacetic anhydride was added. The mixture was swirled followed by the addition of 0.5 ml trifluoroacetic acid. The flask was then placed in a 50 C water bath for 30 min., cooled and evaporated to dryness with dry N_2. Anhydrous phosphoric acid (4 ml of 30 mg/ml) in the THF/MeOH (96:4) was added along with 80 mg of *O*-methyl-*N,N'*-dicyclohexyl pseudourea (13) in 1 ml THF and heat stoppered at 80 C for 16-18 h. The mixture was cooled and the volume adjusted to 5 ml with 96:4 THF/MeOH.

Samples were quantified, using derivatized standards for comparison, on a Tracor Model 220 gas chromatograph; the column was a 10% DC-200 on a Gas-chrom Q with 80-100 mesh 0.64 cm by 91.4 cm; the column temperature was 185 C; the injector temperature 230 C; the detector temperature was at 185 C; N_2 was used as the carrier gas. The flame photometric detector was run in the phosphorous mode.

Results and Discussion

Weeds present in sufficient quantity to evaluate were quackgrass, curly dock, red sorrel, common chickweed, and mouseear chickweed. The

Table 1. Residues of Glyphosate and Its Metabolite in 'Catskill' and 'Surecrop' Strawberry Fruit Following Rope-Wick Applications of Glyphosate[a] on May 28, 1980 to Control Weeds Taller Than the Strawberry Foliage. Fruit Near Treated Weeds Were Harvested June 15, 1980

		Residues in:			
		'Catskill' fruit		'Surecrop' fruit	
		Glyphosate[a]	Metabolite[b]	Glyphosate	Metabolite
No. of passes[c]		(ppm)			
Untreated	none	<0.05[d]	<0.05	<0.05	<0.05
Glyphosate	one	<0.05	<0.05	<0.05	<0.05
Glyphosate	two	0.36	<0.05	0.06	<0.05
Glyphosate	three	0.50	<0.05	0.29	<0.05

[a]*N*—(phosphonomethyl)glycine
[b]Aminomethylphosphonic acid
[c]Number of passes with the rope-wick applicator containing glyphosate: water mixture of the isopropylamine salt of glyphosate (41% active) diluted with three parts water.
[d]Each mean represents three replications.

rope-wick application of glyphosate gave good to excellent control of quackgrass, acceptable control of curly dock, but no control of red sorrel. Although curly dock and red sorrel plants were above the strawberry foliage at the time of treatment, it is likely that effectiveness of control was related to the proportion of weed plant foliage above the strawberry leaves. Curly dock had more leaves exposed to the herbicide than did red sorrel which mostly had only slender flowering stems exposed. No control was obtained or expected of the common and mouseear chickweeds whose plants were below the strawberry leaves since they could not be treated without contacting strawberry leaves. The data indicated that all weeds susceptible to glyphosate that were also taller than the strawberry plants at the time of treatment should be controlled with a rope-wick application of glyphosate.

Residues of glyphosate and its metabolite are presented in Table 1. Residues of glyphosate and metabolite were <0.05 ppm for the one-pass (1X) treatment for the 'Catskill' and 'Surecrop' strawberry fruit. These values, which are below the limits (<0.05 ppm) of detection with the analytical methods used, indicate that a single application should not present a residue problem. It is not known at this time whether residues found following one or two passes with the rope-wick applicator would be acceptable. Residues of the glyphosate metabolite, aminomethylphosphonic acid, were <0.05 ppm for all treatments for both strawberry cultivars.

Acknowledgments

This research was supported in part with funds from IR-4. The cooperation of Monsanto Company, Inc., in providing the chemicals and rope-wick applicator is appreciated. The assistance of Dr. V. Ulrich, Dr. M. Ingle, Prof. C. B. Sperow, Dr. M.E. Gallegly, and Prof. C.W. Collier in reviewing the manuscript is gratefully acknowledged and deeply appreciated.

Literature Cited

1. Abernathy, J.R., and J.W. Keeling. 1979. Silverleaf nightshade control in cotton with glyphosate (Abstr.) Proc. South. Weed Sci. Soc. 32:380.
2. Anon. 1976. Analytical residue method for *N*-phosphonomethylglycine and aminomethylphosphonic acid in apples, pears and peaches. Monsanto Company, St. Louis, MO. pp. 1-12.
3. Bagley, P.C., and C.E. Beste. 1982. Wick-bar application of glyphosate for tomato and pepper (Abstr.) Proc. Northeast. Weed Sci. Soc. 36:203.
4. Creager, R.A. 1982. Evaluation of glyphosate for weed control in cucurbits (Abstr.) Proc. Northeast. Weed Sci. Soc. 36:188-189.
5. Dale, J.E. 1978. The rope-wick applicator—a new method of applying glyphosate (Abstr.) Proc. South. Weed Sci. Soc. 31:332.
6. Dale, J.E. 1980. Control of johnsongrass by wick-applied glyphosate (Abstr.) Proc. South. Weed Sci. Soc. 33:356.
7. Dale, J.E. 1980. Rope wick applicator—tool with a future. Weeds Today 11(2):3-4.
8. Dale, J.E., and N.C. Edwards. 1979. Control of horsenettle in bermudagrass pastures (Abstr.) Proc. South. Weed Sci. Soc. 32:85-86.
9. Daniell, J.W. 1980. Use of modified equipment to apply glyphosate (Roundup) for weed control in tree crops (Abstr.) Proc. South. Weed Sci. Soc. 33:89.
10. Keeling, J.W., and J.R. Abernathy. 1980. Rope application of herbicides to perennial weeds (Abstr.) Proc. South. Weed Sci. Soc. 33:357.
11. Kempen, H.M. 1980. The do's and don'ts of application and incorporation—progress with new equipment for application. Proc. 32nd Annu. Calif. Weed Conf.:135-138.
12. Selleck, G.W., T. Corell, A. Bing, and L.B. Lynn. 1980. Treatment of tall weeds in horticultural crops with glyphosate using wiper and wick spray applicators. Proc. Northeast. Weed Sci. Soc. 34:412-414.
13. Vowinkel, E. 1966. Preparation of *O*-methyl-*N*, *N*'-dicyclohexyl pseudourea. Chem. Ber. 99:1479.
14. Wiese, A.F., and D.E. Lavake. 1980. Experiences with a rope-wick applicator. Proc. South. Weed Sci. Soc. 33:353-355.

Glyphosate Residues in Raspberries and Blackberries Following Preplant and Directed Posttransplant Treatments*

Oscar E. Schubert
Division of Plant and Soil Sciences
West Virginia University
Morgantown, West Virginia 26506
and
Terry D. Spittler and Rocco Marafioti
Northeast Regional Pesticide Laboratory, IR-4,
New York State Agricultural Experiment Station,
Geneva, New York 14456

Abstract

Preplant and directed posttransplant applications of glyphosate (*N*-(phosphonomethyl)glycine) were made at 3.4, 6.7, and 13.4 kg/ha to black raspberries (*Rubus occidentalis* L.) cultivars 'Blackhawk' and 'Bristol.' 'Black Satin' thornless blackberries (*Rubus* spp.) were given similar preplant and directed posttransplant glyphosate treatments at 3.4 kg/ha only. Residues of glyphosate and its metabolite, aminomethylphosphonic acid, were <0.05 ppm for black raspberry fruit samples harvested 59 weeks after planting. Residues of glyphosate and aminomethylphosphonic acid were <0.05 ppm for blackberry fruits harvested 26.5 months after treatment.

Excellent weed control was achieved during the first growing season in all glyphosate-treated plots. Weed control ratings ranged from 90 to 95 percent for orchardgrass (*Dactylis glomerata* L.), Kentucky bluegrass (*Poa pratensis* L.), ground ivy (*Glechoma hederacea* L.), common cinquefoil (*Potentilla canadensis* L.), buckhorn plantain (*Plantago lanceolata* L.), and blackseed plantain (*P. rugelii* Done.). Red sorrel (*Rumex acetosella* L.) and yellow woodsorrel (*Oxalis stricta* L.) were not controlled. One species of panicum similar to switchgrass (*Panicum virgatum* L.) was only partially controlled.

Introduction

Farmers and homeowners often, as a spur of the moment decision, plant raspberries, blackberries, and other small fruits in areas containing perennial weeds. These weeds are most often so difficult or impossible to control after planting the crop that the entire venture is a failure. As the raspberries and blackberries grow and spread into the row, cultivation is ineffective as a satisfactory control measure of perennial weeds. Glyphosate, a nonselective systemic herbicide, is effective in controlling

*Published with the approval of the Director of the West Virginia Agricultural and Forestry Experiment Station as Scientific Article #1757. This research was supported in part with funds appropriated under the Hatch Act.

many perennial and annual weeds at certain growth stages. Glyphosate might, therefore, provide sufficient control of the weeds to allow the satisfactory establishment of a bramble planting without the presence of herbicide residues in the soil and fruit.

The objectives of this experiment were: to determine 1) what weeds may be controlled by a preplanting and posttransplanting application of glyphosate and 2) what herbicide residues, if any, might be found in the first fruit harvested.

Materials and Methods

Glyphosate at 3.4, 6.7, and 13.4 kg/ha (3, 6, and 12 lb/A) was applied May 10, 1978 as a preplant treatment to plots 1.8 m wide and 6.1 m long. Paraquat (1,1'-dimethyl-4,4'-bipyridinium ion) at 2.2 kg/ha (2 lb/A) was applied to similar plots to serve as a check for the glyphosate treatments as well as to compare the efficacy of glyphosate and paraquat for weed control. Paraquat, a nonselective, contact herbicide, is widely used for sod-planting of corn. Glyphosate also is used for sod-planting of corn. These plots were set up in a pasture having a dense, established grass and weed sod. This provided a very severe test for the herbicides. Applications were made with a hand-carried, CO_2 sprayer having a 4-nozzle boom containing TeeJet 8001 tips. The spray pressure was controlled at 2.18 kg/cm^2 (31 psi) with a pressure regulator attached to the CO_2 cylinder. Glyphosate and paraquat treatments were applied in a spray volume of 280 L/ha (30 gpa).

The following day, May 11, 1978, six one-year-old 'Blackhawk' black raspberry plants were set 0.9 m (3 ft) apart in each treated plot. Another similar block was planted with 'Bristol' black raspberries. The same day following plant setting, a directed posttransplant application of glyphosate or paraquat was made at the same rate as the previous preplant application. The same hand-carried CO_2 sprayer was employed with the exception of a 2-nozzle boom containing TeeJet 0C02 tips were used to apply a directed spray 0.9 m (3 ft) wide on each side of the newly set raspberries. Treatments for each raspberry cultivar were replicated four times.

Glyphosate and paraquat were applied to blackberry plots at the same rates as used for the black raspberry plots. The 'Black Satin' thornless blackberry plants were set 1.5 m (5 ft) apart in plots 3 m (10 ft) wide and 9.1 m (30 ft) long. The treated band was 1.8 m (6 ft) for blackberries and raspberries. Similarly, the width of untreated sod between rows was 1.2 m (4 ft) for all plots. The preplant applications were made on May 10, 1978. The blackberries were given the directed posttransplant treatments immediately after setting on May 11. The blackberry plots also were replicated four times.

On June 26, 1979, all mature and immature raspberries were harvested into polyethylene bags. They were then labelled, and placed in an insulated box containing dry ice. These frozen samples were transferred later, the same day, to a freezer at −29 C and stored until shipment, with dry ice, to the Northeast Regional Pesticide Laboratory, New York State Agricultural Experiment Station, Geneva, New York. These samples were received frozen and stored at −23 C, until subsampled. On November 20, 1979, the samples were chopped in a Hobart food chopper, subsampled, and frozen.

The first crop of blackberries were lost due to a late spring frost and bird depredation. Random samples of mature or nearly mature 'Black Satin' blackberries of the second crop were harvested July 24, 1980 (26.5 months after planting) from the paraquat (glyphosate check) and glyphosate plots treated at 3.4 kg/ha. The samples were frozen, stored, shipped for analyses, and subsampled in a manner similar to the black raspberry sampling.

Residues were determined using an adaptation of the manufacturer's procedure (1). Twenty-five g of berries were blended with 50 ml of chloroform and 90 ml of deionized water. Phases were separated by centrifugation and the aqueous phase was diluted to 1200 ml with water. A 2.2 by 30 cm A-101 (HCO_3) anion exchange resin column was prepared in water, and the 1200 ml aqueous phase was passed through it. The column was washed with 3 X 100 ml aliquots of deionized water (discarded) and the residues collected in 4 x 25 ml fractions of 0.5 M ammonium bicarbonate. Two g of Darco charcoal were added to combined fractions and filtered. The filtrate was evaporated to dryness at 50 C on a rotary film evaporator. A 1.2 by 20 cm column in water (H^+ form) of AG50W-X8 cation exchange resin was prepared. The dissolved residue (5 ml) was added to the column and eluted with dionized water, collecting the parent molecule in the 15 to 25 ml fraction, and the metabolite in the 35 to 65 ml fraction. The fractions were evaporated to dryness for derivatization.

After final dry nitrogen drying of the flask containing the parent compound or metabolite, 2.5 ml of trifluoroacetic anhydride was added. After swirling, 0.5 ml trifluoroacetic acid was added. The flask was placed in 50 C water bath for 30 minutes, cooled and evaporated to dryness with dry N. Four ml of 30 mg/ml anhydrous phosphoric acid was added in THF/MeOH (96:4), followed by the incorporation of 80 mg of *O*-methyl-*N,N'*-dicyclohexyl pseudourea (6) in 1 ml THF. The mixture was heat stoppered at 80 C for 16-18 h., cooled and the volume adjusted to 5 ml with 96:4 THF/MeOH.

Samples were quantified, using derivatized standards for comparison, on a Tractor Model 220 gas chromatograph: the column was a 10% DC-200 on Gas-chrom Q with 80-100 mesh 0.64 cm by 91.4 cm; the column temperature was 185 C; injector temperature was 230 C; the detector temperature was at 185 C; N_2 was used as the carrier gas. The flame photometric detector was run in the phosphorous mode.

Weed control and phytotoxicity data were collected July 10, 1978, on black raspberry and blackberry plots.

Results and Discussion

Residues of glyphosate and its metabolite for black raspberries and blackberries are given in Table 1. All residues were below the detection levels (< 0.05 ppm) for the analytical method used.

Average weed control on July 5-6, 1978, in glyphosate and paraquat treated raspberry and blackberry plots compared with untreated plot borders is presented in Table 2.

By July 5, broadleaf and grass weeds in untreated borders comprised a solid stand, 46 to 61 cm (18 to 24 in) tall. The heaviest weed concentration in the glyphosate-treated plots would represent no more than 2% to 5% of the volume of weeds found in the untreated border. In the

Table 1. Residues of Glyphosate and Its Metabolite in 'Blackhawk' and 'Bristol' Black Raspberries and 'Black Satin' Blackberries Given Preplant and Posttransplant Applications of Glyphosate on May 10 and 11, 1978 (Respectively) and Harvested June 26, 1979

		Residues in:			
		Raspberry fruit		*Blackberry fruit*	
Herbicide	*Rate*	*Glyphosate*[a]	*Metabolite*[b]	*Glyphosate*	*Metabolite*
	(kg/ha)	*ppm*		*ppm*	
Glyphosate	3.4	<0.05[c]	<0.05	<0.05	<0.05
Glyphosate	6.7	<0.05	<0.05	--	--
Glyphosate	13.4	<0.05	<0.05	--	--
Paraquat[d]	2.2	<0.05	<0.05	<0.05	<0.05

[a]*N*-(phosphonomethyl)glycine
[b]Aminomethylphosphonic acid
[c]Each mean represents four replications.
[d]Paraquat served as a untreated glyphosate plot.

Table 2. Weed Control and Phytotoxicity in 'Blackhawk' and 'Bristol' Black Raspberry and 'Black Satin' Blackberry Plots Following Preplant and Posttransplant Applications of Glyphosate on May 10 and 11, 1978, Respectively. The Data Were Obtained July 5-6, 1978

		Black raspberry plots		*Blackberry plots*	
Herbicide	*Rate*	*Weed Control*[a]	*Phytotoxicity*[b]	*Weed Control*	*Phytotoxicity*
	(kg/ha)	%		%	
Glyphosate	3.4	92c	0a	92c	0a
Glyphosate	6.7	92c	0a	94c	0a
Glyphosate	13.4	96c	0a	97c	0a
Paraquat[d]	2.2	58b	0a	62b	0a
Untreated plots borders	0.0	0a	--	0a	--

[a]Visual ratings: O = no control, 100 = complete control.
[b]Visual ratings: O = no injury, 100 = complete kill.
[c]Means in the same column followed by a common letter are not significantly different at the 5% level according to Duncan's multiple range test. Each means represents three replications.
[d]Paraquat served as a untreated glyphosate plot.

paraquat-treated area, which served as a "glyphosate-check" for residues, weed growth represented about 10% to 15% of the volume of weeds in the untreated borders of the plots.

When weed control comparisons were made on a visual basis involving percent of ground covered with weeds, the glyphosate-treated plots were significantly better than paraquat-treated plots. Although weed

control in paraquat-treated plots was significantly better than the untreated borders. Weed control at 58% to 62% was considered unacceptable. From a practical standpoint, 70% weed control would be the minimum acceptable level.

By July 5, the control of orchardgrass, Kentucky bluegrass, ground ivy, and common cinquefoil was excellent (95%). Control of buckhorn and blackseed plantains also was excellent (90%). Red sorrel and yellow woodsorrel control was not satisfactory (30% to 40%). One species of panicum similar to switchgrass was only partly controlled (5% to 30%), because it had insufficient growth at the time glyphosate was applied. Grasses usually need to be at least 20 cm tall; however, bluegrass and other lawn grasses are killed at heights of 3 or 4 cm and taller. Although weed control in glyphosate-treated plots was considered to be very good until July 5, the growth of raspberries and blackberries was not as good as similar plants growing in a nearby untreated garden. The growth differences may have been related to the soil fertility levels, however. The garden site had been fertilized with a complete fertilizer and had received some lime for the past five years. The sod area used for the experiment had never been fertilized and had only received one lime application in the past 40 years. Soil test results for the garden site were pH 5.4, 59 lb/a P, 170 lb/A K, 2200 lb/A Ca, and 525 lb/A Mg. Soil from the experimental plots had a pH of 5.0; 28 lb/A P, 119 lb/A K, 1100 lb/A Ca, and 315 lb/A Mg. Growth depression could have resulted from a direct exchange of glyphosate from roots of treated weeds to black raspberry and blackberry roots since the glyphosate is not readily broken down in plant tissues. Bagley and Beste (2) reported that glyphosate applied pretransplant to the soil caused stunting, but no yield reduction of tomato (*Lycopersicon esculentum* Mill.) transplants. Creager (3) reported that cucumber (*Cucumis sativus* L.) and cantaloupe (*Cucumis melo* L.) plants were significantly shorter where glyphosate was applied as a preplant treatment to a stale seedbed compared with unweeded controls. Hilen, Bing, and Good (4) found glyphosate injury on several woody plants grown in soil where glyphosate-treated quackgrass (*Agropyron repens* (L.) Beauv.) was incorporated in the soil. These experiments (2, 3, and 5) indicate that some plants may be injured by glyphosate, if they are planted or seeded into soil where appreciable glyphosate-treated plant residues occur. Gabor and Veatch (4) isolated a phytotoxin from quackgrass which significantly inhibited seedling root growth of cucumber and other plants. Many other examples of allelopathy have been reported with quackgrass and other plants. It is impossible to explain positively why the black raspberry and blackberry plants, in these experiments where the sod was nearly completely killed by glyphosate, were less vigorous than nearby plants growing in a garden.

Acknowledgments

This research was supported in part with funds from IR-4. The cooperation of Monsanto Company, Inc., in providing the chemicals and rope-wick applicator is appreciated. The assistance of Dr. V. Ulrich, Dr. M.E. Gallegly and Prof. C.W. Collier in reviewing the manuscript is gratefully acknowledged and deeply appreciated.

Literature Cited

1. Anon. 1976. Analytical residue method for *N*-phosphonomethylglycine and aminomethylphosphonic acid in apples, pears and peaches.
2. Bagley, P.C., and C.E. Beste. 1982. Wick-bar application of glyphosate for tomato and pepper (Abstr.) Proc. Northeast. Weed Sci. Soc. 36:203.
3. Creager, R.A. 1982. Evaluation of glyphosate for weed control in cucurbits (Abstr.) 1982. Proc. Northeast. Weed Sci. Soc. 36:188-189.
4. Gabor, W.E., and C. Veatch. 1981. Isolation of a phytotoxin from quackgrass (*Agropyron repens*) rhizomes. Weed Sci. 29:155-159.
5. Hilen, A.G., A. Bing, and G.L. Good. 1979. Glyphosate injury as the result of preplant treatment. Proc. Northeast. Weed Sci. Soc. 33:245-250.
6. Vowinkel, E. 1966. Preparation of *O*-methyl-*N,N'*-dicyclohexyl pseudourea. Chem. Ber. 99:1479.

The Status of the Stonefly Genus *Diploperla* (Plecoptera: Perlodidae) in West Virginia

Donald C. Tarter and Mark F. Sheridan

Department of Biological Sciences
Marshall University
Huntington, West Virginia 25701

Abstract

Diploperla robusta is widely distributed, except in the Potomac River drainage, in 17 counties in West Virginia. *Diploperla duplicata* is found only in Braxton and Nicholas Counties, and *D. morgani* is distributed only in Braxton and Pocahontas Counties. No stream thus far sampled in West Virginia contains all three species. The Little Kanawha River contains the naiads of *D. duplicata* and *D. morgani*, while Panther Creek has *D. duplicata* and *D. robusta*.

Introduction

The genus *Diploperla* includes three species: *D. duplicata* (Banks), *D. morgani* Kondratieff and Voshell, and *D. robusta* Stark and Gaufin. *Diploperla* was originally designated as a subgenus of *Perla* by Needham and Claassen (1925). Ricker (1952) recorded it as a monotypic subgenus of *Isogenus*. In 1966, Illies elevated it to generic status and listed the only species as *Diploperla duplicata* (Banks). Stark and Gaufin (1974) described *D. robusta* as a new species that had previously been included in *D. duplicata*. Using adults, Kondratieff and Voshell (1979) described *D. morgani* from Sinking Creek, Giles County, Virginia. The naiadal stages of *D. duplicata*, *D. morgani*, and *D. robusta* were reviewed by Kondratieff et al. (1981). The body of color of *D. duplicata* is light brown with no prominent dark markings, while the body color of *D. morgani* and *D. robusta* is yellow with prominent dark markings. A dark brown longi-

tudinal streak is present on the femora of *D. morgani*, while the longitudinal streak is absent from the femora of *D. robusta*.

Using the key designed by Kondratieff et al. (1981), all naiadal specimens of *Diploperla* in the West Virginia Benthological Survey can be separated into three species. Hissom and Tarter (1976) and Tarter and Kirchner (1980) previously recorded all specimens in West Virginia as *D. robusta*.

Results

Diploperla robusta

Except in the Potomac River drainage, *Diploperla robusta* is widely distributed in 17 counties: Cabell Co., Fourpole Creek, Miller's Fork, Little Cabell Creek, Lusher Hollow of Mud River; Calhoun Co., Leatherbark Creek; Greenbrier Co., North Fork of Cherry River; Jackson Co., Isaac's Run, Mud Run, Cow Run, Elk Creek; Logan Co., Stone Hollow, Frogtown Hollow; Mason Co., Jerry's Run, Old Town Creek, Sixteenmile Creek, Sliding Hill Creek, West Creek, Upper Ninemile Creek; Mingo Co., Laurel Fork at Pigeon Creek; Monongalia Co., White's Run; Nicholas Co., Little Creek, North Fork Cherry River, Jake's Run, Brushy Fork, Brice Run, Glade Creek, Mouse Run, Jim's Creek, Desert Branch, Sugar Branch, Anglius Creek, Roaring Creek, Grassy Creek, Mill Creek, Deer Creek, Panther Creek; Pleasants Co., French Creek; Pocahontas Co., Hills Creek; Putnam Co., Coon Creek, Sam's Fork, Trace Creek, Sleepy Creek, Tackett Creek, Poindexter Branch, City Creek, Hurricane Creek, Dad's Branch, Coon Creek, Kelly Creek; Raleigh Co., Cherry Creek of Beaver Creek; Randolph Co., Gandy Creek, Tygart Valley River; Wayne Co., Twelvepole Creek, Beech Fork, Miller's Fork of Beech Fork; Webster Co., Dry Bread Run; Wirt Co., Short Run. The naiadal habitat is varied for this species. The naiads are generally found in tributaries, branches, runs and creeks.

In addition to West Virginia, the geographic range of *D. robusta* includes Indiana, Kentucky, Ohio, Pennsylvania and Virginia (Kondratieff et al., 1981). Ashley et al. (1976) described the life history and ecology of this perlodid stonefly in a small, woodland stream in West Virginia. Ashley (1977) reported that the naiads of *D. robusta* have a TL_m^{96} pH value of 4.6. The TL_m^{96} is an abbreviation for median tolerance limit (50% survival) for 96 hours.

Diploperla duplicata

Diploperla duplicata is found in only two counties: Braxton Co., Little Kanawha River at Falls Mill (8 May 1981); Nicholas Co., Panther Creek (20 May 1978). The naiads are generally found in creeks (7-12 m wide) and rivers.

In addition to West Virginia, the geographic range of *D. duplicata* includes Georgia, South Carolina, Tennessee and Virginia (Kondratieff et al., 1981).

Diploperla morgani

Diploperla morgani is distributed in only two counties: Braxton Co., Little Kanawha River at Falls Mill (20 March 1980 and 8 May 1981); and

Pocahontas Co., West Fork of Greenbrier River (14 April 1979), East Fork of Greenbrier River (18 May 1972). The geographic range is limited to West Virginia and Virginia (Kondratieff et al., 1981). The naiads are generally found in rivers.

Discussion and Conclusions

Diploperla robusta is the most widely distributed species of the group. *Diploperla duplicata* and *D. morgani* are sparsely distributed in the state. No stream thus far sampled in West Virginia contains all three species. The Little Kanawha River at Falls Mill has the naiads *D. duplicata* and *D. morgani*, while Panther Creek contains *D. duplicata* and *D. robusta*. West Virginia and Virginia are the only states that have a geographic range for all three species.

Acknowledgments

The authors express a special thanks to Ms. Vickie Crager for typing the manuscript, and to Mr. Fred Kirchner, U.S. Army Corps of Engineers, for help with identifications. Also, we thank Ms. Kimberly Benson for making suggestions on the paper.

Literature Cited

1. Ashley, D.L., D.C. Tarter, and W.D. Watkins. 1976. Life history and ecology of *Diploperla robusta* Stark and Gaufin (Plecoptera: Perlodidae). Psyche 83(3-4):310-318.
2. ———. 1977. Low pH tolerance of the naiads of the stonefly *Diploperla robusta* Stark and Gaufin under controlled conditions. Proc. W.Va. Acad. Sci. 49(1):23.
3. Hissom, F.K., and D.C. Tarter. 1976. Taxonomy and distribution of nymphal Perlodidae of West Virginia (Insecta: Plecoptera). J. Georgia Entomol. Soc. 11:317-323.
4. Illies, J. 1966. Katalog der rezenten Plecoptera. Das Tierreich, 82. Walter de Gruyter and Co., Berlin. 632 pp.
5. Kondratieff, B.C., and J.R. Voshell, Jr. 1979. A new species of *Diploperla* (Plecoptera: Perlodidae) from Virginia. Ann. Entomol. Soc. Am. 72(4):451-453.
6. ———, R.F. Kirchner, and J.R. Voshell, Jr. 1981. Nymphs of *Diploperla*. Ann. Entomol. Soc. Am. 74(4):428-430.
7. Needham, J.G., and P.W. Claassen. 1925. A monograph of the Plecoptera of America north of Mexico. Thomas Say Foundation. Ent. Soc. Amer. 2:1-397.
8. Ricker, W.E. 1952. Systematic studies in Plecoptera. Ind. Univ. Pub. Sci. Ser. No. 18. 200 pp.
9. Stark, B.P., and A.R. Gaufin. 1974. The genus *Diploperla* (Plecoptera: Perlodidae). J. Kans. Entomol. Soc. 47:433-436.
10. Tarter, D.C., and R.F. Kirchner. 1980. List of stoneflies (Plecoptera) of West Virginia. Ent. News 91(2):49-53.

New Additions to the Vascular Plant Flora and Other Inportant Plant Information for West Virginia

William Homer Duppstadt
Department of Biology
West Virginia University
Morgantown, West Virginia 26506

Abstract

During the past year, eight new species of vascular plants have been identified or verified at the West Virginia University Herbarium as new records for the state of West Virginia.

The new species reported for West Virginia are:

Isoetes riparia Engelm., Upshur County (*P.D. Strausbaugh* s.n.) July 20, 1933 and July 30, 1933. (To our immediate north. To be expected.)

Chloris verticillata Nutt., Marshall County (*Edward E. Estep* 1371) September 18, 1980. (A prairie species. Found occasionally in our range.)

Carex tetanica Schkuhr, Jefferson County (*Thomas F. Wieboldt* 3741) June 21, 1980. (In our range. To be expected.)

Spiranthes vernalis Engelm. & Gray, Wirt County (*Elizabeth A. Bartholomew* s.n.) August 26, 1947; Nicholas County (*Bob Richardson* s.n.) August 18, 1981. (In our range. To be expected.)

Celtis tenuifolia Nutt. var. *georgiana* (Small) Fern. & Schub. (*C. georgiana* Small), Fayette County (*William N. Grafton* s.n.) April 20, 1974. (To our immediate south. To be expected.)

Polygonum amphibium L. Jefferson County (*Rodney L. Bartgis* s.n.) July 17, 1979. (To our immediate north. To be expected.)

Mazus miquelii Makino., Barbour County (*Kyle and Eleanor Bush* s.n.) May 30, 1981. (Native of east Asia. Escaping Cultivation.)

Krigia oppositifolia Raf. (*Serinia oppositifolia* (Raf.) Ktze.), Kanawha County (*William N. Grafton, Emily Williams, Ann Pyle,* aned *Harold Boecher* s.n.) May 25, 1980. (To our south. To be expected.)

A second collection of *Trillium cernuum* L. has been made after 102 years in West Virginia (Jefferson County, *Rodney L. Bartgis* and *G.R. Welsh, Jr.*, s.n., April 26, 1981). The first and only other record is from Wheeling, Ohio County, WV, *E. Richardson,* May, 1879.

Sibara virginica (L.) Rollins was erroneously reported for West Virginia. Our specimens so labeled are *Cardamine impatiens* L.

Merope tuber Newman (Mecoptera: Meropeidae) Records from West Virginia Collections

Charles C. Coffman
Plant Pest Control Division
West Virginia Department of Agriculture
Charleston, West Virginia 25305

Abstract

Malaise trap surveys conducted in West Virginia from 1976 through 1981 and existing institutional and individual collections yielded 24 specimens of *Merope tuber* Newman representing six new county records. The new county records were: Berkeley, Hampshire, Mineral, Hardy, Monroe, and Kanawha. Six of the specimens were collected in June, 10 in July, 5 in August, and 3 in September. The sex ratio was 1:1. Characteristics of collection sites and collection methods are described and discussed.

Introduction

Merope tuber Newman is one of only two species of Meropeidae in the world, the other being *Austromerope poultoni* Killington, known only from two specimens taken near Perth, Australia (Byers, 1973). *M. tuber*'s known distribution is limited to the eastern half of the United States and southeastern Canada, from Georgia to New England and westward to Ontario, Minnesota and Missouri (Byers, 1973). About 200 specimens have been reported (Barber, 1904; Carpenter, 1932; Byers, 1973; Scarbrough, 1980) in the 145 years since Newman's type specimen, a female, was found by Doubleday in 1837 (Barber, 1904). As indicated by Byers (1973), the species has remained something of a rarity since Newman's description in 1838 and its immature forms are still unknown.

Previous records of *M. tuber* from West Virginia are limited to two locations and are quite old. Osten Sacken collected a single specimen at Berkeley Springs (then in Virginia, now in Morgan County, WV) in the summer of 1856 (Barber, 1904). Seventy-four years later, in the latter part of June, 1930, James G. Needham collected over 100 specimens at Davenport (unincorporated locality 1 mile N. of Friendly), West Virginia in Tyler County (Carpenter, 1932).

That West Virginia should figure at all in the historical record of a species as rarely found as *M. tuber* is in itself unusual, since, with the exceptions of A. D. Hopkins and W. H. Edwards, it is only in relatively recent times that the state has seen much collecting activity by entomologists. What is even more remarkable is that approximately half of the known specimens were taken in one collection (Needham's) and just happened to be from West Virginia.

This paper reports new records of *M. tuber* from West Virginia which help fill the gap in recent discoveries from the Appalachian part of *Merope*'s range referred to by Byers (1973).

Methods

Most specimens recorded here were gleaned incidentally from Malaise trap collections made between 1976 and 1981 that were being examined for released gypsy moth parasites and parasites of native forest Lepidoptera. The traps from which these collections were obtained were operated for varying periods of time depending on the site. Generally, trapping began in late May and ended in October. Once started, collections were made weekly through August and biweekly thereafter until the trap was taken down.

Since the Malaise trap survey was designed for gypsy moth related objectives, the trap sites chosen were mixed-oak (*Quercus alba* L., *Q. prinus* L., *Q. rubra* L., *Q. coccinea* Muenchh., and *Q. velutina* Lam.). Within these sites, traps were placed specifically in or along the edge of woodland openings, such as small natural clearings or infrequently used one-lane woodland roads, and along forest-field borders. Extensive heavy underbrush was avoided.

Records from sources other than Malaise traps were obtained through personal communication with other entomologists at West Virginia University and the University of Charleston.

Results

Twenty *M. tuber* specimens were recovered from Malaise trap collections at nine sites and four, that had not been previously reported, were discovered in existing collections. Nine other Malaise trap sites did not produce any records. Of the four specimens in existing collections, three were found in the West Virginia University (WVU) collection, including a single specimen from Baltimore, Baltimore Co., Maryland, and one in C. T. Meadors' personal collection at the University of Charleston (C. T. Meadors, personal communication, January 19, 1982). Thus, 24 new specimen records, including six new West Virginia county records, were established for *M. tuber*. The new county records include: Berkeley, Hampshire, Mineral, Hardy, Monroe, and Kanawha. Two specimens (the Kanawha Co. collections), which were collected nine years apart, were recovered at essentially the same site (separated by only a few hundred yards) (C. T. Meadors, personal communication, January 19, 1982). The sex ratio for the 24 specimens was 1:1.

Specimen collection data.—Malaise trap surveys: Berkeley Co., Allensville, 13-VII-1977 (2♂), 20-VII-1977 (2♀, 1♂), 23-VIII-1977 (1♂); Hampshire Co., Capon Bridge, 30-VI-1976 (1♂), 28-VII-1976 (1♀), 22-VI-1977 (2♂), 13-VII-1977 (1♀), Romney, 25-VIII-1976 (1♀), Grace, 1-IX-1976 (1♀), 21-VII-1977 (1♀); Hardy Co., Fisher, 29-VI-1976 (1♀), Fort Run, 10-VIII-1976 (1♀); Mineral Co., Junction, 10-VIII-1976 (1♀); Monroe Co., Hollywood, 19-VII-1979 (1♂), 6-IX-1979 (1♂); Kanawha Co., St. Albans, 28-VIII-1977 (1♂), (all coll. C. C. Coffman, WVDA). WVU Collection: Monroe Co., 30-VI-1939 (2♀), coll. L. H. Taylor; Baltimore Co., Baltimore, Maryland, 4-IX-1978 (1♀), coll. L. Westerberg, under stones. C. T. Meadors' collection: Kanawha Co., St. Albans, VII-1968 (1♂), coll. C. T. Meadors, incandescent light trap.

Looking at these data seasonally, 6 specimens were collected in June, 10 in July, 5 in August, and 3 in September. Geographically, distribution

within the state, including both old and new records, is as shown in Figure 1.

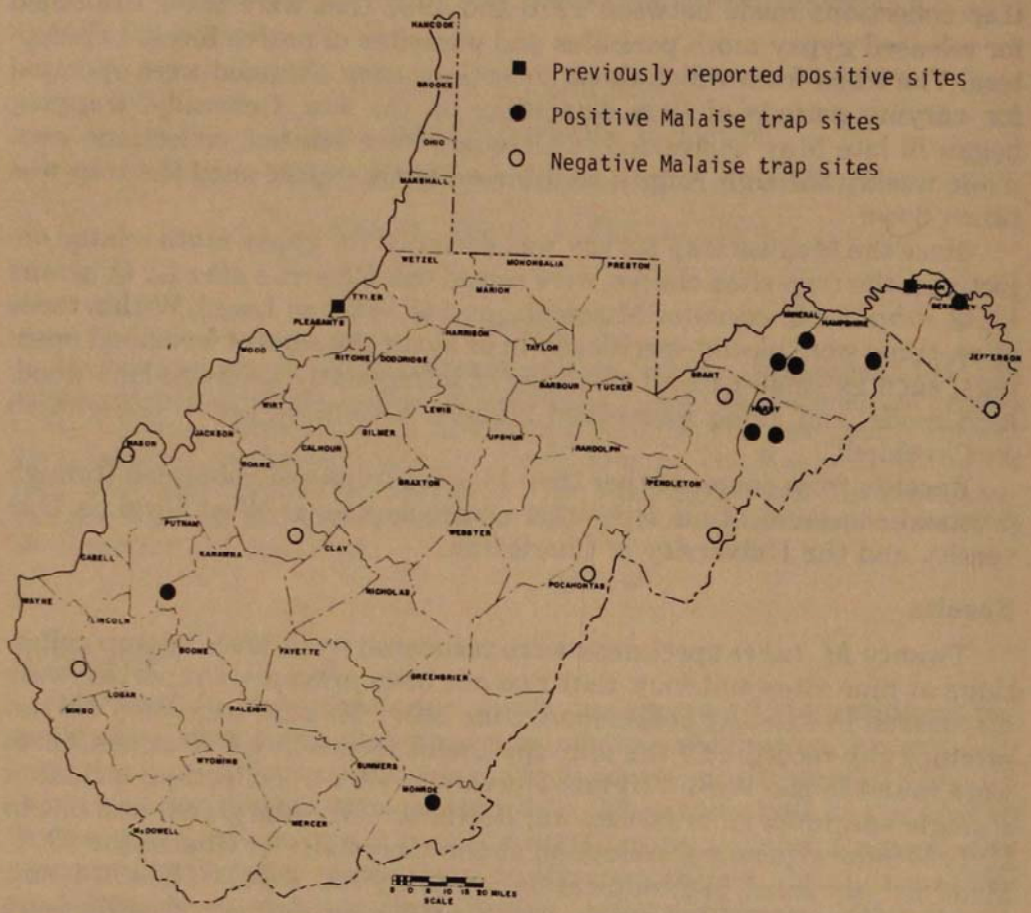


FIGURE 1. Distribution of *Merope tuber* in West Virginia.

Linear distances from traps to larger permanent streams ranged from 0.2 to 6.9 miles. *M. tuber* capture sites ranged from 0.2 to 3.3 miles from larger permanent streams and noncapture sites from 0.3 to 6.9 miles. Averages were 1.2 miles for capture sites and, excluding the one aberrant site of 6.9 miles, 1.5 for noncapture sites.

Elevation of trap sites ranged from 540 to 2,980 feet. Capture site elevation range almost equalled this at 540 to 2,500 feet. The noncapture range was 600 to 2,980 feet. Averages were 1,008′ for capture sites and 1,264′ for noncapture sites.

Of the 20 specimens from Malaise traps, 16 were deposited in the West Virginia Department of Agriculture collection at Charleston and four in the WVU collection at Morgantown. As mentioned, three specimens were already in the WVU collection and one in C. T. Meadors' personal collection at the University of Charleston.

Discussion

Records established here agree with the time frame (late June through September) established by all previous collectors. An inadvertent error

was made by Scarbrough (1980) when he placed Needham's 100+ specimens in the July-September period (A. G. Scarbrough, personal communication, March 5, 1982). According to Carpenter (1932), these specimens were, in fact, collected "during the latter part of June." Other than Needham's unusually large collection, the peak months for adult numbers appear to be July and August.

Byers (1973) noted there seemed to be a correlation between *M. tuber* and woodlands and to a lesser extent proximity to permanent, often large streams. There was no indication of the latter in the current study. All but one of the negative sites were closer to larger permanent streams than the two furthest sites (3 and 3.3 miles, respectively) positive for *M. tuber.* The woodland correlation, also supported by Scarbrough's (1980) collections, is, however, strongly supported here. All collections for which exact locations are known (21 of 24) were from woodland sites. Pursuing this correlation further, I feel that the immatures will most likely be found associated with the forest floor, as is the case with most other mecopterans (Borror, et al., 1981). Byers' (1954) report of an adult taken from a rotten log in a hardwood forest by G. C. Wheeler in Michigan may have some significance. Certainly, there is no known reason to believe that the *Merope* larva would be suited to anything other than a terrestrial habitat.

Although this study is the first to list elevation of *M. tuber* collection sites, there was no correlation with the elevations surveyed. Only one non-capture site was outside the range of capture sites.

Of the methods by which *M. tuber* adults have been collected, candlelight and incandescent bulb light have accounted for all reported light collections (Barber, 1904; Byers, 1954; Scarbrough, 1980), including C. T. Meadors' collection reported here. Apparently, black light traps are not attractive to *M. tuber* adults, since none have been reported from them in spite of the adults' nocturnal habits and the countless black light traps that have been operated in woodland situations. Mercury vapor lights offer an alternative light source for field application that has yet to see widespread use. It is possible that this kind of light would provide a more specialized tool for collecting *Merope* adults.

Prospects for learning additional significant facts about the life history of *M. tuber* continue to improve, since Malaise traps give us exact locations of adults under natural conditions. Concentrated searches of these locations for live immature mecopterans for attempts at rearing are suggested. Large quantities of leaf litter and soil could be processed using Berlese-Tullgren funnels over water to obtain live individuals. However, the prospects for extensive concentrated searches being conducted must be considered dim, since, as Byers (1973) observed, "few North American insects could claim less economic importance than *M. tuber.*"

Acknowledgments

I especially want to thank the following individuals who were involved with the Malaise trap collecting and sorting effort: P. VanBuskirk, W. H. Northeimer, K. A. Elrod, D. J. Wetsch, Dr. D. C. Tartar, M. A. Zeto, T. L. Dotson, B. C. Swoope, V. E. Bostic, R. G. McKee, Jr., S. F. Crum, J. Taylor, A. Stuckey, C. Hinckley, M. Graves, J. Perdue, P. Johnson, K. Huffman, and B. Campbell. Thanks are also due Dr. Linda Butler and C.

T. Meadors for making available their unpublished collection records. Lastly, I extend my appreciation to Dr. A. G. Scarbrough and Dr. G. W. Byers for comments concerning *M. tuber* and to Dr. Byers and Dr. Linda Butler for reviewing the manuscript and making valuable suggestions.

Literature Cited

1. Barber, H.S. 1904. The occurrence of the earwig-fly, *Merope tuber* Newman. Proc. Entomol. Soc. Wash. 6:50-51.
2. Borror, D.J., D.M. DeLong and C.A. Triplehorn. 1981. An introduction to the study of insects. Fifth Edition. CBS College Publishing, New York. 827 pp.
3. Byers, G.W. 1954. Notes on North American Mecoptera. Ann. Entomol. Soc. Amer. 47:484-510.
4. Byers, G.W. 1973. Zoogeography of the Meropeidae (Mecoptera). J. Kansas Entomol. Soc. 46:511-516.
5. Carpenter, F.W. 1932. Additional notes on nearctic Mecoptera. Bull. Brooklyn Entomol. Soc. 27:149.
6. Scarbrough, A.G. 1980. Recent collection records of *Merope tuber* Newman (Mecoptera: Meropeidae) in Maryland. Proc. Entomol. Soc. Wash. 82(1): 153-154.

Winter Bat Survey in West Virginia Caves

John C. Delfino
356 Roxalana Hills Drive
Dunbar, West Virginia 25064

Abstract

Eleven caves in West Virginia were surveyed between 14 January and 27 March, 1981 for species diversity and abundance of bats. A total of seven species, numbering 4,154 individuals, was present. No cave housed all species. The following numerical frequencies and percentages of occurrence, respectively, were determined: *Pipistrellus subflavus* (2,160;52.00), *Myotis lucifugus* (1,715;41.29), *Eptesicus fuscus* (187;4.50), *Myotis sodalis* (60;1.44), *Myotis keenii* (12;0.29), *Plecotus townsendii* (12;0.29), and *Myotis leibii* (8;0.19). The relative abundances of these species varied from cave to cave. A chi-square test for independence between this study and Dotson's (1977) work for the same six caves indicated no significant difference in species distribution of all the bats in all the caves.

Introduction

Many investigators have conducted mammalian or faunal studies in West Virginia and in the process have recorded county occurrence data for bats (Surber, 1909; Brooks, 1911; Brooks, 1929; Reese, 1934; Kellogg, 1937; Haller, 1938; Wilson and Friedel, 1941; Barbour, 1950, 1951; McKeever, 1952; Bradshaw and Gibbons, 1967; Dotson and Griffith, 1969).

In addition work concerning individual bat species within the state has occurred and continues to date (Frum, 1944, 1948, 1953; Davis and Lidicker, 1956; Davis, 1959, 1966; Krutzsch, 1961; Hall, 1972, 1975, pers. comm.; Tipton pers. comm.). While geographic distributional data for our chiropteran fauna may be obtained and consolidated from these works, they are at best a substitute for the general survey-type studies (Wilson, 1946; Frum, 1947; Dotson, 1977).

The extensive gaps in the knowledge of the geographic distribution of bats in West Virginia are being closed slowly. Few individuals are actively conducting surveys in our many caves.

This paper is intended to be the first in a series of winter population surveys conducted in the state to evaluate species diversity and relative abundance of bats. Hopefully, it will amplify the existing data concerning the geographic ranges of these mammals.

Materials and Methods

Selection of Caves

Eleven caves were surveyed between 14 January and 27 March, 1981 (Figure 1). They were chosen for study because (1) previous chiropteran work (Frum, 1947; Dotson, 1977; Hall, 1972, pers. comm.) had shown some of them as housing rare, threatened, or endangered bats (Delfino, ms.), and (2) personal correspondence with area spelunkers (Berger, Liebman, Peteck) indicated that in certain caves numbers of bats were being killed by indirect or direct vandalism. The size and current accessibility of each cave was of secondary importance, and these determinations were made from cave descriptions reported by Davies (1958), Hempel (1975), Medville and Medville (1976), and Garton and Garton (1976).

Sampling technique

A Wheat Mark II electric cap-lamp (15,000 beam candlepower, non-fading) served as the light source for the study. A thirty foot retractable, solid-cupped golfball-retriever was used to dislodge bats from the ceiling and walls when necessary for identification.

Survey Date	*Survey Time (hrs.)*	*Cave*	*County*
14 January 1981	3.5	Bob Gee	Greenbrier
31 January 1981	4.0	Higginbothams #1	Greenbrier
31 January 1981	2.0	Higginbothams #2	Greenbrier
01 February 1981	5.0	Higginbothams #4	Greenbrier
07 February 1981	7.5	Cornwell	Preston
19 February 1981	5.0	General Davis	Greenbrier
28 February 1981	1.0	Mill Run	Tucker
11 March 1981	4.5	McFerrin	Greenbrier
12 March 1981	5.5	Poor Farm	Pocahontas
26 March 1981	10.5	Greenville Saltpeter	Monroe
27 March 1981	9.0	Patton	Monroe

FIGURE 1. List of the caves visited January-March, 1981, along with the survey date and time, and location of each.

The amount of time spent in each cave was determined by the total number of hours needed to accurately assess the bat population within. Each survey was conducted irrespective of a time limit and once initiated was completed the same day. Cave passages were surveyed to their point of termination except when deemed inaccessible by their being too small to negotiate, or warranting extremely dangerous climbing or repelling, or requiring total underwater travel to allow further examination. Even though other more easily traversed passages may have and in a few instances did continue beyond those barriers, such passages could not be reached. Observed bats were counted and positive identifications were based on external morphological features, characteristic hanging postures and cluster traits, and vocalizations. If the above criteria did not yield accurate identifications, only then were the bats directly handled, and it was done quickly and gently so as not to arouse them from hibernation. They were then returned to their original locality, and those that would not regrasp that spot were placed in an immediately adjacent area which afforded a more graspable surface.

Duplicate counts of individual bats presented no problem for (1) on very rare occasion were bats flying while conducting the study, and those seen doing so or having recently lighted were not counted, and (2) counts were not made while exiting a passage.

Statistical analysis

A chi-square test ($\chi^2, \propto = 0.005$) for independence (Simpson et al., 1960) was used to compare the results of this study with Dotson's (1977) work for six West Virginia caves covered in both surveys. Results were tabulated for the distribution of bat species in all these caves and the individual caves, namely Higginbothams #1 and Poor Farm. Chi-square comparisons for each of the remaining four caves were not made, since their data were in violation of the rχc contingency-table laws.

Results

Observations in 11 caves yielded a total of seven species of bats (Table 1). No cave contained all species. Cornwell and Greenville Saltpeter Caves displayed similar species diversity, both containing 6 species, and McFerrin Cave housed 5 species. Bob Gee, General Davis, and Patton Caves showed similar diversity with 4 species, and Higginbothams #1 Cave also contained 4 species but with unlike diversity. Higginbothams #4 and Poor Farm Caves showed corresponding species diversity, both containing 3 species, while Mill Run Cave also housed 3 species but of dissimilar diversity. Higginbothams #2 Cave contained only 1 bat species.

The numerical frequencies and percentages of the bat species observed in each cave are presented in Table 2. The most abundant species observed during the survey was *Pipistrellus subflavus,* totalling 2,160 individuals and occurring in all 11 of the caves. *Myotis lucifugus* was the next most common species observed, numbering 1,715 individuals and inhabiting 10 of the 11 caves. *Eptesicus fuscus* numbered 187 individuals and appeared in seven caves, followed by *Myotis sodalis* with 60 occurrences in six caves, *Myotis keenii* with 12 individuals in five caves, *Plecotus townsendii*

Table 1. Species Diversity of Bats Observed in Eleven West Virginia Caves.

	Species of Bats						
Cave	*Pipistrellus subflavus*	*Plecotus townsendii*	*Eptesicus fuscus*	*Myotis lucifugus*	*Myotis sodalis*	*Myotis keenii*	*Myotis leibii*
Bob Gee	x		x	x	x		
Higginbothams #1	x		x	x		x	
Higginbothams #2	x						
Higginbothams #4	x			x		x	
Cornwell	x		x	x	x	x	x
General Davis	x		x	x	x		
Mill Run	x	x		x			
McFerrin	x		x	x	x		x
Poor Farm	x			x		x	
Greenville Saltpeter	x		x	x	x	x	x
Patton	x		x	x	x		

Table 2. Numerical Frequencies and Percentages ( ) of Bat Occurrence Observed in Eleven West Virginia Caves.

	Species of Bats							
Cave	*Pipistrellus subflavus*	*Plecotus townsendii*	*Eptesicus fuscus*	*Myotis lucifugus*	*Myotis sodalis*	*Myotis keenii*	*Myotis leibii*	*Bat Total*
Bob Gee	13 (31.71)	0 (0.00)	6 (14.63)	16 (39.02)	6 (14.63)	0 (0.00)	0 (0.00)	41 (99.99)
Higginbothams #1	105 (83.33)	0 (0.00)	11 (8.73)	4 (3.17)	0 (0.00)	6 (4.76)	0 (0.00)	126 (99.99)
Higginbothams #2	28 (100.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	28 (100.00)
Higginbothams #4	138 (86.79)	0 (0.00)	0 (0.00)	20 (12.58)	0 (0.00)	1 (0.63)	0 (0.00)	159 (100.00)
Cornwell	8 (2.53)	0 (0.00)	13 (4.13)	249 (79.05)	41 (13.02)	1 (0.32)	3 (0.95)	315 (100.00)
General Davis	53 (22.55)	0 (0.00)	10 (4.26)	166 (70.64)	6 (2.55)	0 (0.00)	0 (0.00)	235 (100.00)
Mill Run	1 (6.25)	12 (75.00)	0 (0.00)	3 (18.75)	0 (0.00)	0 (0.00)	0 (0.00)	16 (100.00)
McFerrin	96 (45.07)	0 (0.00)	11 (5.16)	103 (48.36)	2 (0.94)	0 (0.00)	1 (0.45)	213 (99.98)
Poor Farm	346 (60.17)	0 (0.00)	0 (0.00)	228 (39.65)	0 (0.00)	1 (0.17)	0 (0.00)	575 (99.99)
Greenville Saltpeter	975 (50.83)	0 (0.00)	108 (5.63)	826 (43.07)	2 (0.10)	3 (0.16)	4 (0.21)	1918 (100.00)
Patton	397 (75.19)	0 (0.00)	28 (5.30)	100 (18.94)	3 (0.57)	0 (0.00)	0 (0.00)	528 (100.00)
Bat Total	2160 (52.00)	12 (0.29)	187 (4.50)	1715 (41.29)	60 (1.44)	12 (0.29)	8 (0.19)	4154 (100.00)

with 12 individuals in one cave only, and *Myotis leibii* was observed in 3 of the 11 caves with a total number of 8 individuals.

Table 3 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 7, since 7 species were encountered; an actual minimum relative abundance of 6 occurred, since no cave was found that contained more than 6 species). Table 3 shows that the relative abundance of a particular species varies from cave to cave. A rarely occurring bat such as *Plecotus townsendii* may be the most abundant species where it does occur. Conversely, an abundant species like *Pipistrellus subflavus* may rank fourth in relative abundance in a particular cave.

Table 4 compares my results with those of Dotson (1977) for the six caves covered in both surveys (for the purpose of a compatible comparison, Dotson's (1977) count data for the species were additionally converted to percentages of occurrence observed in each cave). The chi-square test for independence between these two samples for all species of bats in all the caves was non-significant ($\chi^2=11.40, \propto=0.005$). The chi-square result for a difference in species distribution for Higginbothams #1 Cave was non-significant ($\chi^2=7.94, \propto=0.005$), while significant ($\chi^2=14.41$, $\propto=0.005$) for Poor Farm Cave.

Discussion

The chiropteran fauna in West Virginia is represented by 12 species, eight of which make use of hibernation caves. All hibernating species except *Plecotus rafinesquii* were sighted during the study. The other four species are currently regarded as non-cave hibernators but occasionally may be found there. In particular *Lasiurus borealis* and *Lasiurus cinereus* may enter caves in late summer and fall when bats swarm and may remain there indefinitely, possibly because they are not able to find their way out (Myers, 1960; Barbour and Davis, 1969); while *Nycticeius humeralis* may be seen swarming with other bats around cave entrances during this time but almost never enter caves (Barbour and Davis, 1969). During their work in West Virginia, Frum (1947) and Dotson (1977) never sighted these particular bats in caves. While *Lasionycteris noctivagans* rarely enters limestone caves (Barbour and Davis, 1969), it has been taken in a Minnesota cave (Beer, 1956) and is a regular winter resident in the silica mines of southern Illinois (Pearson, 1962). In West Virginia Frum (1947) did not record *L. noctivagans* in any caves, and Dotson (1977) observed only two in one Monroe County cave, which represented less than one-percent of the total number of bats observed during that survey. None of these non-cave hibernating species were observed during the present study.

Based on the arrival and departure dates of bats in hibernation caves gathered from previous West Virginia and Kentucky surveys and those performed in other eastern states (Barbour and Davis, 1969), this survey was conducted between the specified months of January-March in anticipation of observing the peak abundance of those species which were expected to occur there. However, prior winter use of the caves by spelunkers may have occurred in some or all of them, and the resulting disturbance may have been enough to coerce certain species to relocate in neighboring caves, thereby influencing the species diversity and abundance of bats found in each one.

Table 3. 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 7). Since No Cave Contained More Than Six Species, the Minimum Relative Abundance Level Actually Observed Was 6.

Relative Abundance Level (1-max.—7-min.)	*Species of Bats*						
	Pipistrellus subflavus	*Myotis lucifugus*	*Eptesicus fuscus*	*Myotis sodalis*	*Myotis keenii*	*Plecotus townsendii*	*Myotis leibii*
1	6 (54.55)	4 (36.36)	0 (0.00)	0 (0.00)	0 (0.00)	1 (9.09)	0 (0.00)
2	3 (27.27)	5 (45.45)	1 (9.09)	1 (9.09)	0 (0.00)	0 (0.00)	0 (0.00)
3	1 (9.09)	0 (0.00)	6 (54.55)	1 (9.09)	3 (27.27)	0 (0.00)	0 (0.00)
4	1 (9.09)	1 (9.09)	0 (0.00)	3 (27.27)	0 (0.00)	0 (0.00)	1 (9.09)
5	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	1 (9.09)	0 (0.00)	2 (18.18)
6	0 (0.00)	0 (0.00)	0 (0.00)	1 (9.09)	1 (9.09)	0 (0.00)	0 (0.00)
7	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)

As for the variability observed in the abundance data per cave (Table 2), there are two apparent reasons. First, the larger caves provided more observation sites. This factor should not alter percentages appreciably, especially for the more abundant species. Second, the internal network structure of the caves varied considerably which provided a difference in the number and type of suitable microhabitats. This factor probably accounts for the majority of the variability encountered. The ecological factors operating here need to be studied and evaluated.

The comparison between Dotson's (1977) work and this study for the same six caves (Table 4) was to serve as an indicator of the apparent similarity of the species distribution of bats within them. The chi-square comparison for all the species of bats in all the caves showed this similarity. Of interest would be the number of these caves which supported this general finding. Regretfully, chi-square comparisons were tabulated only for two caves, and of these, one upheld this generalization while the other did not. The remaining four caves with such small numerical frequencies could give no reliable information; even to conjecture here would be considered premature. This generalization is anticipated to probably be supported by more than one cave, but the small statistical cell frequencies of these data prevent its occurrence. Nevertheless, except for the heterogeneity of the data as depicted particularly by the *P. subflavus* and *M. lucifugus* counts for these two studies, Dotson's (1977) survey and this work display what appears to be rather similar data for species diversity and abundance in each cave.

At best the variability existing in the data of Table 4 may be explained by a variety of reasons. Dotson's (1977) study was not intended to serve as a control; and as such inconsistencies existed in the dates of the surveys, the time spent in each cave counting bats, and no attempt was made to insure commonality between the inception of a count on a particular day. Comparison of the survey dates (month and day) for these caves showed a small (4 day) to large (42 day) disparity, with 3 of 6 caves showing a 3+ week difference. It has been shown that bats do arouse and move in and out of caves and even move to neighboring ones during the hibernation season in response to changing environmental and microhabitat conditions and disturbance (Barbour and Davis, 1969). It would be erroneous to assume that the outside and internal cave environments were identical for this study and Dotson's (1977) work, even if this study were conducted at the same month and day. Therefore, this assumption should not be made for increasing survey-date intervals. It would be more reasonable to assume that different conditions existed which perhaps account for a certain amount of the variability observed. In addition an average of 4.3 hours (range of 1.0 to 10.5) was spent in each cave looking for bats during this survey in contrast to Dotson's (1977) 2 hour criterion established as a maximum time-limit spent in each cave. Perhaps this additional time allowed for more observation sites to be surveyed in the many large and internally intricate caves. Yet, perhaps these disparities may simply be the result of the normal fluctuation pattern in abundance occurring from day to day or year to year during the hibernation season.

Commonly the bats appeared at their expected location and were hanging singly or forming clusters in typical fashion (Barbour and

Table 4. Comparison of Winter Bat Surveys Conducted in West Virginia Presented As the Numerical Frequencies and Percentages ( ) of Bats Observed. Data Above the Diagonal Within Each Cave Category Were Modified From Dotson (1977).

	Species of Bats							
Cave	*Pipistrellus subflavus*	*Plecotus townsendii*	*Eptesicus fuscus*	*Myotis lucifugus*	*Myotis sodalis*	*Myotis keenii*	*Myotis leibii*	*Bat Total*
Bob Gee	134 (77.46)		14 (8.09)	16 (9.25)	8 (4.62)		1 (0.58)	173 (100.00)
	13 (31.71)		6 (14.63)	16 (39.02)	6 (14.63)		0 (0.00)	41 (99.99)
Higginbothams #1	66 (76.74)		10 (11.63)	9 (10.47)		1 (1.16)		86 (100.00)
	105 (83.33)		11 (8.73)	4 (3.17)		6 (4.76)		126 (99.99)
Cornwell	4 (1.70)		10 (4.26)	198 (84.26)	21 (8.94)	1 (0.43)	1 (0.43)	235 (100.00)
	8 (2.53)		13 (4.13)	249 (79.05)	41 (13.02)	1 (0.32)	3 (0.95)	315 (100.00)
Mill Run	3 (9.09)	24 (72.73)		6 (18.18)				33 (100.00)
	1 (6.25)	12 (75.00)		3 (18.75)				16 (100.00)
McFerrin	25 (19.08)		4 (3.05)	100 (76.34)	0 (0.00)		2 (1.53)	131 (100.00)
	96 (45.07)		11 (5.16)	103 (48.36)	2 (0.94)		1 (0.45)	213 (99.98)

Table 4—*Continued*

Poor Farm	236 (59.75) ———	———	———	149 (37.72) ———	———	10 (2.53) ———	———	395 (100.00) ———
	346 (60.17)			228 (39.65)		1 (0.17)		575 (99.99)
Bat Total	468 (44.44) ———	24 (2.28) ———	38 (3.61) ———	478 (45.39) ———	29 (2.75) ———	12 (1.14) ———	4 (0.38) ———	1053 (99.99) ———
	569 (44.25)	12 (0.93)	41 (3.19)	603 (46.89)	49 (3.81)	8 (0.62)	4 (0.31)	1286 (100.00)

Davis, 1969). On occasion *M. sodalis* were hanging individually deep within caves where *P. subflavus* or a very occasional *M. lucifugus* would be regularly expected to occur and the relative humidity appeared very high, but water had not condensed on the backs of the bats. Of particular interest were the *M. sodalis* clusters located in Cornwell Cave. They were observed at very close range due to their location; and it was found that one such cluster contained 26% *M. lucifugus* and the other 24% *M. lucifugus*. The only other cave within which *M. sodalis* could be observed as closely was General Davis Cave and there the cluster contained no *M. lucifugus*. This observation suggests that *M. sodalis* populations often may be overestimated, when the investigator identifies only a few individuals before counting the entire cluster.

Acknowledgments

I thank the Natural Heritage Program of the West Virginia Department of Natural Resources for funding this study. I am grateful to Mike Watson, Brian McDonald, Bob Liebman, and T.J. Stetz for their field assistance. I particularly thank all the landowners who allowed access to the caves on their property.

Literature Cited

1. Barbour, R.W. 1950. A preliminary list of the mammals of Preston County, West Virginia. Proc. W.Va. Acad. Sci. 22:48-53.
2. Barbour, R.W. 1951. Notes on mammals from West Virginia. J. Mamm. 32(3):368-371.
3. Barbour, R.W., and W.H. Davis. 1969. Bats of America. Univ. Press of Kentucky. Lexington. 286 pp.
4. Beer, J.R. 1956. A record of a silver-haired bat in a cave. J. Mamm. 37:282.
5. Berger, S. 1981. Personal Communication.
6. Bradshaw, W.N., and A.E. Gibbons. 1967. The recent mammals of Monongalia County, West Virginia. Proc. W.Va. Acad. Sci. 39:243-251.
7. Brooks, A.B. 1929. Mammals of West Virginia. The West Virginia Encyclopedia, ed. 1. xxiv+1052 pp.
8. Brooks, F.E. 1911. The mammals of West Virginia. Rpt. W.Va. Board Agr. 20:9-30.
9. Davies, W.E. 1958. Caverns of West Virginia. State of W.Va. Geological and Economic Survey. xIx(A) with supplement, 1965. Biggs-Johnston-Withrow, Beckley. 402 pp.
10. Davis, W.H. 1959. Disproportionate sex ratios in hibernating bats. J. Mamm. 40(1):16-19.
11. Davis, W.H. 1966. Population dynamics of the bat *Pipistrellus subflavus*. J. Mamm. 47(3):383-396.
12. Davis, W.H., and W.Z. Lidicker, Jr. 1956. Winter range of the red bat, *Lasiurus borealis*. J. Mamm. 37(2):280-281.
13. Delfino, J.C. ms. Mammals. In: J.C. Delfino(Ed.), ms. Wildlife Species For Special Consideration In West Virginia: Their Status, Distribution, and Habitat. W.Va. Department of Natural Resources, Wildlife Resources Division, Operations Center, Elkins.
14. Dotson, T.L. 1977. The Status of Bats In West Virginia. Unpubl. M.Sc. thesis, Marshall Univ. Huntington. 63 pp.
15. Dotson, T.L., and M. Griffith. 1969. Recent mammals of Cabell County, West Virginia. Proc. W.Va. Acad. Sci. 41:69-74.
16. Frum, W.G. 1944. *Pipistrellus subflavus obscurus* in West Virginia. J. Mamm. 25(2):195.

17. Frum, W.G. 1947. The Bats Of West Virginia: Identification, Measurements, and Distribution. Unpubl. M.Sc. thesis, West Virginia Univ. Morgantown. 21 pp.
18. Frum, W.G. 1948. *Corynorhinus macrotis*, big-eared bat, in West Virginia. J. Mamm. 29(4):418.
19. Frum, W.G. 1953. Silver-haired bat, *Lasionycteris noctivagans*, in West Virginia. J. Mamm. 34(4):499-500.
20. Garton, R., and M.E. Garton. 1976. Caves Of North Central West Virginia. W.Va.S.S. Bulletin 5. W.Va.S.S. Press. Pittsburgh. 108 pp.
21. Hall, J.S. 1972. The Status Of *Myotis sodalis*, the Indiana Bat, In West Virginia. Unpubl. report for The State of West Virginia, Department of Natural Resources. Albright College. Reading. 5 pp.
22. Hall, J.S. 1975. The Status Of The Indiana Bat, *Myotis sodalis*, In The Monongahela National Forest. Unpubl. report to the Forest Superintendent. Unpaged.
23. Hall, J.S. 1981. Personal Communication.
24. Haller, K. 1938. Three new mammal records from the northern panhandle of West Virginia. Proc. W.Va. Acad. Sci. 12:67-68.
25. Hempel, J.C. 1975. Caves and Karst of Monroe County, W.Va. W.Va.S.S. Bulletin 4. W.Va.S.S. Press. Pittsburgh. 149 pp.
26. Kellogg, R. 1937. Annotated list of West Virginia mammals. Proc. U.S. Nat. Mus. 84(3022):443-479.
27. Krutzsch, P.H. 1961. A summer colony of male little brown bats. J. Mamm. 42(4):529-530.
28. Liebman, B. 1981. Personal Communication.
29. McKeever, S. 1952. A Survey of West Virginia Mammals. Conservation Commission West Virginia, Pittman-Robertson Project 22-R. 126 pp.
30. Medville, D.M., and H.E. Medville. 1976. Caves and Karst Hydrology in Northern Pocahontas County. W.Va.S.S. Bulletin 6. W.Va.S.S. Press. Pittsburgh. 174 pp.
31. Myers, R.F. 1960. *Lasiurus* from Missouri caves. J. Mamm. 41:114-117.
32. Pearson, E.W. 1962. Bats hibernating in silica mines in southern Illinois. J. Mamm. 43:27-33.
33. Peteck, F. 1981. Personal Communication.
34. Reese, A.M. 1934. The fauna of West Virginia caves. Proc. W.Va. Acad. Sci. 7:39-53.
35. Simpson, G.G., A. Roe, and R. C. Lewontin. 1960. Quantitative Zoology. Harcourt, Brace and Co., Inc. 440 pp.
36. Surber, T. 1909. Some remarks on the game mammals of West Virginia. Proc. 3rd. Annual Meeting W.Va. Fish and Game Prot. Assoc. 49-56 pp.
37. Tipton, V. 1982. Personal Communication.
38. Wilson, L.W. 1946. Notes on bats from eastern West Virginia. J. Mamm. 27(1):85-86.
39. Wilson, L.W., and J.E. Friedel. 1941. A list of mammals collected in West Virginia. Proc. W.Va. Acad. Sci. 15:85-92.

Chemistry, Geology and Engineering Section

Trans-Bis(N-cyanato)bis(ethylenediamine)chromium(III) Bromide and Its Structure.

B. Das Sarma
West Virginia State College
Institute, West Virginia 25112
and
S. DasSarma
Department of Biology
Massachusetts Institute of Technology
Cambridge, Massachusetts 02139

Abstract

Crystalline trans-bis(N-cyanato)bis(ethylenediamine)chromium(III) tribromide has been synthesized by a novel method of oxidation of the N-thiocyanato analog with potassium bromate. The structure for the complex bromide, derived from the tribromide, was deduced from the mode of synthesis, analytical data, infrared and electronic spectra, and confirmed by single crystal x-ray analysis. Electronic and infrared spectra of the product formed by the reaction of trans-dibromobis(ethylenediamine)chromium(III) bromide with silver cyanate indicated possible existence of a O-bonded cyanato complex, which could not yet been obtained in a pure state.

Like the other chalcocyanates, ambidentate cyanate ion should be capable of coordination either through the nitrogen or the oxygen atom. Many mixed ligand transition metal complexes with thiocyanate are known as linkage isomers, often in fairly stable crystalline state. Very little is yet known about linkage isomerism involving cyanate (16).

Oxygen bonding in discrete monomeric cyanato complexes were claimed for a few (3, 8, 13) but have mostly been shown to be nitrogen bonded by single crystal x-ray diffraction studies (2). The only reported linkage isomers (1) of cyanato-tris(triphenylphosphine)rhodium(I) have not yet been confirmed by x-ray.

The scarcity of oxygen bonded cyanato complexes is normally explained by the relatively low electron density on cyanate oxygen (15, 20); this has also been used to rationalize the tendency of cyanate ion to form single atom nitrogen bridges (6). Molecular orbital calculations (12) have, however, not indicated a disparity in net electron density between the nitrogen and oxygen atoms of cyanate ion to preclude ligation through oxygen. X-ray structure of end-to-end μ-cyanato complexes (10) indicates that cyanate is capable of effective coordination on either end. In addition to N- and/or O-ligation, three membered ring structures involving a metal, nitrogen and carbon are known in complexes with aryl and alkyl isocyanates (18), but not for cyanato complexes.

Nitrogen and oxygen are not only two of the most important ligating atoms in coordination chemistry, they are also the closest in terms of electron configuration, size and electronegativity. Contrary to experimental data, the cyanato complexes should thus be ideal for linkage isomerism. One of the reasons for the scarcity of monomeric O-cyanato complexes may be the ease of the free nitrogen end undergoing further coordination to a second metal atom and resulting in polymeric species. Because of the preference of Cr(III) for oxygen donors and of cyanate to coordinate through the nitrogen atom, we expected a good potential of linkage isomerism in Cr(III)- cyanato complexes (9).

We report here the syntheses of two chromium(III)-cyanato complexes in solid crystalline state, which have been found to be N-bonded. Some evidence for the formation of its linkage isomer is also presented.

Experimental:

Ethylenediamine and pyridine have been abbreviated as en and py, respectively. Pseuduhalide NCX has been written as NCX when coordinated through nitrogen, and as XCN when ligated through X.

trans-$[Cren_2(NCS)_2]$ Br: Trans $[Cren_2(NCS)_2]$ NCS was prepared according to the method of Rollison and Bailar (19). The complex bromide was obtained by the reaction of a saturated solution of potassium bromide in water on a solution of the complex thiocyanate in the minimum quantity of cold (about 5°C) water. The product obtained was purified by recrystallization from water at 70°C. The purity of the compound was ascertained from elemental analysis and its infrared spectra.

Silver cyanate was prepared by the reaction of a fresh solution of potassium cyanate (Matheson, Coleman, and Bell) in cold water to a 20% solution of silver nitrate in water. The product was collected on a sintered glass crucible, washed several times with water, dried at 60°C and kept in an amber bottle in a desiccator. Elemental analysis and infrared spectra indicated that the product was pure.

Trans$[Cren_2Br_2]$ Br. H_2O: 5.32 g of trans$[Cren_2F_2]$ $C10_4$, prepared according to reference (11), was boiled under reflux with 50 mL of 48% HBr for 3 hours. The green product formed was collected, washed with 30 mL cold conc., HBr, and then with 60 mL ethanol. It was purified by precipitating with acetone from a concentrated aqueous solution containing a little HBr. The purity was determined from elemental analysis.

Trans-bis(N-cyanato)bis(ethylenediamine)chromium(III)tribromide: $[Cren_2(NCO)_2]Br_3$ 0.74 g of finely trans$[Cren_2(NCS)_2]$Br was added to 10 mL

of water, followed by 1.35 g of finely powdered $KBrO_3$ and stirred magnetically. A highly exothermic reaction ensued in 5-10 minutes, with liberation of some bromine. The reaction mixture was cooled in ice water to about 25°C, and the stirring continued for 30 minutes. The yellow orange crystals separated were collected by filtration and washed several times with ice cold water and dried in air. Yield 0.40 g.

The complex tribromide was found to be quite stable in the solid state. Thermal analysis indicated that it is stable up to 116°C in vacuum, and it loses a molecule of bromine (TGA peak at 164°C, N_2) to form the complex bromide. It dissolves in water with partial decomposition, and can be recrystallized from warm water, but with a low yield.

It is soluble in dimethyl sulfoxide and in dimethyl formamide. The compound also dissolves in acetone, where it is soon converted into the corresponding complex bromide and bromine.

It should be remembered that bromate oxidation of the thiocyanato complex is highly exothermic and potentially explosive. A dry mixture of the two will burst into flame. Preparation involving large quantity should be avoided. Anal. Calcd. for $CrC_6H_{16}N_6O_2Br_3$: Cr, 10.48; C, 14.52; H, 3.23; N, 16.93. Found: Cr, 10.41; C, 14.57; H, 3.22; N, 16.97.

Trans-bis(N-Cyanato)bis(ethylenediamine)chromium(III)bromide: $[Cren_2(NCO)_2]$ Br

0.8 g of the complex tribromide was finely ground and placed in a beaker with 200 mL of acetone. The mixture was briskly stirred with a magnetic stirrer when the material dissolved with an orange-yellow solution. As the stirring continued, the complex tribromide was converted into the complex bromide and bromine in 30-45 minutes:

$trans[Cren_2(NCO_2)]\ Br_3 - trans[Cren_2(NCO)_2]\ Br + Br_2$

The complex bromide, insoluble in acetone, separated leaving bromine in an almost colorless solution in acetone. The product was collected by filtration on a glass-sintered gooch and recrystallized from water at 70°C. The bromide can also be obtained by heating the powdered complex tribromide in an oven at 158°C. Yield 0.5 g.

The compound is orange yellow, soluble in water, dimethyl sulfoxide, and dimethyl formamide, but insoluble in acetone and ethanol. A 0.003 M solution in water gave three absorption bands at 492 nm ($\in$57), 367 nm ($\in$42) and at 248 nm ($\in$470).

Anal. Calcd. for $CrC_6H_{16}N_6O_2Br$: Cr, 15.48; C, 21.43; H, 4.76; N, 25.00. Found: Cr, 15.24; C, 21.52; H, 4.69; N, 24.91.

Trans $[Cren_2(OCN)_2]$ NCO:

4.3 g of $trans[Cren_2Br_2]\ Br.H_2O$ was finely ground with 4.6 g of AgNCO in a mortar and the mixture was stirred with 50 mL of dimethyl sulfoxide for about 8 hours. The resulting dark red solution was filtered from AgBr and AgNCO. An excess of diethyl ether was added to the filtrate when a red oily solid was precipitated. The supernate was poured off and fresh ether was added. The product turned into a solid when left overnight in the refrigerator. It was collected by suction, washed several times with ether and dried in a vacuum desiccator.

The material gave two strong peaks at 2165 and 2230 cm^{-1}, corresponding to ionic and coordinated cyanate respectively, with the intensity of the former being much less than that of the latter. A water solution

gave absorption bands at 515 nm and at 392 nm. Chemical analysis for Cr, C, H and N indicated that the product was impure. The existence of trans-bis(O-cyanato)bis(ethylenediamine)-chromium(III) in the solid state must be taken at best as tentative at present.

AR chemicals and reagents were used throughout. Infrared and electronic spectra were recorded in 599B Perkin Elmer and 634S Varian spectrometers, respectively. DSC and TGA were done on DuPont Thermoanalyzer System.

Results and Discussions

Synthesis of a monomeric chromium(III) cyanato complex in pure cystalline state and possible existence of its linkage isomer in solution were first reported (9) from this laboratory. The electrical conductance of these non-ionic complexes in nitromethane solution was found to increase with time, indicating gradual polymerization with briding cyanate:

$n[Cr(pyridine)_3(NCO)_3] \rightarrow [Cr_n(pyridine)_{3n}(NCO)_{3n-m}] (NCO)_m$

It was expected that cyanato complexes in a cationic mixed ligand complex like the ones described in this paper may stabilize linkage isomers with some appropriate counter ion (reference 16, page 353).

Oxidation of captive N-thiocyanates with Br_2 and H_2O_2 were found to result in ammine and cyano complexes (17) as the sole products. Out of a large number of oxidizing agents attempted, only the bromate was found to convert trans-bis(ethylenediamine)bix(N-thiocyanato)chromium(III) into the N-cyanato analog:

$trans[Cren_2(NCS)_2] Br + 3 KBrO_3 + H_2O \rightarrow trans[Cren_2(NCO)_2] Br_3 + 2KHSO_4 + KBr$

The product is obtained as pure crystalline tribromide, where the anion Br_3^- has been stabilized by the large complex cation. The complex tribromide can be easily converted to the complex bromide as indicated earlier, and the tribromide may be regenerated by treatment of the complex bromide with bromine in carbon tetrachloride.

The mode of formation from N-thiocyanato compound indicates that the complex tribromide and bromide derived from it are both N-bonded. The infrared spectra in KBr disks of both compounds have a strong band at 2235 cm^{-1}. The integrated intensity for the complex bromide for this CN stretching band was found to be 16×10^4 cm^{-2} $(mol. CN)^{-1} L^{-1}$, indicating M $-$ N $\equiv$ C $-$ O coordination (4). The structure of the complex bromide is unequivocally confirmed by X-ray analysis of a single crystal by Dr. Steward Hawkinson, (figure 1). The Cr $-$ N $-$ C angle shows a 48.9% s character in the Cr $-$ N $-$ C bond hybridization compared to 50% for pure sp hybridized nitrogen in Cr $-$ N $\equiv$ C $-$ O. A bent angle is expected for the linkage isomer. Cr $-$ O $=$ C $=$ N, closer to sp^2 hybridized oxygen.

The integrated intensity of the coordinated cyante band in the tentative O-bonded isomer was not determined because of the poor analysis, but the peak was more sharp than that of tran $[Cren_2(NCO)_2] Br$. This has been found to be true for N- and S-thiocyanato complexes (16). The ligand field may be expected to decrease in the series M-NCS, M-NCO, M-OH_2 M-OCN. This has been found to be the case with an increase in the wavelength of the first (highest wavelength) d-d transition bands in trans-$[Cren_2(NCS)_2]^+$ 483 nm (5), trans $[Cren_2(NCO)_2]^+$ 492 nm, trans-

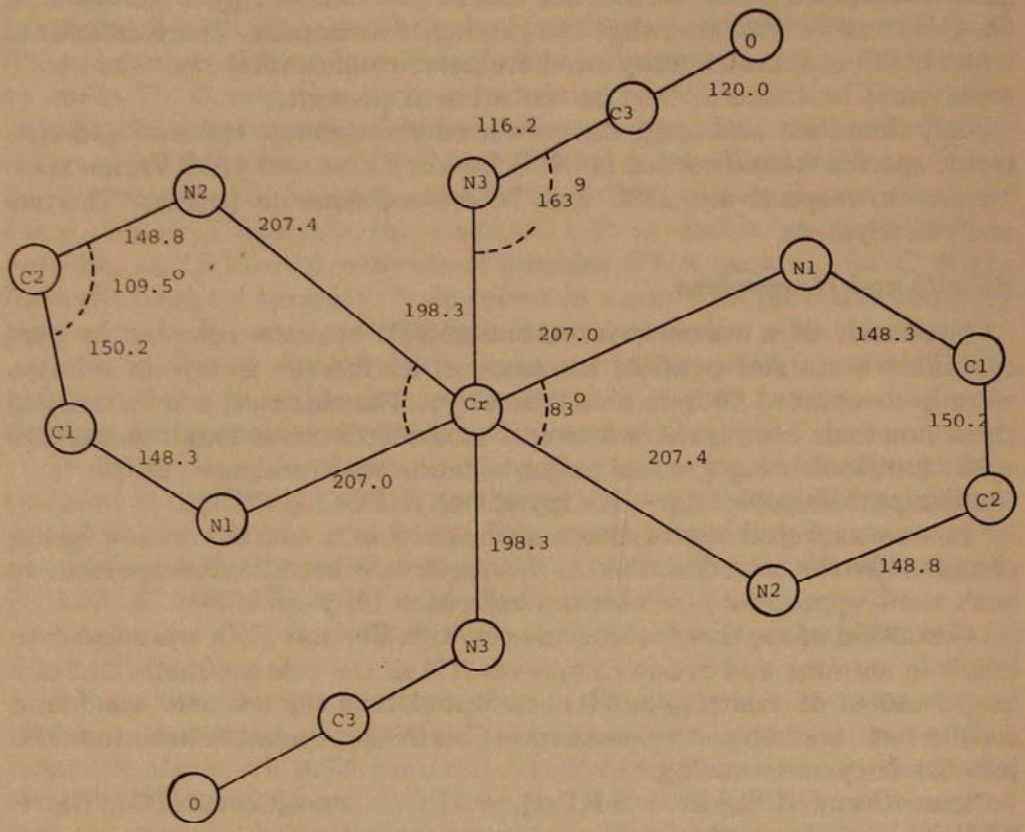


FIGURE 1. Trans-bis(N-cyanato)bis(ethylenediamine)chronium(III) bromide Bond distances are in pm, ±0.5 pm.

$[Cren_2(H_2O)_2]^{3+}$ 508 nm (5) and trans$[Cren_2(OCN)_2]^{+}$ (?) 515 nm. The bathochromic shift in the cyanato complexes are also in the expected range. Further work for the isolation of pure O-cyanato complexes in pure crystalline state are in progress.

Acknowledgments

The authors would like to express grateful thanks to Dr. Hawkinson, Department of Bio-chemistry, University of Tennessee, Knoxville, Tennessee 37016, for X-ray analysis and to Dr. S. Hager and Mr. J. Hildebrand of Union Carbide Technical Center, South Charleston, West Virginia 25303, for thermal analysis and C, H, N, analyses, respectively.

Literature Cited

1. Anderson, S.J., and Norbury, A.H. 1974. "Linkage Isomers of the Cyanate Group: O-Cyanato and N-Cyanato-tris(triphenylphosphine)rhodium(I)." J. Chem. Soc. Chem. Comm. 37-38.
2. Anderson, S.J., Brown, D.S., and Finney, S.D. 1979, "Molecular Structures of bis(η-cyclopentadienyl)diisocyanatotitanium(IV) and Zirconium(IV)." J. Chem. Soc. Dalton Trans. 152-154.
3. Bailey, R.A., and Kozak, S.L. 1969. "Complex Hexacyanates of Rhenium and Molybdenum." J. Inorg. Nucl. Chem. *31*, 689-93.
4. Bailey, R.A., Michelsen, T.W., and Mills, W.N. 1971. "Infrared Intensity Criterion for Bonding Mode in Thiocyanate Complexes." J. Inorg. Nucl. Chem. *33*, 3206-3210.

5. Baker, W.A., Jr., and Phillips, M.G. 1966. "Band Splitting in trans-Diacidobisethylenediamine Complexes of Chromium(III)." Inorg. Chem. *5*, 1042-1046.
6. Britton, D., and Dunitz, J.D. 1965. "The Crystal Structure of Silver Cyanate." Acta Cryst. *18*, 424-428.
7. Burmeister, J.L., and O'Sullivan, T.P. 1969. "Ligand Effects in the Bonding Mode of the Thiocyanate Ion in Complexes of Copper(II) and Nickel(II)." Inorg. Chim. Acta. *3*, 479-486.
8. Burmeister, J.L., Deardroff, E.A., Jensen, A., and Christensen, V. 1970. "Bonding Patterns in Metallocene Pseudohalide Complexes." Inorg. Chem. *9*, 58-63.
9. DasSarma, S., and Das Sarma, B. 1979. "Meridional Tris(pyridine)tris(thiocyanato-N analogue by a Novel Method." Inorg. Chem. *18*, 3618-3620.
10. Duggan, D.M., and Hendrickson, D.N. 1974. "Magnetic Exchange Interactions in Transition Metal Dimers(III). Nickel(II)-di-μ-cyanato, di-μ-thiocyanato and di-μ-selenocyanato complexes and related Outer-sphere Copper(II) Complexes." J. Inorg. Chem. *13*, 2929-2940.
11. Glerup, J., Josephsen, J., Michelsen, K., Pedersen, E., and Schaffer, E.C. 1970. "Preparation of Chromium(III) Complexes with Two Fluorine Atoms and Four Nitrogen Atoms as Ligators. trans-Difluorotetrakis(pyridine)chromium-(III) Salts as Initial Materials." Acta Chem. Scand. *24*, 247-254.
12. Hasboer, F.J., and Beck, W. 1970, Chem. Comm. 262.
13. Jensen, A., Christiansen, V.H., Hansen, J.F., T. Kikewski and Burmeister, J.L. 1972. "Electric Dipole Moments and Infrared Spectral Studies of bis(cyclopentadienyl)titanium(IV) and Zirconium(IV) Pseudohalide Complexes in Various Solvents." Acta. Chem. Scand. *26*, 2898.
14. Nelson, J., and Nelson, S.M. 1969. "Cyanate and Azide Ions as Bridging Ligands in Transition Metal Complexes of 3- and 4-cyanopryidines." J. Chem. Soc. A. 1597-1603.
15. Norbury, A.H., and Sinha, A.I.P. 1968. (V)"Coordination behavior of the cyanate group towards Palladium(II) and Platinum(II)." J. Chem. Soc. A., 1598-1603.
16. Norbury, A.H. 1975. "Coordination Chemistry of Caynate, Thiocyanate and Selenocyanate Ion." Adv. Inorg. Chem. and Radiochem., *17*, 231-383.
17. Norris, A.R., and Wilson, J.W.L. 1973. "Hydrogen Peroxide Oxidation of Coordinated Thiocyanate Ion in cis- and trans-$[Coen_2NH_3NCS]^{2+}$: The Preparation and Properties of trans-$[Coen_2NH_3CN]^{2+2}$." Can. J. Chem. *51* 4152-4158.
18. Richards, R., and Rouschias, G. 1976. "Synthesis and structure of a stable crystalline complex of methyl isocyanate, J. Am. Chem. Soc., *98*, 5729-5731.
19. Rollison, C.L., and Bailar, J.C., Jr. 1946. "Cis-Dichlorobis(ethylenediamine)-chromium(III)chloride and trans-bis-(thiocyanato)bis(ethylenediamine)-chromium(III)." Inorg. Synthesis, *2*, 200-202.
20. Wagner, E.L. 1965. "Calculated Bonding in the Pseudohalide Anions and their Hydracids." J. Chem. Phys. *43*, 2728-2735.

Fauna of the Winifrede Limestone (Middle Pennsylvanian), Upper Kanawha Fm., Mingo County, West Virginia

Ronald L. Martino and Richard B. Bonnett
Department of Geology
Marshall University
Huntington, West Virginia 25701

Abstract

An unusual, shallow marine fossil assemblage was collected from the Middle Pennsylvanian Winifrede Limestone northeast of Musick in Mingo County. The assemblage consists of echinoid plates with primary and secondary spines, a pelmetazoan columnal, productid and spiriferid brachiopods, michelenoceroid nautiloids, bivalves, tiny gastropods, fenestellid bryozoans, and plant fragments. The fauna occurs in a sandy siltstone and mudstone facies of the Winifrede Limestone exposed 4.6-6.1 m above the Chilton Coal. Of particular interest is the occurrence of numerous well preserved echinoid plates with spines of the genus *Archaeocidaris*. The ecologic tolerances of the indigenous faunal components and the vertical sequence of sedimentary facies suggest that the Winifrede Limestone accumulated in a shallow marine embayment, lagoon, or nearshore shelf environment.

Introduction

The Kanawha Formation in southern West Virginia is punctuated by at least 12 thin marine zones (Hennen and Teets, 1919, p. 279). These zones are important for stratigraphic correlation and structural mapping of Kanawha strata which include over 2 dozen commercial coal seams. The Winifrede Limestone is one such zone which occurs between the Chilton and Winifrede Coals in the upper parts of the Kanawha Formation (Figure 1). In the Type Area, near Winifrede in Kanawha County, the Winifrede Limestone occurs 6.1-9.1 m above the Chilton Coal and consists of 1.5-3.0 m of dark gray argillaceous shale with abundant marine fossils (Hennen and Teets, 1919).

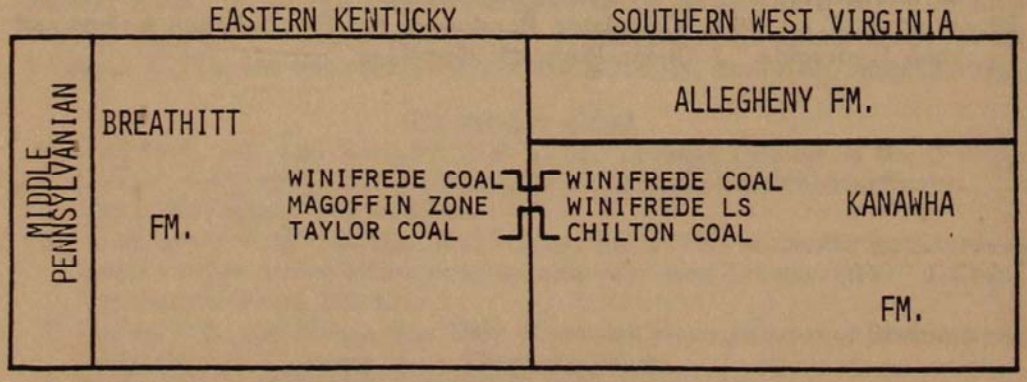


FIGURE 1. Correlation of Middle Pennsylvanian stratigraphic units in eastern Kentucky and southern West Virginia.

In Mingo County, the Winifrede Limestone is not well understood. Early workers may have misnamed it the Buffalo Creek Limestone (Hennen and Reger, 1914, p. 78, 101, 143; Hennen et al., 1919, p. 243). The Winifrede fauna was collected from a gas pipeline trench 4.3 km northeast of Musick (Barnabus 7½′ quadrangle). The locality is on a hillside south of Rockhouse Fork about midway between Timothy Branch and Bearwallow Branch (Figure 2). The elevation of the fossiliferous zone is estimated at 427 m (1400 ft).

The objectives of this paper are 1) to describe the fauna collected along with the associated sedimentary facies, and 2) to interpret the assemblage and associated facies in terms of the existing paleogeo-

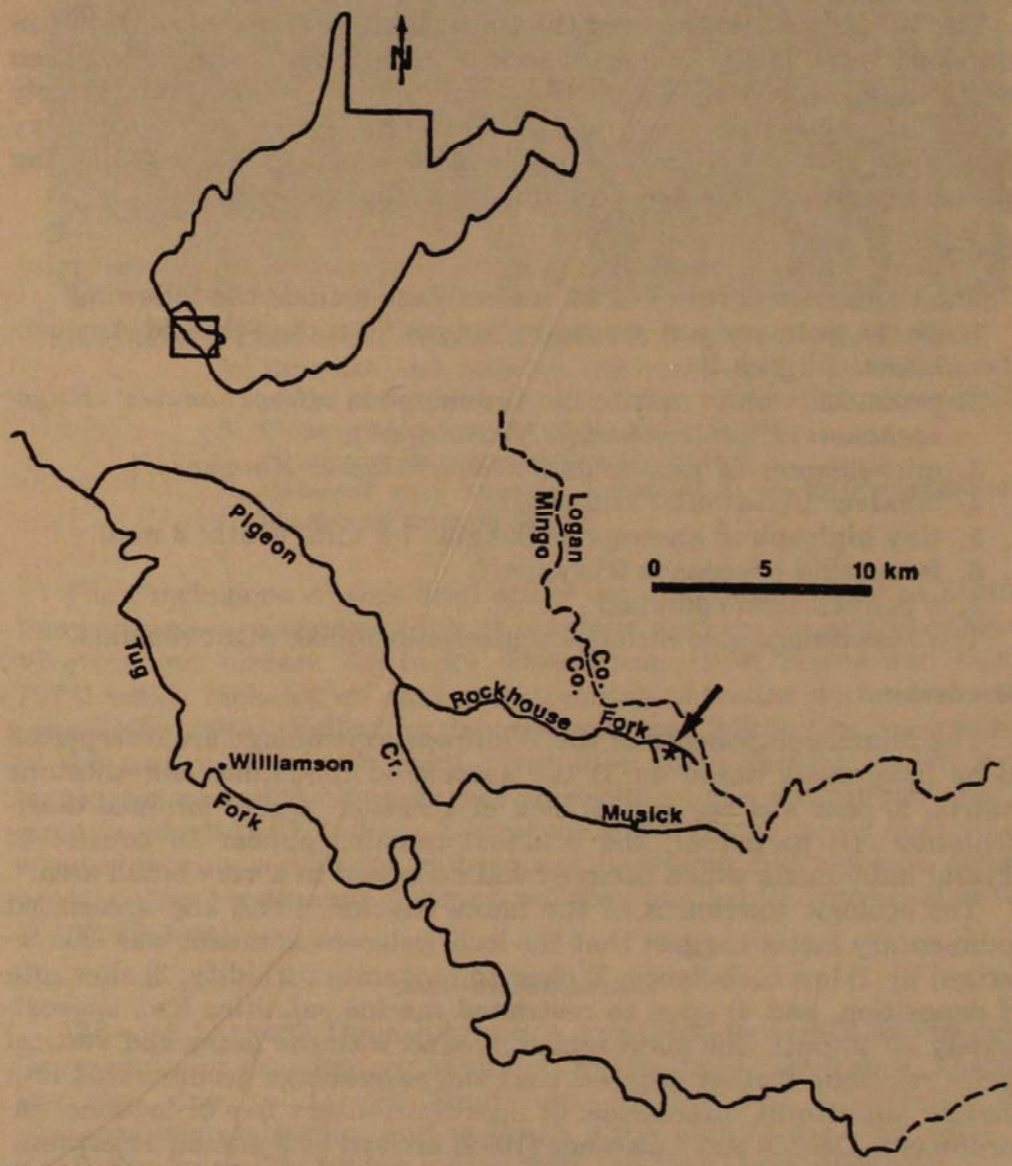


FIGURE 2. Location map. At upper left, Mingo County is shown with a square inset of the study area. Inset is expanded below. Asterisk shows fossil locality on south side of Rockhouse Fork between Timothy Branch and Bearwallow Branch (37° 41′ 16″ N latitude, 82° 02′ 36″ W longitude).

graphic model of previous workers for the Middle Pennsylvanian (Donaldson, 1974; Horne and Ferm, 1978).

Lithology/Stratigraphy

The fossiliferous zone occurs approximately 4.6-6.1 m above a coal seam 76-91 cm thick; this unit was identified as the Chilton Coal from Map II of the Mingo and Logan County Report (Hennen and Reger, 1914). The fossils occur in dark gray and greenish gray, locally calcareous, sandy siltstone and mudstone. The exposed thickness of the fossiliferous interval was about 30-60 cm, but total thickness could not be determined because its lower boundary was covered. Approximately 4.6 m of nonfossiliferous, dark gray mudstone overlies the fossil zone.

The Winifrede Limestone of the Barnabus Quadrangle probably correlates with the Magoffin marine zone of Kentucky. This zone has been described near the study area in the Delbarton Quadrangle (immediately west of the Barnabus Quadrangle). There the zone consists of waxy black shale with a few brackish and marine fossils at the base grading upward into silty shale and very fine sandstone (Alvord, 1971).

Fauna

The faunal components of the assemblage include the following:

1. plates, primary and secondary spines from the echinoid *Archaeocidaris* (Figure 3)
2. productid and spiriferid brachiopods (*Neochonetes Rugosochonetes?, Schizophoria*?, *Neospirifer*?)
3. michelenoceroid nautiloids (*Pseudorthoceras Knoxense?*)
4. bivalves (*Astartella*? and others)
5. tiny high-spired gastropods (height: 7-8 mm, width: 3 mm)
6. fenestellid bryozoans (*Polypora*?)
7. a pelmetazoan columnal

The assemblage also includes scattered reed-like plant remains.

Discussion

The faunal components of the Winifrede assemblage are interpreted to be indigenous based on 1) the associated mudstone and siltstone matrix, 2) poor size sorting, 3) lack of abrasion, and 4) minimal disarticulation. In particular, the echinoid remains appear to consist of several individuals which decayed and collapsed in a very small area.

The ecologic tolerances of the fauna (Heckel, 1972) and associated sedimentary facies suggest that the local paleoenvironment was characterized by 1) low turbulence, 2) clear to moderate turbidity, 3) slow rate of deposition, and 4) open to restricted marine salinities (i.e., approximately 20-40 ppt). The plant remains found with the fauna and vertical facies relations further suggest that the assemblage accumulated in a shallow sublittoral, interdeltaic or interdistributary bay or lagoonal environment. Dennis and Lawrence (1979) arrived at a similar interpretation for the Magoffin marine zone in eastern Kentucky. They recognize 3 facies in the Magoffin zone: a fossiliferous thin basal transgressive facies above the Taylor Coal overlain by fossiliferous bayfill and nonfossiliferous delta lobe-building facies.

FIGURE 3. Fossils of the cidaroid echinoid *Archaeocidaris*. Scale in cm.
A: External and internal impressions of interambulacral plates on left with primary and secondary spines on right.
B: Closeup of spines in sample shown in A.
C: Closeup of interambulacral plates in A.
D: External and internal impressions of interambulacral plates and primary spines.

The conclusions of this brief study are consistent with the Middle Pennsylvanian paleogeography of previous workers for southern West Virginia and eastern Kentucky (Donaldson, 1974; Horne and Ferm, 1978) which includes an east-west trending shoreline with northward prograding deltas. Following deposition of the Chilton Coal in marshes of the transitional lower delta plain, lobe abandonment caused local transgression and the formation or enlargement of a widespread embayment in which the Winifrede Limestone accumulated under open to restricted marine conditions. Subsequent bayfilling and renewed deltaic progradation terminated marine conditions and led to deposition of the Winifrede Coal.

Acknowledgments

We wish to thank Dave Johnson, a construction worker on the pipeline trench, for drawing our attention to the fossil occurrence. Thanks are also due to Dewey Sanderson of Marshall University for photographic assistance, and to Frank Ettensohn of the University of Kentucky for reviewing the manuscript and fossil identifications.

Literature Cited

1. Alvord, D.C. 1971. Geologic Maps of Parts of the Naugatuck and Delbarton Quadrangles, Eastern Kentucky. U.S. Geol. Survey, Geol. Quad. Map GQ-879.

2. Dennis, A.M., and Lawrence, D.R. 1979. Paleoecology of the Magoffin Marine Zone, Pennsylvanian Breathitt Formation, Near Hazard, Kentucky, p. 256-258, *In*: Ferm, J.C., and Horne, J.C. (*eds.*), Carboniferous Depositional Environments in the Appalachian Region, Carolina Coal Group, University of South Carolina, 760 p.
3. Donaldson, A.C. 1974. Pennsylvanian Sedimentation of Central Appalachians, p. 47-78, *In*: Briggs, (*ed.*), Carboniferous of the Southeastern United States, Geol. Soc. Amer. Spec. Paper 148.
4. Heckel, P.H. 1972. Recognition of Ancient Shallow Marine Environments, p. 226-286. *In*: Rigby, J.K., and Hamblin, W.K., (*eds.*), Recognition of Ancient Sedimentary Environments, Soc. Econ. Mineral. Paleontol., Spec. Pub. No. 16, 340 p.
5. Hennen, R.V., and Reger, D.B. 1914. Logan and Mingo Counties: West Virginia Geol. Survey (County Rept.), 776 p.
6. Hennen, R.V., and Teets, D.D. 1919. Fayette County: West Virginia Geol. Survey (County Rept.), 1,002 p.
7. Horne, J.C., and Ferm. 1978. Carboniferous Depositional Environments: Eastern Kentucky and Southern West Virginia. Univ. South Carolina, Field Guidebook.

A Heated Ultrasonically Vibrated Trough for the Drying of Pulverized Washed Coal

Harold V. Fairbanks and Tetsuro Otsuka
Department of Chemical Engineering
West Virginia University
Morgantown, West Virginia 26506

Abstract

Ultrasonic vibrations were coupled directly to a heated, inclined aluminum trough for the purpose of drying washed, fine coal particles. The particle size ranged from 50 to 400 microns. The ultrasonic frequency used was 20 kHz. The flat section of the trough was 8 cm wide and 90 cm long, having 2 cm walls to contain the particles while being dried. The experimental parameters included the following: (1) ultrasonic intensity, (2) initial moisture content, and (3) particle size range. It was found that there was a maximum drying rate for each parameter. The efficiency for the removal of moisture was best when a particle size range of 110-150 microns was used. Over 70% of the energy applied to the drying system was used for the removal of the moisture from the coal.

Introduction

Millions of tons of coal are available for commercial use if the pyritic sulfur could be economically removed. One of the most economical methods used for removal of pyrite from coal is washing the coal with

water in a specific gravity separation process. Adequate removal of the pyritic sulfur from coals requires pulverization of the coal to particle sizes of less than 200 microns. The drying of this pulverized coal after washing is a major problem.

Filtration reduces the water content level down to approximately 20% moisture content on a dry basis. However, for commercial use, the coal should not contain over 7% moisture on a dry basis. There are two major factors which contribute to this difficulty in drying pulverized coal to a 5-7% moisture content. These factors are, (1) coal is a temperature sensitive material which degrades readily at elevated temperature and (2) the small particle size gives a large surface area to which polarization bonding of the water takes place.

Several papers have reported the fact that the introduction of sonic vibrations into a drying system increases the rate of drying of materials (Boucher, 1958; Soloff, 1959). Over the past several years, research studies have been made at West Virginia University applying sonic vibrations to various drying systems. The most informative investigation made use of airborne sonic vibration. The sonic vibrations were radiated upon the drying surface of the material. A schematic sketch of the apparatus used is shown in Figure 1. The sonic vibrations used had a frequency of 20 kHz with intensities of up to 160 dB.

Figure 2 shows a drying rate graph with typical results obtained when drying washed pulverized coal. It can be seen that the introduction of sonic vibrations not only increased the rate of drying, but also extended the constant rate drying curve to a lower moisture content before the falling rate portion of the curve began.

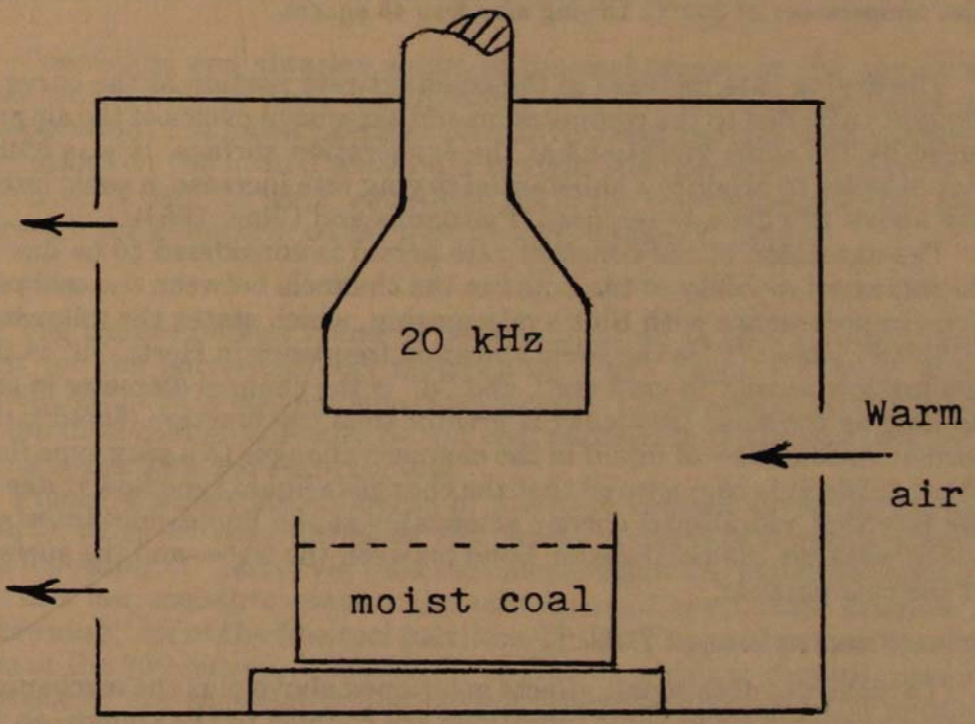


FIGURE 1. Schematic sketch of oven drier with airborne sonic vibrations radiated onto the drying surface of moist pulverized coal.

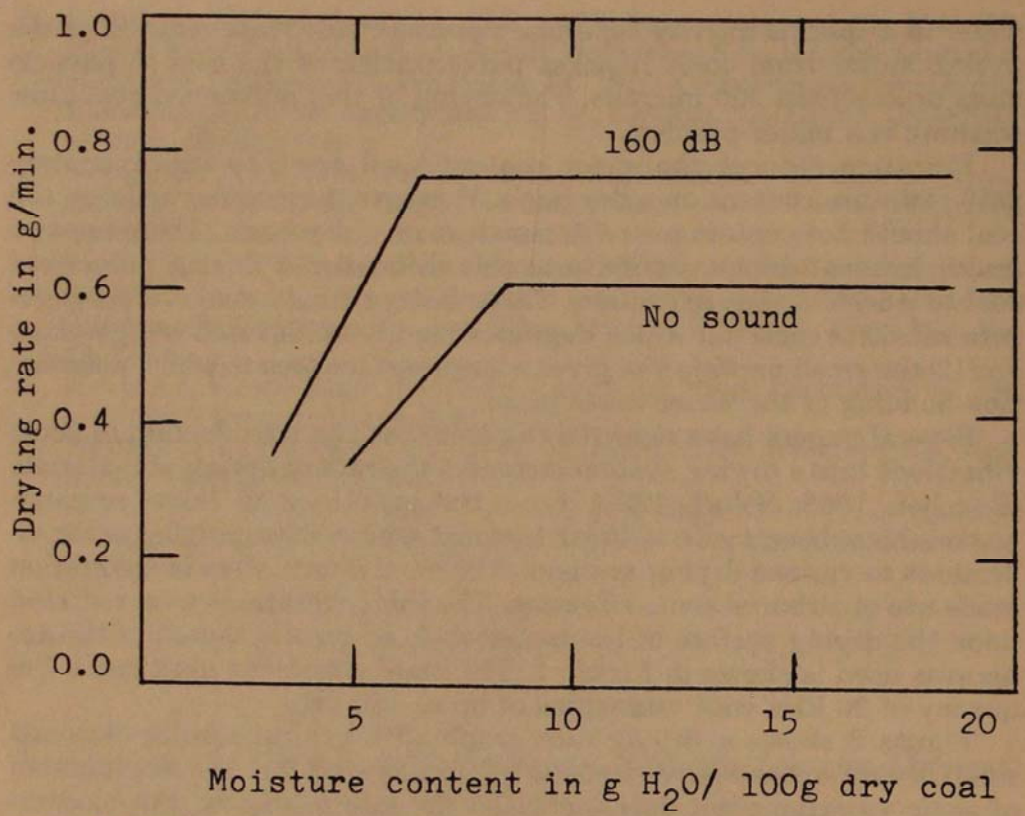


FIGURE 2. Typical drying rate curves showing the influence of 20 kHz airborne sonic vibrations upon drying of minus 200μm pulverized washed coal particles. Air flow over the drying surface was approximately two liters per second with an inlet temperature of 200°C. Drying area was 45 sq. cm.

The drying rate increase in the constant rate portion of the curve is thought to be due to the compression and expansion cycles of the air produced by the sonic vibrations at the evaporation surface. It was found that in order to produce a substantial drying rate increase, a sonic intensity above 130 dB was required (Fairbanks and Cline, 1967).

The extension of the constant rate period is considered to be due to the increased mobility of the liquid in the channels between the coal particles in accordance with Biot's relationship, which states the following: $f < \P u/4d^2$, where "f" is the sonic vibration frequency in Hertz, "u" is the kinematic viscosity in cm^{-2} sec^{-1}, and "d" is the channel diameter in cm. As long as the sonic frequency is greater than the function ($\P u/4d^2$), the normal viscous flow of liquid in the channels changes to a plug type flow (Biot, 1956). It is conjectured that the change in liquid type flow is due to the fact that vibrational energy attenuates at the liquid-solid interface which weakens the polarization bond between the water and the surface of the coal particle.

Sonic Vibrated Trough Drier

To make use of the sonic effects mentioned above plus the mechanical action available when sonic vibrations are coupled to the trough, an inclined, electrically heated sonically vibrated aluminum trough drier was

designed and is shown in Figure 3 (Fairbanks and Purdum, 1976). With this arrangement, the wet coal is fed onto the top of the inclined heated trough and slowly moved down the trough due to the sonic vibrations.

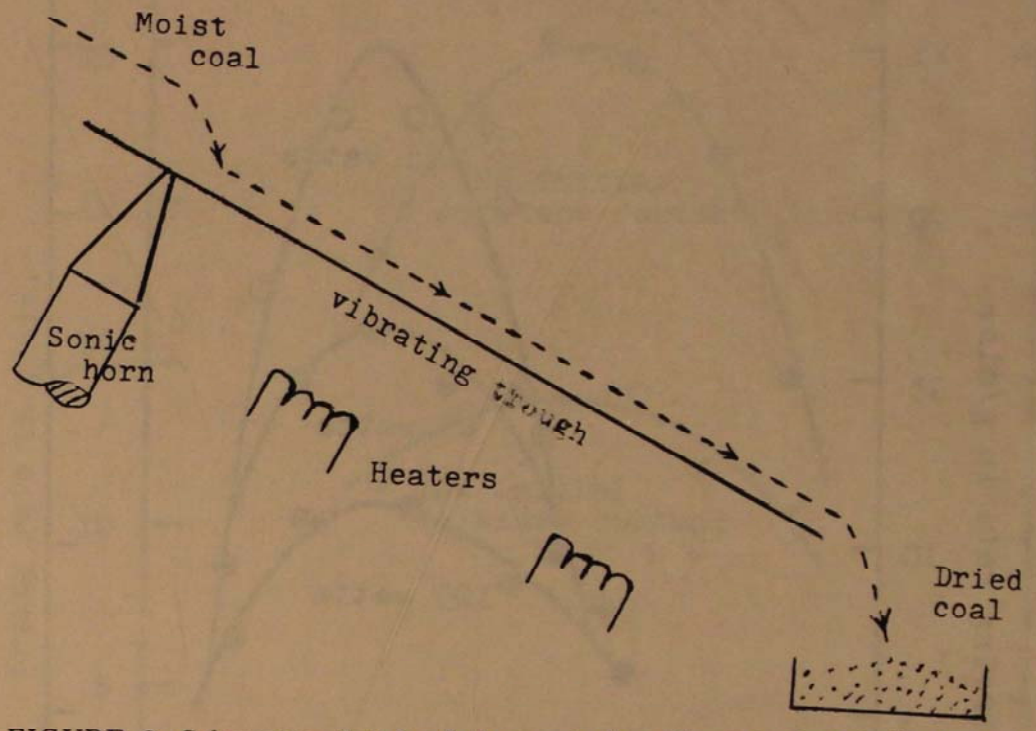


FIGURE 3. Schematic sketch of the sonically vibrated, electrically heated, aluminum trough drier used in the experimentation.

The rolling and abrasive action of the coal breaks up the agglomerates which tend to form. This process produces more surface area for evaporation. The moist particles also have direct contact with the sonic vibrations in the heated aluminum trough. Another positive feature of the drier is that the sonic vibrations aid in the transmission of the heat through the aluminum to the moist coal (Fairbanks, 1978).

Results

The apparatus was found to be functional up to 20% moisture content for the pulverized coal particles on a dry basis. However, some stable wet balls of coal agglomerates formed. These comprised about 5% of the total coal processed. The wet coal adhered to the trough at conditions above 20% moisture content.

Figure 4 shows the influence of moisture content upon the drying rate for three different ultrasonic intensities. Aspects of Figure 4 include the following: (1) the curves tend to coincide below 7% moisture content. At this low moisture content the vibrations of the trough produce a "throwing" off of the fine coal particles. (2) The curves also tend to coincide at the 20% moisture content level. At this moisture content, the adherence of the material to the trough effectively stopped the normal operation of the drying process.

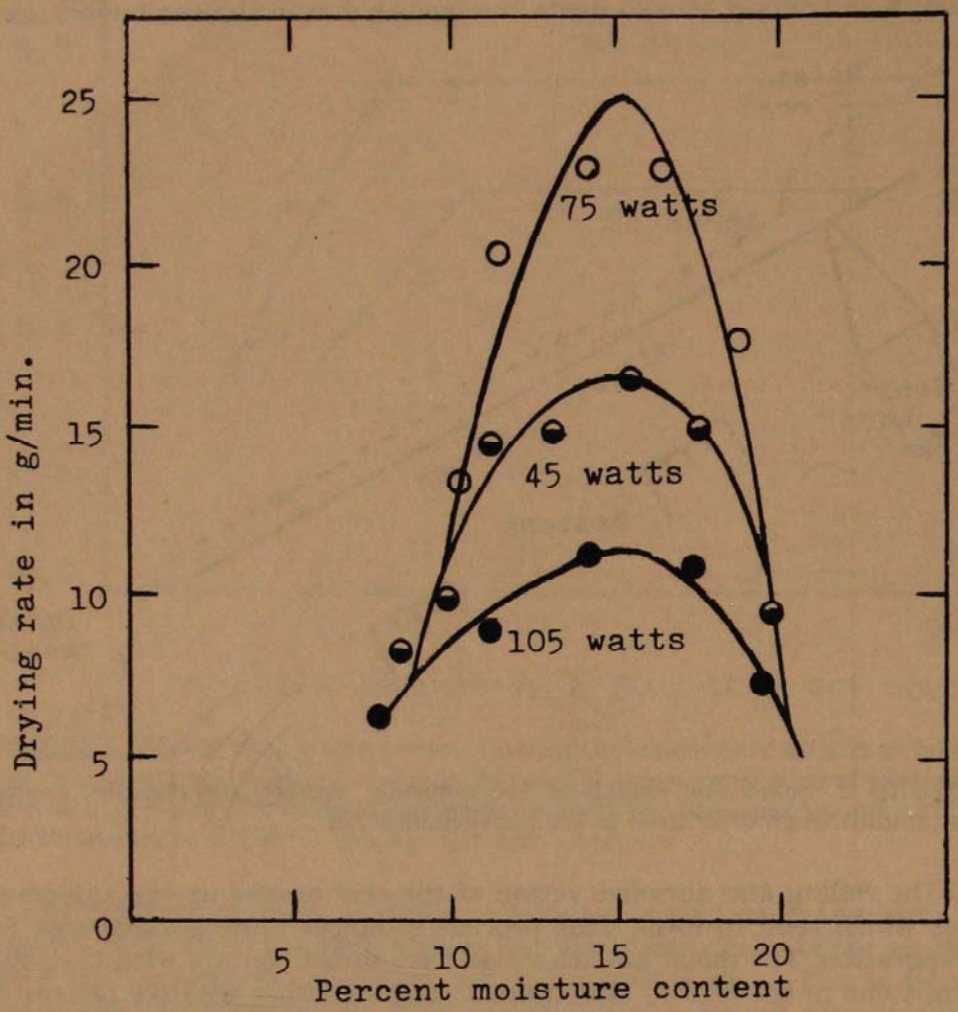


FIGURE 4. Curves showing the influence of sonic intensity upon the drying rate verus the moisture content in pulverized coal. Coal size was 60% through 100 mesh screen. Drier surface was 265 sq. cm. Coal flow rate through drier was one Kg/min.

Acknowledgments

The authors wish to thank the many students whose work contributed to this paper, the NSF-URP summer grant and the Coal Research Bureau of West Virginia University who helped sponsor these projects; and the Branson Sonic Power Company of Danbury, Connecticut for the instrumentation used.

Literature Cited

1. Boucher, M.G. 1958. "Drying by Airborne Ultrasonics," *Ultrasonic News*, Vol. 4, pp. 8-13.
2. Soloff, R.S. 1959, "Sonic Drying," *J. Acoust. Soc. Am.*, Vol. 36, pp. 961-965.
3. Fairbanks, H.V., and Cline, R.E. 1967. "Acoustic Drying of Coal," IEEE *Trans. on Sonics and Ultrasonics*, Vol. Su-14, pp. 175-177.
4. Biot, M.A. 1956. "Theory of Propagation of Elastic Waves in a Fluid-Saturated Porous Solid," *J. Acoust. Soc. Am.*, Vol. 28, pp. 168-191.

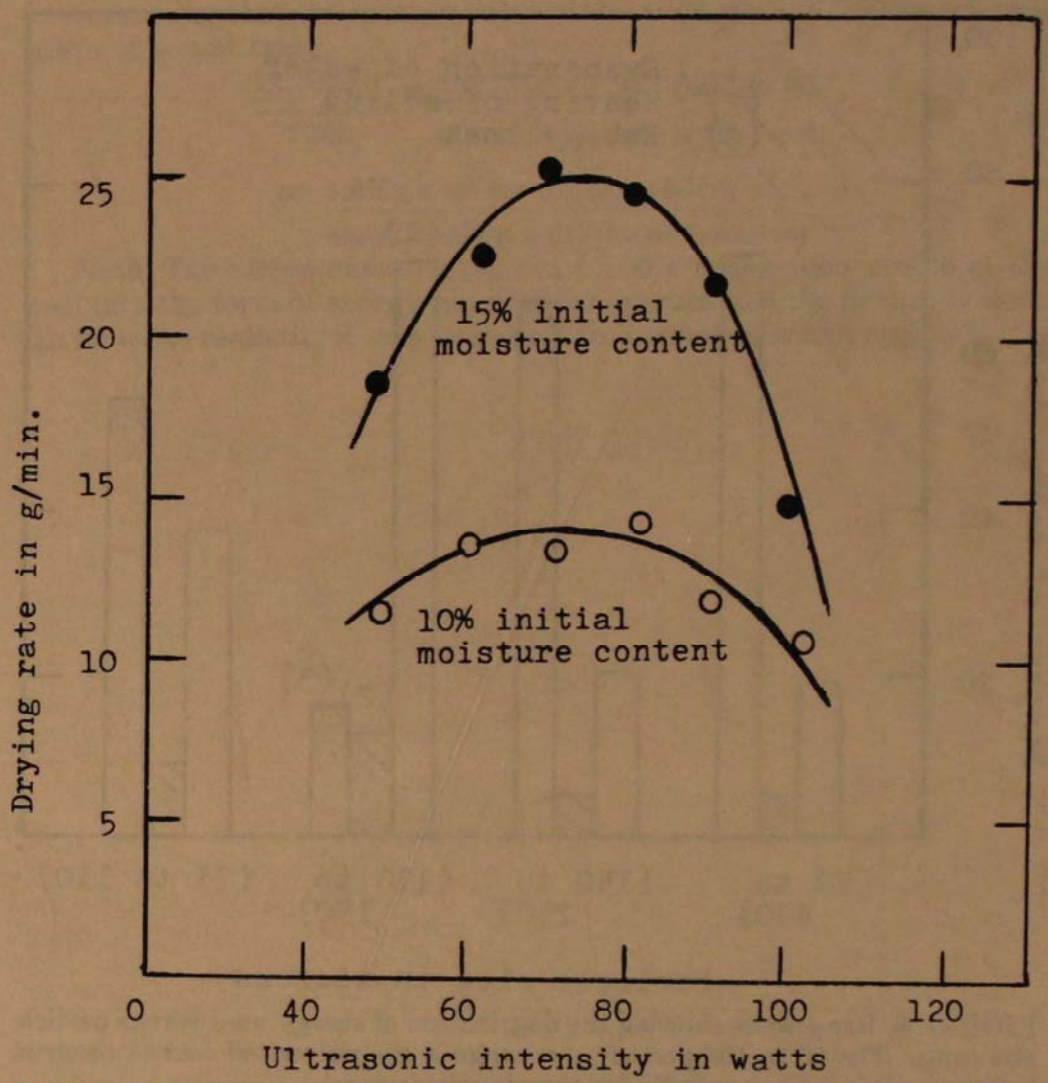


FIGURE 5. Curves showing the influence of initial moisture content upon drying rate with increasing ultrasonic intensity. Coal size was 60% through 100 mesh screen. Drier surface was 265 sq. cm. Coal flow rate through drier was one Kg/min.

5. Fairbanks, H.V., and Purdum, H. 1976. "Drying of Heat Sensitive Powders Using a Heated Ultrasonically Vibrated Chute," *1976 Proc. WVAS*, Vol. 48, Abs., p. 41.
6. Fairbanks, H.V. 1978. "Heat Conduction in Metals," *J. Acoust. Soc. Am.*, Vol. 64, Abs., pp. 563.

Appendix

The following are calculations for energy distribution in drying washed, pulverized coal, having a particle size range of 110 to 150 microns. Also included is a calculation for the amount of coal needed to operate the trough drier. The coal was drier from 17% to 3% water content on a dry basis for the coal.

The total energy input into the drying system was measured to be 12.63×10^4 calories per Kg coal on a dry basis per minute.

The amount of calories required to heat and evaporate the moisture in the coal is as follows:

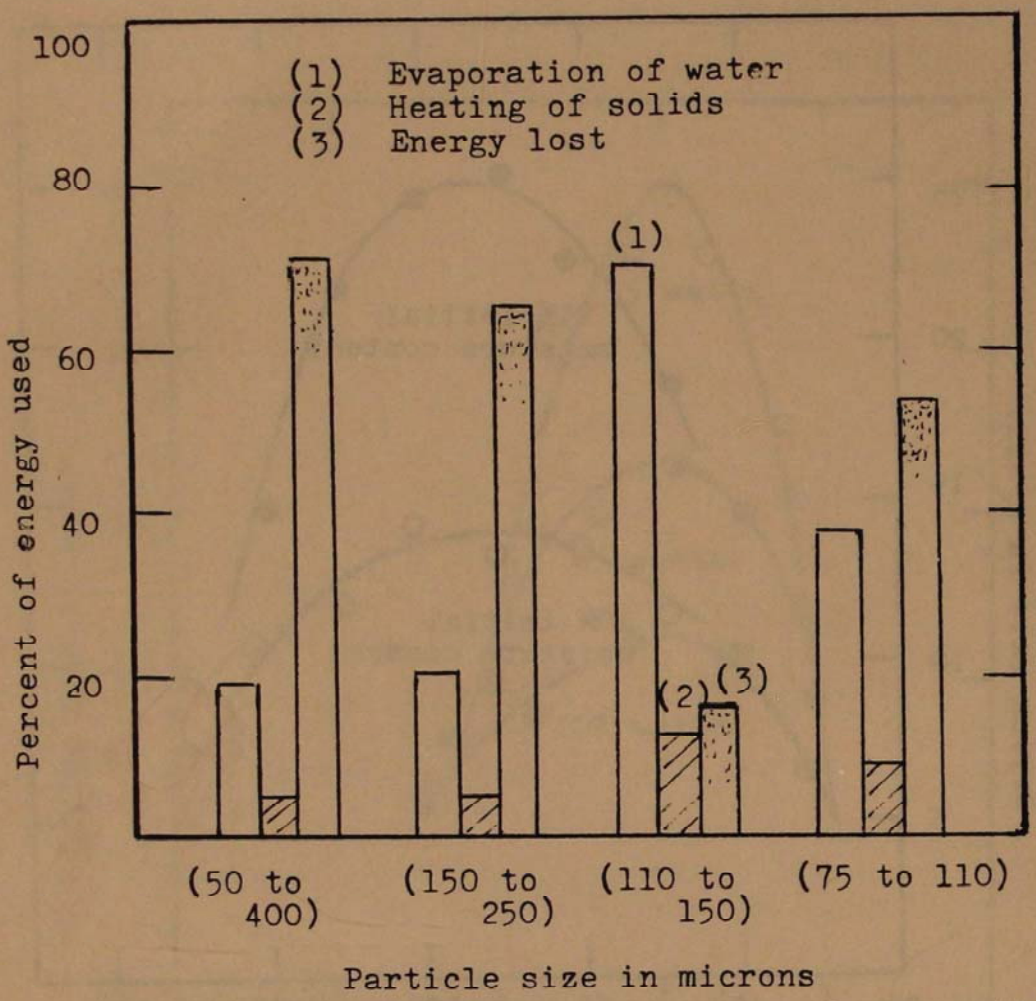


FIGURE 6. Bar graphs showing the distribution of energy used versus particle size range. The 50 to 400 particle size range is the pulverized coal as received before screening. See appendix for sample calculations.

Sensible heat: 170(g) x 80(°C) x 1(sp. ht.) = 1.36×10^4 calories

Latent heat of evaporation: 140(g) x 534(cal/g) = 7.48×10^4 calories

Total — — 8.84×10^4 calories

Therefore, the percent energy used to heat and evaporate the moisture is

$$\frac{8.84 \times 10^4}{12.63 \times 10^4} \times 100 = 70\%$$ answer

The percent energy to heat the solids, mainly coal,

0.2(sp. ht.) x 1000(g) x 80(°C) = 1.6×10^4 calories

$$\frac{1.6 \times 10^4}{12.63 \times 10^4} \times 100 = 12.7\%$$ answer

Percent energy unaccounted for (lost)

$100 - (70 + 12.7) = 17.3\%$ answer

Assuming that the heating value of the dried coal is 7,000 calories per gram, it would take:

$$\frac{12.63 \times 10^4}{7000} = \frac{18g \text{ coal}}{\text{of moist coal on a dry basis}} \text{ for drying one Kg}$$

or 1.8Kg coal for drying 100Kg of moist coal on a dry basis (answer)

Note: The above answer assumes a 100% energy conversion of the coal into the form of energy required for operation of the drying system. To be more realistic, it may require 3 to 5 times as much coal.

Ecology Section

Reciprocal Succession of *Spartina alterniflora* and *Avicennia nitida*

Lawrence J. Chlumsky, M. Ian Jenness,
Stokes S. Baker, and Leslie Gordon
Davis and Elkins College
Elkins, West Virginia 26241

Abstract

The reciprocal succession of *Spartina alterniflora* and *Avicennia nitida* was investigated on the island of Seahorse Key, Florida, part of the Cedar Key National Wildlife Refuge, located 60 miles southwest of Gainesville. Facilities were provided by the University of Florida Marine Laboratory.

The windward side of the island has two distinct beaches. The first is occupied by *S. alterniflora* and *A. nitida*, while the other has neither of these species. Based on initial observations the following successional pattern was hypothesized. *S. alterniflora* is a primary successional species that, given a good substrate and protection from strong currents, will establish itself on the beach. *A. nitida* has seeds that germinate on the tree and then fall into the water and are carried until they take root. Those mangrove seedlings that root in intertidal mudflats are eventually swept away by currents, but those that establish themselves at the upper limit of the *S. alterniflora* are more likely to remain established. As the *A. nitida* grow, they shade out and kill the *S. alterniflora*. When the *A. nitida* die two possibilities exist: (1) the *S. alterniflora* recolonize the area, initiating a new cycle, or (2) erosion of the beach continues until a cove is formed.

Introduction

This report is based on a continuing study of *Spartina alterniflora*, a cord grass, and *Avicennia nitida*, a mangrove, on the island of Seahorse Key, Florida. Seahorse Key is part of the Cedar Key National Wildlife Refuge, located 60 miles southwest of Gainesville. The study was begun in January 1980 and was continued during January of each of the following two years. Facilities on the island were provided by the University of Florida Marine Laboratory.

The study sites were located on the windward side of the island, which

has two distinct beaches: the first, a *S. alterniflora* covered beach running from the north-northwest to the south-southeast; and the second, an open sand beach running from the northwest to the southeast (See Figure 1).

Reciprocal succession is the process by which a community fails to develop a true climax; instead, the climax alternates between two or more different seral stages, in this case, the *S. alterniflora* alternates with *A. nitida*, both of which are shade intolerant species (West, 1956 and MacRae, 1963).

Initial observations suggested that the following sequence of events may be taking place on the beach. The seeds of the mangrove germinate on the tree, fall into the water, and are dispersed. The seedlings then establish either on the mudflats or on the beach near the upper limits of the *S. alterniflora*. As the mangrove matures, it begins to shade out the *S. alterniflora*. When the *S. alterniflora* has died back totally around the mangrove, the pneumatophores of the tree become exposed to tidal action; eventually killing the tree. At this point, one of two events may occur: the area may be reinvaded via rhizomatous growth of the *S. alterniflora*, or if the area exposed is too extensive to be recolonized by the *S. alterniflora* a cove may begin to form. It is our intention to show that the process of reciprocal succession of *S. alterniflora* and *A. nitida* is taking place on Seahorse Key.

Methods

Several types of investigations were made. First, a mangrove count was performed. Three plots were established along the inhabited beach, one large and two smaller plots (See Figure 1). The upper limits of the plots were set at 21 feet above the upper limit of the *S. alterniflora* (See Figure 2). The large plot was 125 meters long and was divided into five subplots of equal size; the small plots were each six meters wide. The plots ran 25 meters from their upper limits down onto the mudflats. Zones parallel to the beach were then marked off one meter apart. The mangroves were counted according to the zone where they were found, and stage of growth (seed, seedling, established seedling, immature, mature, or dead) was recorded.

To determine the amount of light reaching each area of the beach, a chemical light meter was adapted from the report of Marquis and Yelenosky (1967) for this study. This light meter is based on the polymerization of anthracene by light. For three consecutive nights, three glass vials of anthracene were placed in each of the following areas: under the *S. alterniflora*, *A. nitida*, and *Spartina patens*; and on the open sand beach. The vials were retrieved the following night at approximately the same time and replaced with new vials for the length of the study. The concentration of remaining anthracene in the retrieved vials was measured using a spectrophotometer.

To determine the direction of sand movement, fluorescein dye was used to dye beach sand that was placed at various locations within the coves around the study site. At night, the drifting of the dyed sand was observed under ultraviolet light. The direction and length of the drifts were measured. The current of the water was also determined by releasing a small quantity of fluorescein into the water and observing the direction in which it drifted.

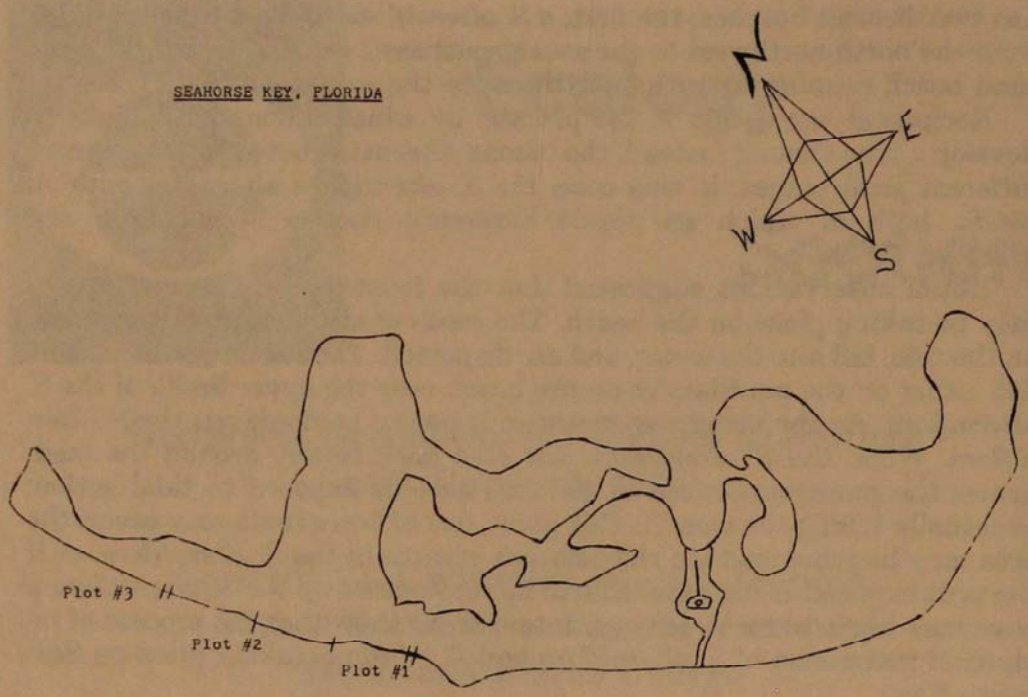


FIGURE 1

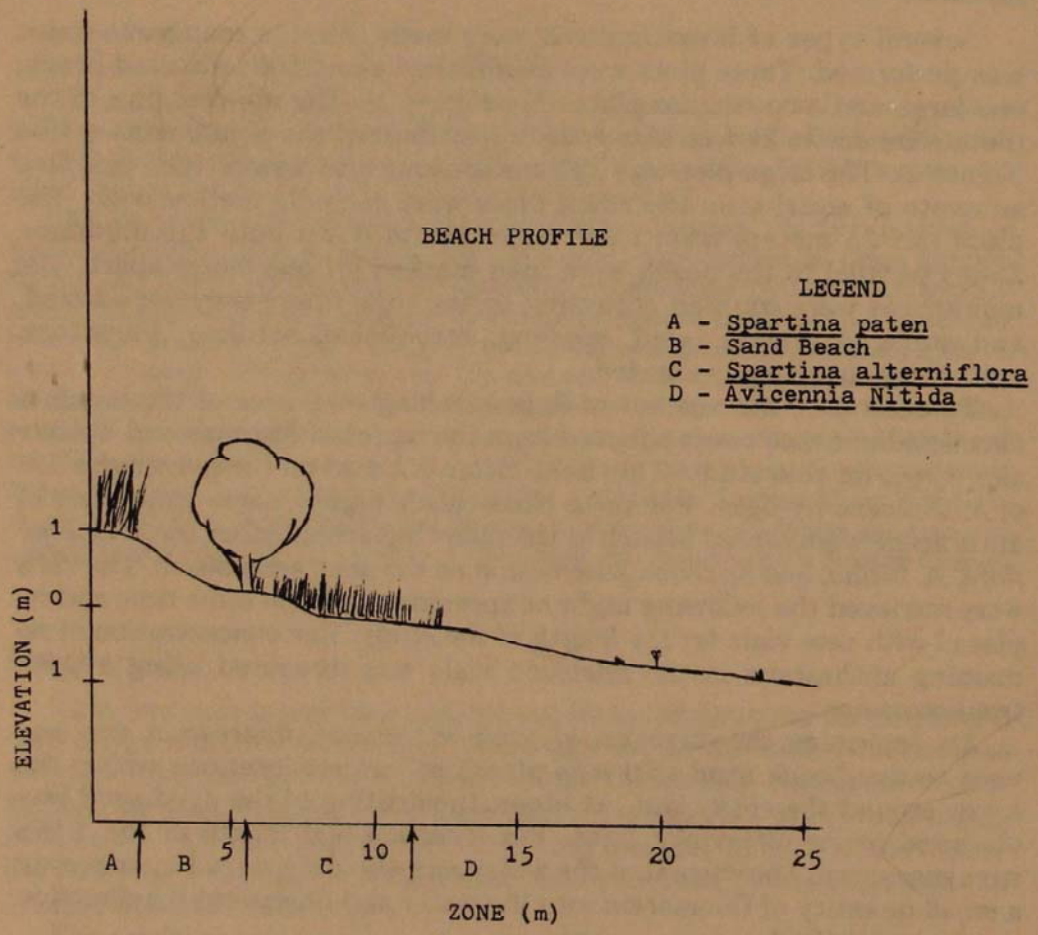


FIGURE 2

Finally, to determine whether the coves are shifting on the beach, the study areas were surveyed using a Brunton compass. Measurements were made of the angles and changes in elevation of all the transects and reference lines, the length of these lines, and the locations of mangroves, Spanish bayonets, and cacti. These measurements were taken to compare with data gathered by later studies.

Results

The mangrove count showed that in the early stages of development the mangroves demonstrated a bimodal distribution, the peaks occurring on the mudflats and above the *S. alterniflora* (See Figure 3). Established seedlings were found in greatest numbers on the mudflats, with fewer being found at the upper and lower limits of the *S. alterniflora* (See Figure 4). Immature and mature plants were found only at the upper limits of the *S. alterniflora* (See Figures 5 and 6).

The chemical light meter data shows that the amount of light penetrating both *A. nitida* and *S. alterniflora* is greatly decreased from the amount that reached the open beach over the three days of the experiment (See Figure 7).

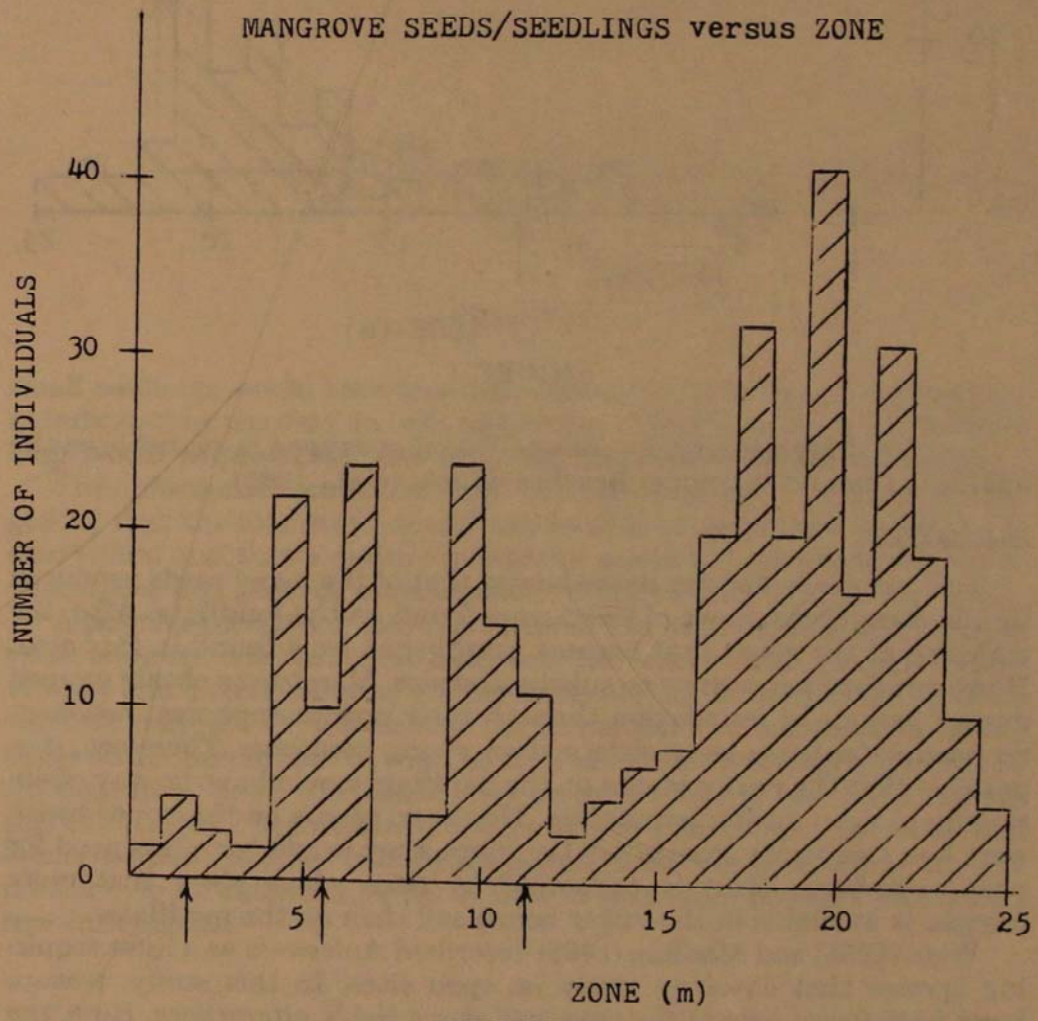


FIGURE 3

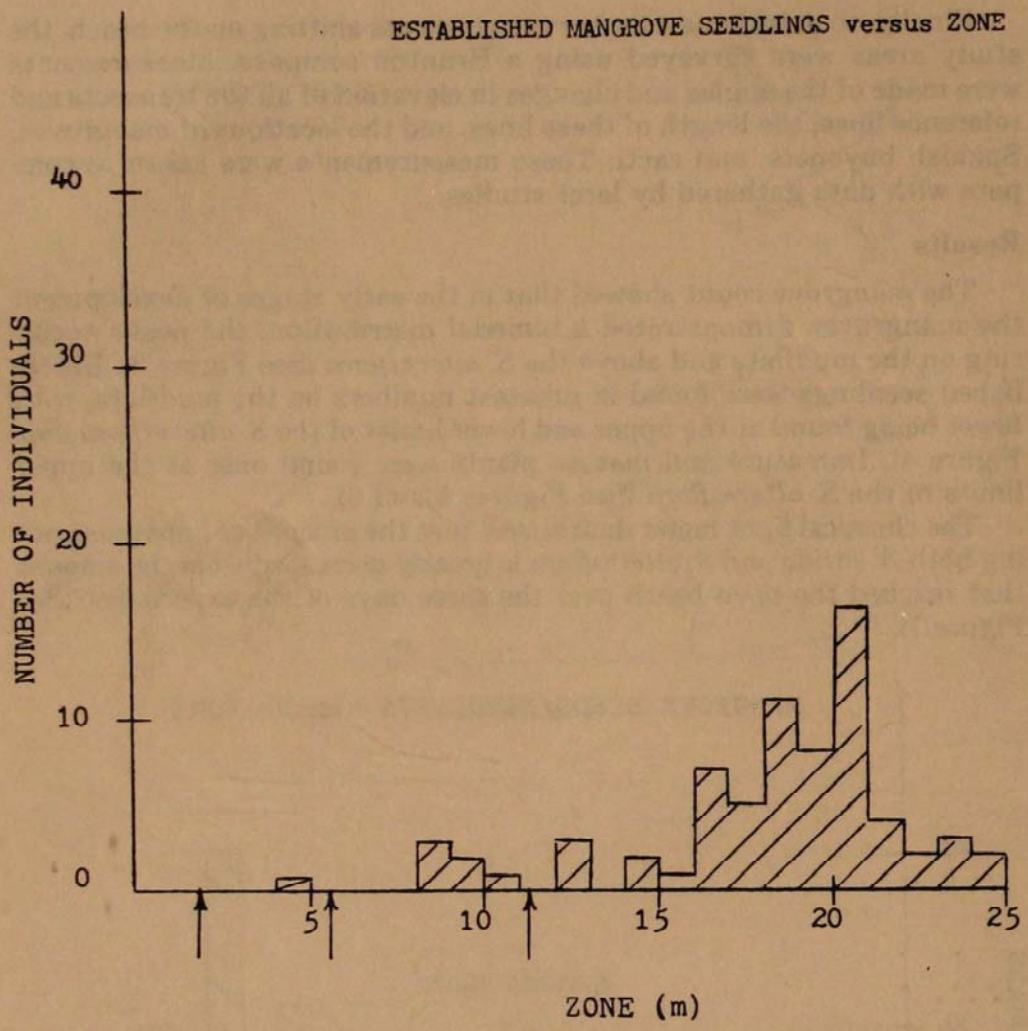


FIGURE 4

Tests of dissolved oxygen showed that less oxygen is available on the mudflats than on the upper beaches (Huck, et al., 1981).

Discussion

The mangrove density data showed that of the many seeds produced by the mangroves, most of them were found on the mudflats. Also, the majority of the seeds that became established were found in this area. However, they never grew to substantial size. Mangroves obtain oxygen during periods of inundation through their pneumatophores; however, no pneumatophores were observed on young seedlings. Therefore, it is possible that the young plants on the mudflats would have no way of obtaining oxygen during inundation. However, plants on the upper beach were less frequently inundated; therefore, they would have less need for pneumatophores. This is supported by data which show that more oxygen is available in the upper beach soil than on the mudflats.

West (1956) and MacRae (1963) described *Avicennia* as a light requiring species that develops nicely on open sites. In this study, mature trees were found only in the area just above the *S. alterniflora.* Here, the

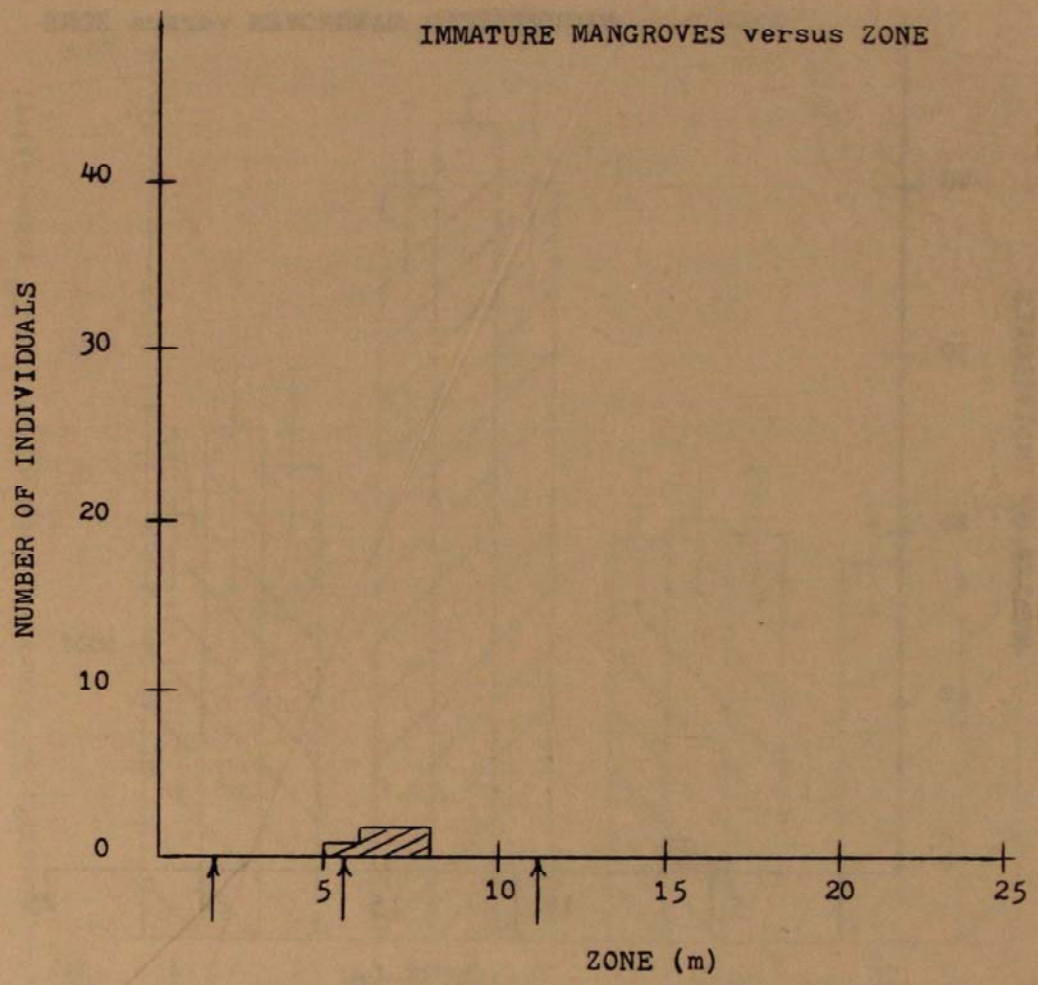


FIGURE 5

small seedlings would have less competition for light from *S. alterniflora*, as indicated by the data on light penetration (See Figure 7). Also, the seedlings would be protected from tidal and wave action by the cord grass.

The information obtained from the chemical light meter also suggested that the mangrove would not be able to germinate under the *S. alterniflora* and that a mature mangrove would in turn shade out the *S. alterniflora* and prevent establishment of its own seedlings.

A positive correlation between currents and sand drifting was found to exist; however, it is difficult to determine the mean annual average current velocity and direction during a short study period. Data collected on these currents may tell us more about the formation and maintenance of the coves on the beach; that is, whether they are static, growing, shrinking, or shifting up or down the beach. Two procedures could be used to obtain this information: subsequent surveys of the area to compare cove and beach positions to those initially measured, or the use of recording current meters over an extended period of time to give more accurate yearly current information.

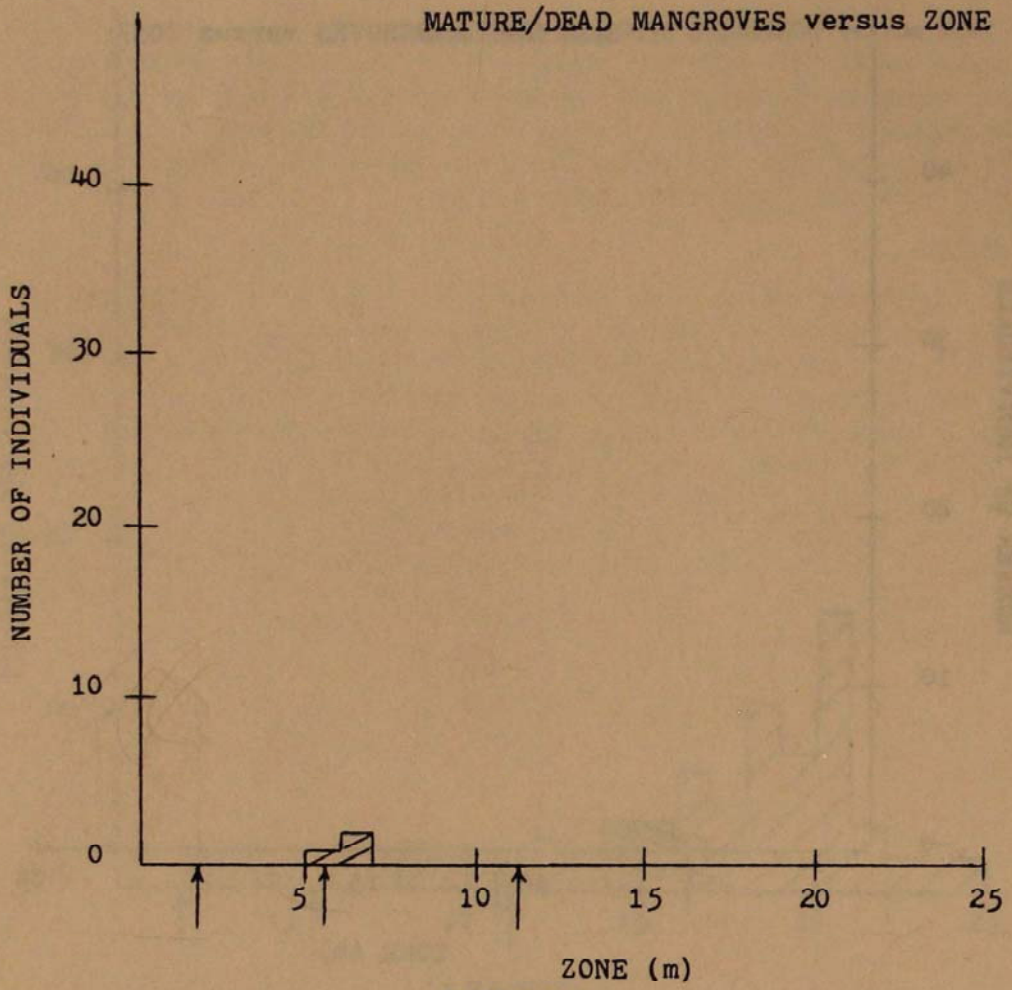


FIGURE 6

Conclusion

The data supports the hypothesis that reciprocal succession of *S. alterniflora* and *A. nitida* is occurring on Seahorse Key. Empiricial observations suggest that if a mangrove dies, either a cove is formed or the area is invaded by *S. alterniflora.* Long term studies have been begun that should determine the accuracy of these observations.

Many questions remain to be answered. The difference in the two beaches and the formation of a point where they meet may be explained by long term studies on the mean current velocities. Also, a nonvegetated sand beach exists between the *S. alterniflora* zone and the *S. paten* zone. Tolerance tests on both species for factors such as salinity, inundation, pH, and soil nutrients, compared to actual soil parameters; should provide some insight into this problem.

Literature Cited

1. Huck, et al. "Intertidal Zone Study," Group Study Project for Seashore Ecology, Davis and Elkins College, 1981.
2. MacRae, W. "Mangrove Swamps in South Africa," *Journal of Ecology,* 51, 1-25. 1963.

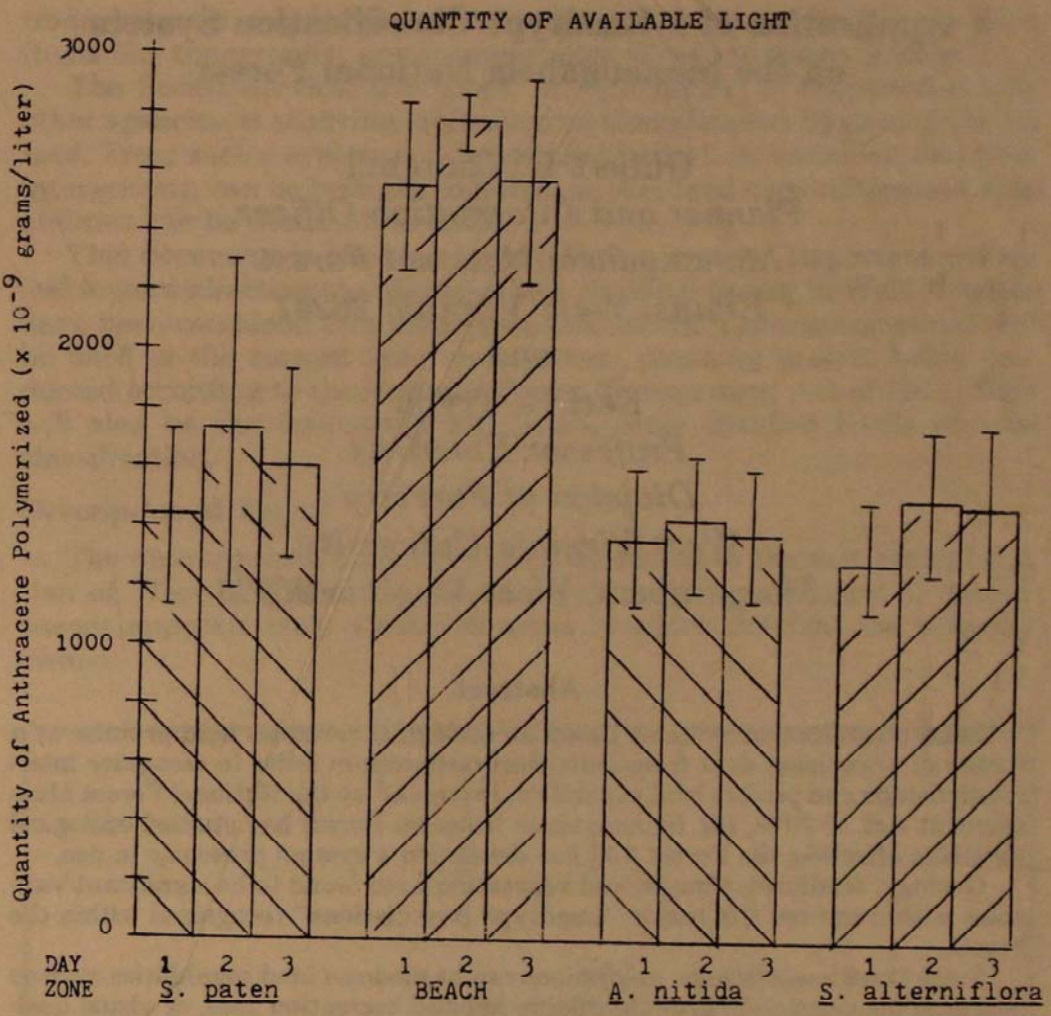


FIGURE 7

3. Marquis, David A., and Yelenosky, George. "A Chemical Light Meter for Forest Research." 25 pp. USFS Report. 1967.
4. West, R.C. "Mangrove Swamps of the Pacific Coast of Columbia," *Ann. Amer. Geog. Assoc.* 46, 98-121. 1956.

Application of a Landtype Classification System on the Monongahela National Forest

Gilbert B. Churchill
Planner and Information Officer
Monongahela National Forest
Elkins, West Virginia 26241
and
Earl H. Tryon
Professor Emeritus
Division of Forestry
West Virginia University
Morgantown, West Virginia 26506

Abstract

Land classification systems based on ecological variables hold promise as a means of organizing data from individual resources in order to recognize interrelationships and predict land capability. Prompted by the National Forest Management Act of 1976, the Monongahela National Forest has studied ecological variables affecting the Forest and has developed a system presently in use.

Geology, landform, climate, and vegetation were found to be significant variables within the ten (10) major "Landtype Associations" recognized within the Forest.

From these associations, predictions can be made on land capabilities such as potential for vegetation growth, wildlife habitat, recreation uses, or visual quality. Water yield and quality can also be predicted as well as the potential of an area to support intensive uses such as road or building construction.

The Forest Landtype Associations will become the basis for studying land capabilities in the evolving Monongahela National Forest Land Management Plan and are expected to become the foundations for future land classifications based on local and specific variables.

The ecological classification system offers significant advantages to decision makers by predetermining land capabilities, in lieu of more traditional approaches of collecting data from several disciplines and integrating them for decision making. The objective is to improve the ability of the forest managers to designate projects in well suited areas.

Introduction

Information about land and its resources is an essential, and often expensive element of planning. Traditional inventory systems for resources like timber or soil contain only part of the data needed. They do not facilitate interpretations based on the interactions of ecological factors.

For example, a timber data base may provide information on wood available for harvest. A soil data base may reveal limitations for road building. Deciding if the area is suitable for commercial timber opera-

tions, however, requires information from both these sources plus other items like topography, scenic importance or risk to water quality.

The Forest Service, U.S. Dept. of Agriculture, in cooperation with other agencies, is studying an Ecological Classification System (ECS) for land. From such a system it is hoped that important variables, and their interactions, can be brought together so that land capabilities and suitabilities can be better understood.

This document is one step toward such a system. Important ecological factors affecting the Monongahela National Forest in West Virginia have been combined into landtype associations. These associations will be used in the current land management planning project being conducted according to the National Forest Management Act of 1976. They will also be the framework for future, more detailed levels of land classification.

Description of Forest

The Monongahela National Forest is located in the east central portion of West Virginia. The boundary of the Forest (Figure 1) encompasses approximately 1,650,900 acres of which 850,000 are federally owned.

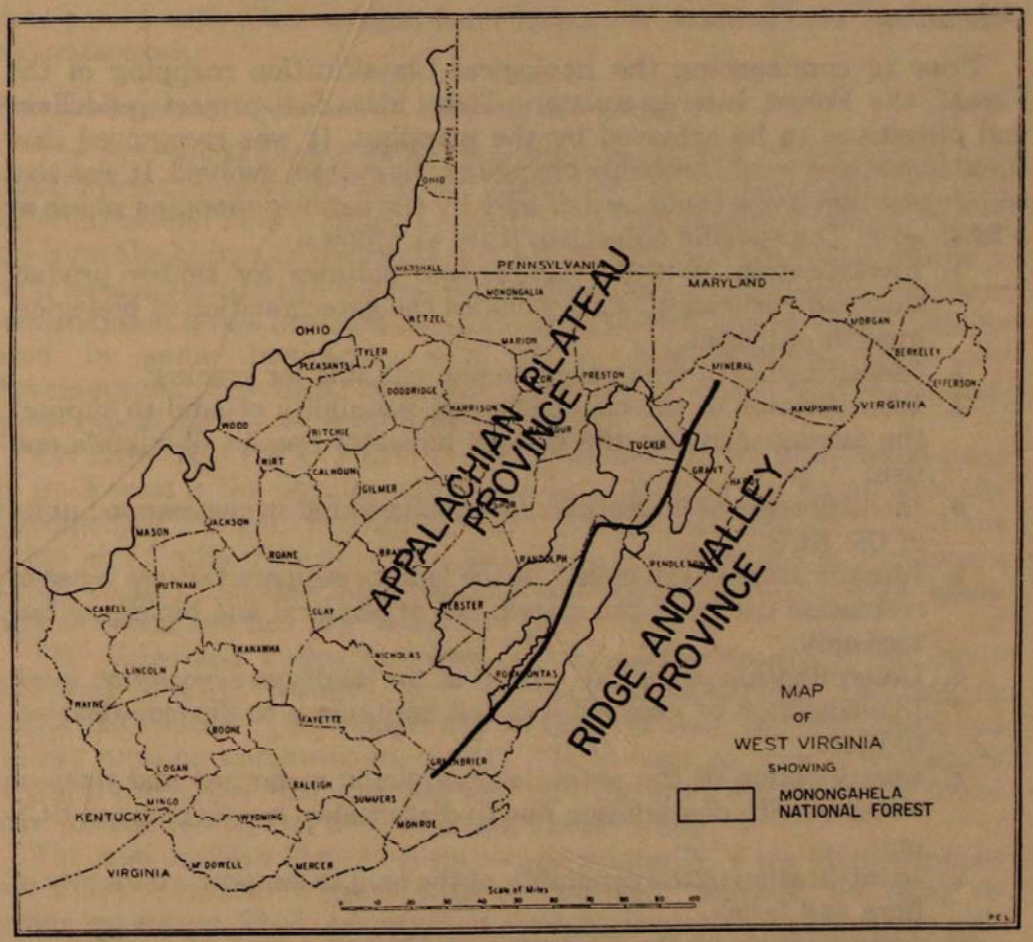


FIGURE 1. Map of Monongahela National Forest and Physiographic Province.

Bedrock ranges from strongly folded and faulted in the eastern portion to slightly folded in the west.

Landform is variable. It ranges from long ridges with steep slopes, wide alluvial bottoms and a trellis drainage pattern to broad rolling uplands and dissected mountainous areas with dendritic drainage. Elevations range from approximately 1,100 to 4,860 feet.

The soils are predominately ultisols, alfisols, and inceptisols formally of the red-yellow to gray-brown podzolic groups. Major timber types include northern hardwoods, Allegheny mixed hardwoods, central hardwoods, oak-hickory, and spruce.

Even though average productivity for tree growth is high, site quality varies significantly, even within short distances, and strongly contributes to high species diversity.

Temperatures, precipitation, and length of growing season are favorable for forest growth. Mean annual temperatures range from 39° to 54° F, Department of Commerce (1951-80). A "rain shadow" effect causes a precipitation range from 30″ to 60″ per year, Department of Commerce (1951-80). The average length of the growing season ranges from 140 to 160 days, USDA Yearbook of Agriculture (1941).

Project Methods

Objectives

Prior to commencing the Ecological Classification mapping of the Forest, the Forest Interdisciplinary Team identified project guidelines and objectives to be achieved by the mapping. It was recognized that these objectives would probably change as the system evolved. It was also recognized that some could be met only by the detailed mapping phase at a local level. The specific objectives were as follows:

1. Identification of lands capable and suitable for timber production and harvesting. This includes the determination of biological growth potential.
2. Identification of lands capable and suitable for grazing.
3. Identification of the capability and suitability of land to support the management for the various indicator species of wildlife and fish.
4. Identification of limitations for mining found in the mapped units of the ECS.
5. Identification of the ability of the land to support various types of recreation use from the standpoint of physical and biological factors only.
6. Determination of the fire hazard at the landtype association level.
7. Identification of geologic and soil limitations to development activities.
8. Identification of the potential hydrologic responses and risks of water quality degradation due to disturbance in any mapped ECS unit.
9. Identification of the capability of the land to support a diversity of flora and fauna.
10. Identification of the limitations for development of facilities including structures, recreation sites, and roads or trails.

11. Identification of most likely climax vegetation for each ECS unit. This may help determine timber management objectives for forest stands.
12. Identification of research needs for developing the ECS on the Monongahela National Forest.

The Ecological Classification System Evolution

Ecological Classification Systems, or Land Evaluation Classifications have been independently developed by other agencies and in other countries. Great differences have occurred between these systems because of ecological differences, the approaches of different scientists, and the influence of economic, social, or administrative variables. The Food and Agriculture Organization of the United Nations (FAO) is attempting to create a uniform system and the status of this work is presented in a bulletin entitled, "A Framework for Land Evolution."

In spite of the differences in approach, purpose, and personalities, there are common grounds among the various methods. First of all, the purpose is to gather and organize natural resource information for decision making, communication or inventory purposes. Secondly, the project is generally carried out on sparsely developed lands with difficult access. Thirdly, the project involves large areas and usually has a short time period with a low budget considering the detailed data needed for accurate work.

The Ecological Classification System Hierarchy

The Ecological Classification System used on the Monongahela National Forest involves dividing the Forest into similar ecological units at different levels. This is called a hierarchical classification system. In going from the higher to the lower stratification levels, the characteristics, such as site factors and vegetation, become more uniform. Three major stratification levels are used on the Forest, and two minor levels may be used in some instances. The major stratification levels are Physiographic Province, Landtype Association, and Ecological Landtype. The minor levels are Phase and Site.

PHYSIOGRAPHIC PROVINCE—The first and highest level used by the Forest is the physiographic province. Most of the Forest is in the Appalachian Plateau Province, with a smaller eastern portion in the Ridge and Valley Province. The provinces are described in Fenneman (1938). Figure 1 shows the Monongahela National Forest and the boundary between the two provinces.

The Ridge and Valley Province is composed primarily of the Devonian and Silurian Systems with the bedrock moderately to strongly folded and faulted. The topography consists of long, narrow ridges and valleys running northeast-southwest. The stream pattern is commonly of the trellis type. Precipitation and site qualities are generally lower than for the rest of the Monongahela Forest lands.

The Appalachian Plateau is composed primarily of the Mississippian and Pennsylvanian Systems with sedimentary bedrock, flat-lying or somewhat folded. The topography is variable from broad flat, gently rolling uplands to long narrow ridge lines which are highly dissected. The

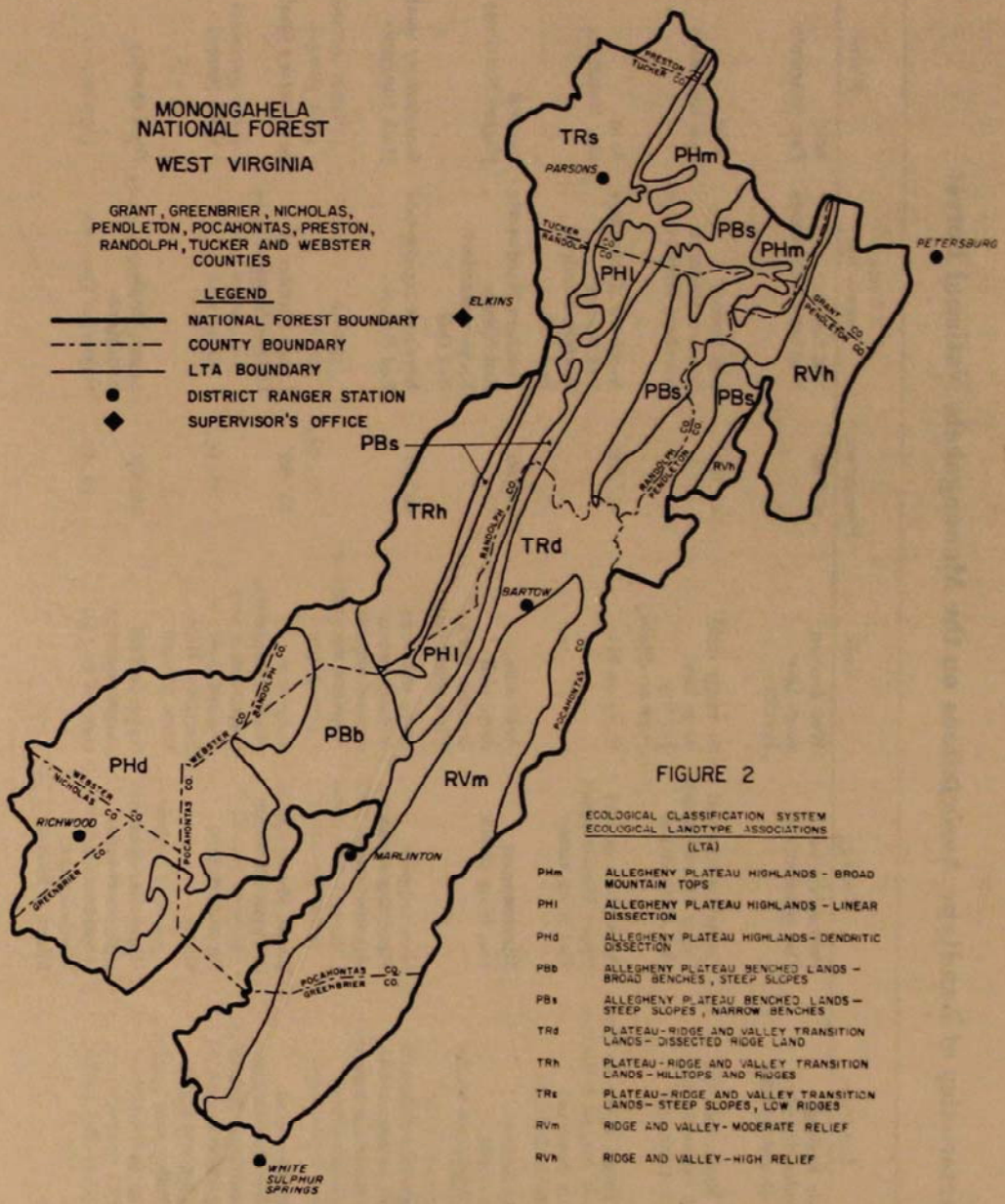


FIGURE 2

The capability ratings of uses by Landtype Associations are presented in Table 2.

In Table 2 each use was rated on a scale from 1 to 10, with 10 being highest. The rating of each potential use was made by the appropriate Forest scientist, and is independent of the ratings of the other uses considered. Thus, the ratings between uses are not necessarily comparable as some are based on data of different types, and some are subjective by necessity. In addition, the considerable variability within associations compounds the rating problem.

The last column, Sensitivity to Intensive Use, differs from the others in that it is related to use only but not to biological productivity. It is based mainly on soil erodibility.

drainage pattern is predominantly dendritic. Elevations, precipitation, and site quality are also variable, but generally are high. Portions of this province are transition in landform and geology between the two provinces.

LANDTYPE ASSOCIATION (LTA)—Each Province is divided into homogeneous ecological units called Landtype Associations. Major factors involved, and interrelated, in distinguishing the different Landtype Associations are:

Landform—including elevation, relief, degree of dissection, and geomorphic process;
Geology and Soils;
Climate—especially precipitation;
Dominant Vegetation—especially climax species.

Ten Landtype Associations have been identified on the Forest and are shown on the map in Figure 2.

ECOLOGICAL LANDTYPE (ELT)—The lowest major stratification level will be the Ecological Landtype which is important in project planning on the Forest. The Landtype Associations will be divided into many smaller units called Ecological Landtypes. These units are much more uniform with respect to ecological factors than are the associations. The size of the ELT's are expected to range from about 30 to well over 1,000 acres.

PHASE—Phase involves an area within an Ecological Landtype where environmental factors are different from the rest of the ELT, but is too small in area to classify as a separate ELT. For example, nine acres of wet land could be included with 400 acres of well-drained land in a single ELT. A phase or phases may, or may not, occur within an ELT.

SITE—Site is the smallest unit in the hierarchy, often being as small as one acre or even less, especially on this National Forest where variation is great and changes are constantly occurring within short distances. Environmental factors and vegetation are fundamentally uniform within a site. Generally these small units are not mapped and would be used only for very detailed project planning.

Results

The Landtype Association (LTA's)

Ten Landtype Associations have been identified, mapped, and described for the Forest. Table 1 summarizes these LTA's, however the reader is urged to obtain a copy of the full descriptions if any applications of the system are contemplated. Gross summaries have been made to create Table 1.

Capability of Landtype Associations

Capability is defined by the Eastern Region Forest Service Handbook, November, 1979, as the "ability of a unit of land to produce resources, respond to impacts or changes, and allow resource use under specific management activities usually expressed as interpretations for uses, production, or potential impact." The capability of a commodity, such as timber, or a use, such as recreation, refers to the average productivity of each Landtype Association for that product or use.

Table 1. Characteristics of Landtype Associations on the Monongahela National Forest

LTA Name	*Acreage*	*Landform*	*Geology*	*Soils*	*Precipitation*	*Climax Vegetation*	*Water*
Allegheny Plateau Highlands with Broad Mountain tops (PHm)	59,770	Gently Rolling, Irregular drainage, Flat Mountain tops	Pennsylvanian Flat lying strata	Well drained, deep, Low Fertility	45"-60"	Red Spruce Northern Hardwoods	Acid Few Nutrients
Allegheny Plateau Highlands with Linear Dissection (PHl)	105,350	Flat Mountain tops Steep escarpments Linear Drainage	Pennsylvanian and Upper Mississippian Flat lying strata	Strongly Acid, deep, Low Ferility, High erodibility	45"-60"	Red Spruce Eastern Hemlock Northern Hardwoods	Acid Few Nutrients
Allegheny Plateau Highlands with Dendritic Dissection (PHd)	307,760	Few Broad Mountain Tops Narrow Ridges & Bottom Highly dissected Dendritic drainage	Pennsylvanian and Upper Mississippian Flat lying strata	Same as PHe	45"-60"	Northern Hardwoods Red Spruce Eastern Hemlock Red Oak	Acid Few Nutrients
Allegheny Plateau Bench lands— Broad benches and steep slopes (PBb)	117,130	Broad benches steep slopes high Mountain knobs	Mississippian Flat lying strata	Acid soils, deep, well drained, Rocky, High erodibility	45"-60"	Northern Hardwoods Red Spruce Eastern Hemlock Red Oak	Neutral Higher Nutrients
Allegheny Plateau Bench lands— Narrow benches & steep slopes (PBs)	168,530	Long, steep dissected Mountain slopes with high Mountain benches High depressional areas	Mississippian Flat lying strata often out crops	Some wet bogs in deep, poorly drained soil. Alluvium occurs	45"-60"	Northern Hardwoods Red Spruce	Satisfactory Quality High Nutrients
Plateau—Ridge & Valley transition— Dissected Ridges (TRd)	320,530	Highly dissected Narrow, Rounded, & discontinuous Ridges. Long, steep slopes dendritic and trellis drainage	Lower Mississippian & Upper Devonian Strongly folded strata	Very Acid Medium texture deep, well drained, Low Fertility, High Rock content	45"-60"	Large Number of Climax Species	Satisfactory Quality
Plateau—Ridge & Valley transition— Hilltops & Ridges (TRh)	67,950	Similar to TRd	Upper Devonian with Narrow outcrops from Lower Mississippian, folded & faulted	Same as TRd except low rock content	35"-60"	Sugar Maple Red Maple Oaks	High Quality

Table 1—*Continued*

Plateau—Ridge & Valley transition—steep slopes, Low Ridges (TRs)	133,950	"exceedingly rough" highly dissected, short, steep slopes, discontinuous Ridges dendritic drainage	Chemung Group, & Hampshire strata of Devonian, folded & faulted	Same as TRd alluvial in bottoms	45"-60"	Eastern Hemlock Oaks Northern Hardwoods	Satisfactory
Ridge & Valley Moderate Relief (RVm)	251,070	Long broken Ridges running NE-SW, steep slopes, escarpments common	Devonian and Silurian strongly folded & faulted	Wide Range of Properties, well drained, Medium Texture	35"-60"	Mixed Oak Red Maple Eastern White Pine	High Quality High Nutrients
Ridge & Valley High relief (RVh)	118,910	Sharp ridges with wide alluvial bottoms, NE-SW long Ridges, steep sloped, escarpments common, trellis drainage	Lower Devonian, Silurian and Upper Ordivician strongly folded and faulted	Like RVm High Rock Content talus and out-crop common	35"-45"	Oaks Hickory	High Quality Highest Nutrients

Table 2. Capability Rating of Uses by Landtype Associations[1]

Association Symbol	*Timber*	*Wildlife[2]* *Animals*	*Fish*	*Forage Production*	*Water* *Yield*	*Quality*	*General Recreation*	*Visual Quality*	*Sensitivity to Intensive Use[3]*
PHm	4	5	1	4	5	3	9	8	7
PHl	6	9	2	3	7	4	9	6	5
PHd	9	10	5	3	6	4	10	6	6
PBb	7	6	7	10	6	6	7	6	9
PBs	5	6	5	9	5	5	10	8	10
TRs	6	7	7	4	5	9	7	4	4
TRd	9	10	10	5	4	9	9	6	1
TRh	7	7	7	6	4	10	6	4	3
RVh	2	8	7	3	5	8	10	10	2
RVm	5	8	3	3	5	6	9	6	3

[1]Ratings: 10 = high, 1 = low
[2]Based on primary species. This refers to Featured Species identified in the Monongahela National Forest Plan.
[3]Based on erodibility and mass slide.

Suitability of Landtype Associations

Suitability as well as capability needs to be known for forest areas before determining their proper uses. Whereas capability refers to the ability of an area to produce; suitability; as defined by the Eastern Region Handbook, November, 1979, and as used here, is the "Appropriateness or acceptability of specified management activities for application to a given unit of land." In this instance, suitability of an area for management practices may be determined by factors of any kind as physical, biological, or political which may hinder or enhance these practices. For example, an area may have moderately high productivity or capability, but the presence of an erodible, limestone soil on a steep slope would tend to reduce the suitability of the area for practices requiring road building and intensive land use.

The suitability ratings of the uses for the Landtype Associations are presented in Table 3.

The criteria for rating the suitability of the Landtype Associations for the various uses follow:

Timber—Erodibility of soil, and slope steepness are major criteria.

Wildlife—Considered here are mainly land use impacts and adequacy of land for hunting and fishing.

Grazing—Soil erodibility, slope steepness, and availability of open land are major considerations.

Water Quality—The criteria used are water quality (measured and predicted from geologic strata) and water temperature for desirable cold-water fisheries habitat.

General Recreation—Based on relationship to natural attractions such as streams, rock formation and other scenic qualities. Also slope, vegetation, soil erodibility, availability of drinking water and flood risk were factors regarding recreation.

The ratings for each use were made independently, and again are not necessarily comparable. For each use the ratings between Landtype Associations are mainly subjective.

Table 3. Suitability Rating of Uses by Landtype Associations[1]

Association Symbol	*Timber*	*Wildlife*		*Grazing*	*Water Quality*	*General Recreation*
		Animals	*Fish*			
PHm	4	4	1	5	5	8
PHl	5	4	2	1	6	8
PHd	8	7	5	2	4	7
PBb	3	5	8	9	3	4
PBs	4	4	4	8	4	7
TRs	6	4	7	1	7	6
TRd	10	9	9	3	7	7
TRh	6	7	6	4	8	4
RVh	2	7	7	4	10	9
RVm	6	6	4	4	8	7

[1]Ratings: 10 = high, 1 = low

Discussion

The LTA Mapping and Interpretations are now in use to give Forest personnel a general view of the capability and suitability of land to support certain types of activity. As examples, the Landtype Association TRd in the central Middle Mountain area shows especially high suitability ratings for timber and wildlife. Landtype Association RVh in the Northeast corner of the forest shows high ratings for recreation, wildlife, and water quality, but is low for timber. These interpretations are valuable in determining the priority of projects proposed. Other items being equal, it would be logical to locate trail opportunities in RVh and make timber stand improvement investments in TRd.

The Landtype Associations are now being used by the Monongahela National Forest staff to help define areas to be analyzed in the Forest Planning Process. Prescriptions for managing an area, the costs to implement them, and the commodity outputs from them vary by LTA. By using the LTA system of classification, the forest can better analyze the economic efficiency of various types of work and can do a better job of applying practices where they are best suited.

An added benefit of mapping the Forest LTA's will be realized when the more specific mapping of Ecological Landtypes occur. The framework exists now for such future expansion of the system into the definition of specific subtypes.

Acknowledgments

The development of the Ecological Classification System is a project of the Interdisciplinary Team on the Monongahela National Forest.

The Team members follow: Gilbert B. Churchill, Chairman, Forest Planner; Harvey E. Fleming, Forest Silviculturist; William J. Kerr, Forest Landscape Architect; June McMillan, Director, Cranberry Mtn. Visitor Center; Thomas R. Manley, Forest Geologist; Paul Myers, Forest Preconstruction Engineer; Arnold F. Schulz, Forest Wildlife Biologist; Linton Wright, Jr., Forest Soil Scientist.

Former Interdisciplinary Team members: Dain Maddox, Forest Hydrologist; Frank W. Hahnenberg, Forest Soil Scientist.

Others are: Hugh Cunningham, Forest Soil Scientist; Delmer C. Stott, Zone Range Specialist; Joseph Tekel, Recreation VIS Planner; Earl H. Tryon, Ecologist and Coordinator of ECS Project.

Literature Cited

1. Brooks, A.B. 1911. Forestry and Wood Industries. West Virginia Geological Survey 5:xvi + 481 p. Acme Publishing Co., Morgantown, WV.
2. Chang, Mingteh, and Lee, Richard. 1975. Snowfall distribution in West Virginia. West Virginia Agriculture and Forestry 6(2):5-8.
3. Clarkson, Roy B. 1966. The vascular flora of the Monongahela National Forest, West Virginia. Castanea 31:1-119.
4. Department of Commerce. (1951-80). Yearly Climatological Data. West Virginia. NOAA.
5. Doolittle, W.T. 1958. Site index comparisons for several forest species in the southern Appalachians. Proc. Soil Science Soc. America 22:455-458.
6. Fenneman, N.M. 1938. Physiography of the Eastern United States. McGraw-Hill Book Co., Inc., New York, xiii + 714 p., illustration.

7. Food and Agriculture Organization of the United Nations. 1976. A framework for land evaluation. Soils Bulletin 32, FAO. Rome, vii + 72 pp.
8. MacLean, D.A., and R. W. Wein, 1976. Biomass of jack pine and mixed hardwood stands in northeastern New Brunswick. Canadian Jour. of Forest Res. 6:441-447.
9. Monongahela National Forest, 1982. Report on Landtype Associations of the Ecological Classification System. Unpublished. Elkins, WV. 69 pp.
10. Platts, William S., 1980. A plea for fishery habitat classification. Fisheries 5:2-6.
11. Smalley, Glendon W. 1979. Classification and evaluation of forest sites on the Southern Cumberland Plateau. USDA, Forest Service. General Tech. Report SO-23. 59 pp.
12. Society of American Foresters, 1980. Forest Cover Types of the United States and Canada. Washington, D.C. vi + 148 pp.
13. U.S. Forest Service Handbook, 1979. Eastern Region Land and Resource Management Planning Handbook. FSH 1909.21 56 pp. (mimeo.)
14. USDA Yearbook of Agriculture. 1941. Climate and Man. xii + 1248 pp.
15. Wendt, G.E., R.A. Thompson, and K.N. Larson, 1975. Land systems inventory, Boise National Forest, Idaho. USDA, Forest Service. Intermountain Region. Ogden, Utah. viii + 54 pp.
16. Wertz, W.A., and J.F. Arnold. 1972. Land systems inventory. USDA, Forest Service, Intermountain Region. Ogden, Utah. 12 pp.

Low pH Tolerance Under Laboratory Conditions of the Nymphs of Three Congeneric Mayflies, *Baetisca berneri, B. carolina,* and *B. lacustris.*

Donald C. Tarter, Dwight L. Chaffee, and
Kimberly B. Benson
Department of Biological Sciences
Marshall University
Huntington, West Virginia 25701

Abstract

The nymphal populations of the mayflies *Baetisca berneri* Tarter and Kirchner, *B. carolina* Traver and *B. lacustris* McDunnough were experimentally tested under laboratory conditions to determine their tolerance to low pH. The straight-line graphical interpolation method was employed to determine the pH values at which 50 percent of the mayflies survived after 96 hours. The medium tolerance limit at 96 hours (TL_m^{96}) pH values were 3.6, 3.5 and 3.2 for *B. lacustris, B. carolina,* and *B. berneri,* respectively.

1955. 1977). *Baetisca berneri* is known only from Virginia and West Virginia (Tarter and Kirchner, 1978).

Generally, the nymphs of *Baetisca* spp. are found in small to moderate-sized streams. They live partially buried in sand, silt and gravel.

Materials and Methods

One-hundred and twenty nymphs of *Baetisca lacustris* and *B. berneri* were collected from Laurel Fork, Mingo County, West Virginia, and 120 nymphs of *B. carolina* were collected from Panther Creek, Nicholas County, West Virginia. They were returned to the laboratory for observation and acclimation over a 12-hour period. Ten nymphs of each species were carefully placed in each of six small bowls which contained the following pH values: 7.0, 6.0, 5.0, 4.0, 3.0 and 2.0. Each bowl contained natural substrate and an air stone. A Model 5 Corning Scientific pH meter was employed to establish the various pH values using dilutions of sulfuric acid. The range of temperature was from 14 to 17 C. A replicate experiment was performed for each species.

The 96-hour TL_m (median tolerance limit) test (Standard Methods, A.P.H.A.I., 1965) was employed as the measure of acute toxicity to low pH. A straight-line graphical interpolation method along with a linear regression technique were used to determine the pH value at which approximately 50 percent of the mayfly nymphs survived after 96 hours.

Results and Discussion

Under laboratory conditions, the mayfly nymphs of *Baetisca lacustris*, *B. carolina* and *B. berneri* showed 96-hour TL_m pH values of 3.6, 3.5 and 3.2, respectively (Table 1 and Figures 1-3). According to these results, the nymphs of *B. berneri* are slightly more tolerant to low pH than the nymphs of *B. lacustris* and *B. carolina*. In all three *Baetisca* species, less than 50 percent of the nymphs survived below a pH of 3.0 (Table 1), and only 65 percent of the nymphs of *B. carolina* survived at a pH value of 5.0.

Bell and Nebeker (1969) recorded laboratory TL_m^{96} pH values of 4.65 and 3.32 for *Ephemerella subvaria* McDunnough and *Stenonema rubrum*

Table 1. Experimental Data From Laboratory Tests of Selected pH Values on Nymphs of *Baetisca* spp. A = *B. lacustris*, B = *B. berneri* and C = *B. carolina*

	Number of Nymphs			*Percent Survival (after 96 hours)*		
pH	*A*	*B*	*C*	*A*	*B*	*C*
7.0	20	20	20	100	100	100
6.0	20	20	20	100	95	90
5.0	20	20	20	90	95	65
4.0	20	20	20	80	95	60
3.0	20	20	20	0	35	40
2.0	20	20	20	0	0	0
TL_m^{96}	Estimated by interpolation			3.6	3.2	3.5
	Estimated by linear regression			4.1	3.7	4.0

Introduction

Acid mine drainage is a major water pollution problem in the Appalachian region (Biesecher, 1966) and most of the continental United States (Jones, 1951; Nemerow, 1971; and Brezina et al., 1972). Each year active and abandoned mines release thousands of tons of sulfuric acid, iron, and manganese, silt and heavy metals into drainage basins in West Virginia. It has been conservatively estimated that damages from acid mine drainage pollution in the Upper Ohio River basin exceeds 10 million dollars annually (USDI, 1968). Generally, acid mine drainage alters or destroys the aquatic food web and wildlife habitat.

Several authors, including Jewell (1922), Lackey (1938), Parsons (1952), Parsons (1968), Brezina et al. (1972), Nichols and Bulow (1973), Letterman and Mitsch (1978) and Tolbert and Vaughn (1979), have reported the reduction or elimination of the benthic macroinvertebrates by acid mine drainage. Hoehn and Sizemore (1977) noted that the benthic diversity was reduced to zero in a small Virginia stream polluted by acid mine drainage (pH 3.0 to 3.6). In a stream marginally polluted by acid strip mine drainage, the Shannon Weaver index was reduced from 3.10 (pH = 6.0) to 1.95 (pH = 4.8) (Tomkiewicz and Dunson, 1977). In Roaring Creek, a tributary of the Tygart Valley River near Elkins, West Virginia, there were 12 or fewer taxa of benthic macroinvertebrates at stations with median pH values below 3.8 (Warner, 1971). At stations with median pH values of 4.5 or higher, there were 25 or more taxa of benthic macroinvertebrates. Tomkiewicz and Dunson (1977) found 13-15 taxa at pH values between 4.8 and 5.0. Stress, caused by changes in dissolved oxygen and pH or concomitant with increases in iron and sulfates, led to a decrease in the number of taxa of ephemeropterans, plecopterans and coleopterans in Redstone Creek in southwestern Pennsylvania (Moon and Lucostic, 1979).

Various authors, including Traver (1931), Berner (1940, 1955), Schneider and Berner (1963), Pescador and Peters (1971, 1974), Lehmkuhl (1972), Tarter and Kirchner (1978), Chaffee and Tarter (1979) and Morris et al. (1980), have reported studies on the taxonomy and ecology of the genus *Baetisca*. The life history and ecology of *B. bajkovi* (=*B. lacustris*) and *B. berneri* have been investigated by Chaffee and Tarter (1979) and Morris et al. (1980), respectively. However, no information was found on the laboratory tolerance of nymphs to low pH.

The primary objective of this investigation was to determine the effects of low pH, under laboratory conditions, on the nymphs of three congeneric mayflies, *Baetisca berneri*, *B. carolina* and *B. lacustris*.

Taxonomy and Distribution

The family Baetiscidae is endemic to North America and contains the genus *Baetisca*. Presently, thirteen species of *Baetisca* are recorded from North America (Edmunds et al., 1976 and Tarter and Kirchner, 1978). The distribution of *B. lacustris* includes Alberta, Manitoba, Saskatchewan in Canada, and Illinois, Indiana, Minnesota, Missouri, Tennessee, West Virginia and Wisconsin in United States (Hilsenhoff, 1970; Lehmkuhl, 1972; and Pescador and Peters, 1974). *Baetisca carolina* is known from Georgia, North Carolina, Tennessee, West Virginia and Quebec (Berner,

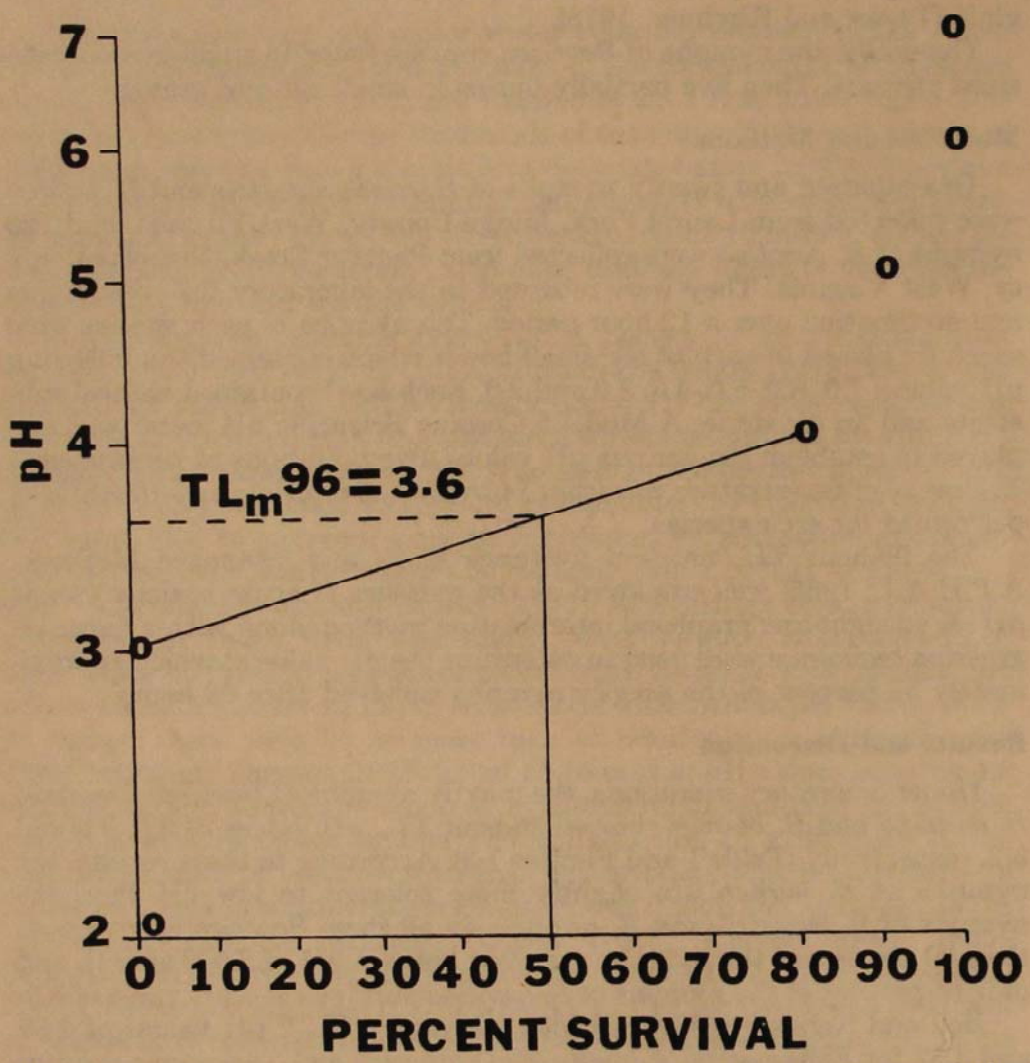


FIGURE 1. Estimation of the median tolerance limit of pH, using straight-line graphical interpolation, on *Baetisca lacustris* nymphs.

McDunnough, respectively. Kimmel and Hales (1973) recorded the laboratory 96-hour TL_m pH value of 3.31 for *Stenonema* sp. Gaufin (1973) recorded the following laboratory TL_m^{96} mean pH values for selected ephemeropterans: *Ephemerella doddsi*, pH = 5.13 (4.95-5.35); *Leptophlebia* sp., pH = 5.21 (5.11-5.30); *Hexagenia limbata*, pH = 5.90 (5.40-6.40); and *Heptagenia* sp., pH = 6.18 (6.11-6.25).

Warner (1971) noted the following pH ranges for ephemeropterans found in Roaring Creek, an acid mine tributary of the Tygart Valley River in West Virginia: *Ameletus*, pH = 4.9 to 5.7; *Ephemerella*, pH = 4.5 to 5.7; *Hexagenia*, pH = 4.5 to 5.7; *Epeorus*, pH = 5.1 to 5.7; *Paraleptophlebia*, pH = 4.5 to 5.7; and *Stenonema*, pH = 4.5 to 5.7. Berner (1950) recorded the nymphs of *Stenonema smithae* from a pH range of 4.0 to 7.8. The genera *Stenonema*, *Baetis* and *Paraleptophlebia* were collected in a naturally acid stream (pH = 4.5 and 5.0) by Bick et al. (1953).

Based on stream studies in the genus *Baetisca*, Hubbard and Peters (1978) reported nymphs of *B. bajkovi* (= *B. lacustris*) and *B. escambiensis*

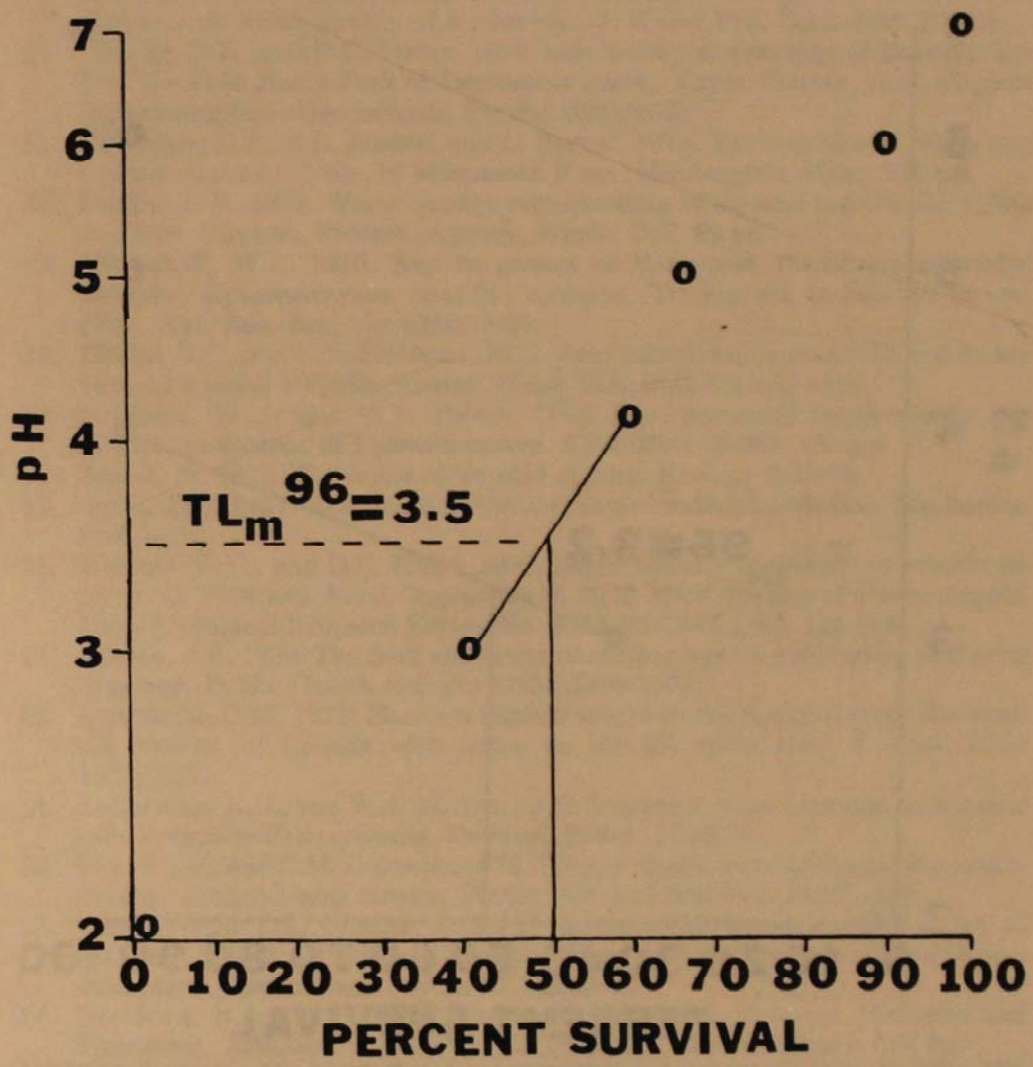


FIGURE 2. Estimation of the median tolerance limt of pH, using straight-line graphical interpolation, on *Baetisca carolina* nymphs.

are alkaliphilous (occurring at pH 7.0-8.5), while the nymphs of *B. obesa* and *B. rogersi* are acidophilous (occurring at pH 5.5-7.0). Nymphs of *B. becki* are acidobiontic (occurring at pH below 5.5).

Based on stream studies, the nymphs of *Baetisca* spp. show a wide tolerance for pH (below 5.5-8.5). While the nymphs of *Baetisca lacustris* are normally alkaliphilous, our laboratory TL_m^{96} pH values indicate they can be acidobiontic. Other than the genus *Stenonema*, the laboratory studies on other genera of mayflies show a higher TL_m^{96} pH value than *Baetisca* spp. The large mesonotal shield covering the gills may provide protection for the *Baetisca* nymphs. Additionally, the nymphs bury in sand, silt and gravel.

Acknowledgments

The authors are grateful to Ms. Vickie Crager for typing the manuscript. Also, we thank Dr. Dean Adkins, Marshall University, for making suggestions on the manuscript.

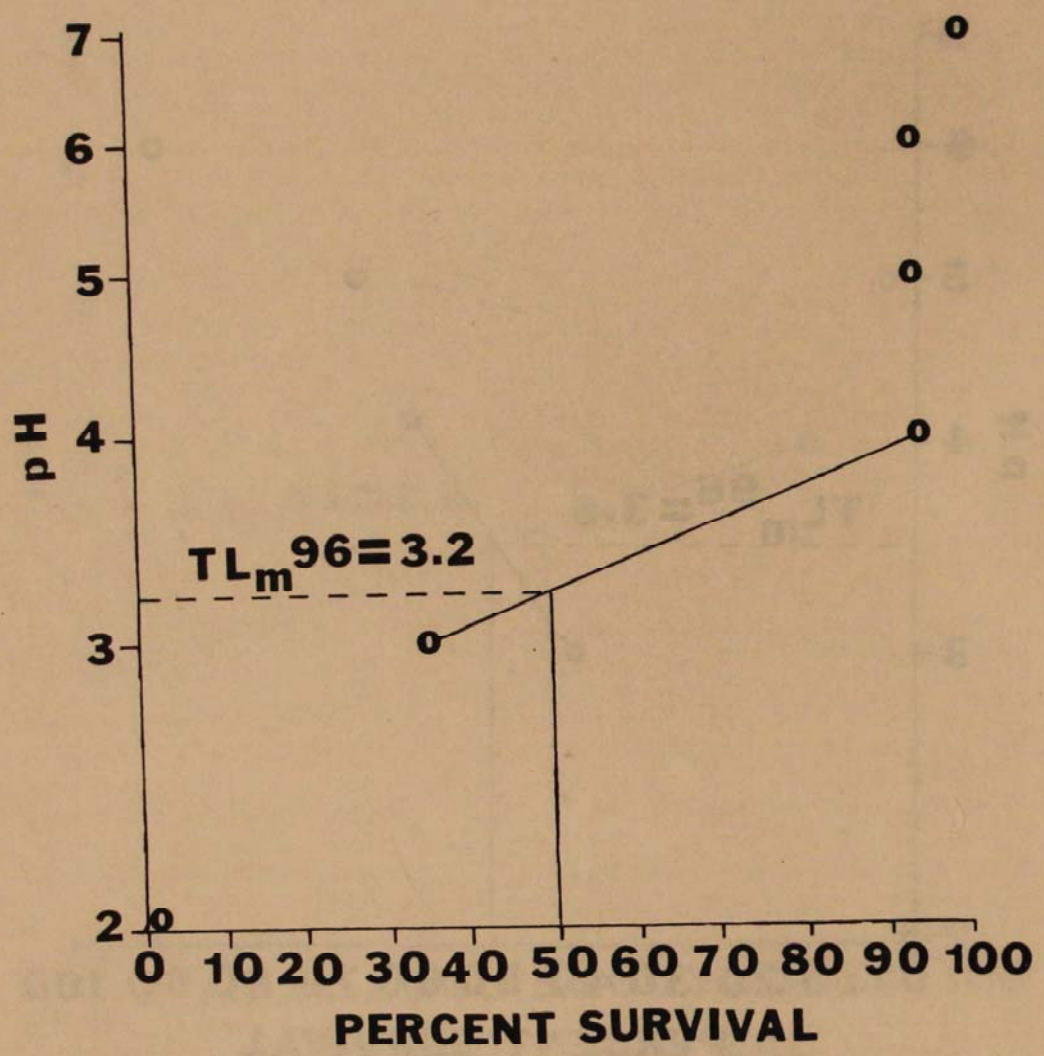


FIGURE 3. Estimation of the median tolerance limit of pH, using straight-line graphical interpolation, on *Baetisca berneri* nymphs.

Literature Cited

1. American Public Health Association, Inc. 1965. Standard Methods for the Examination of Water and Wastewater (12th ed.). New York, N.Y. 744 pp.
2. Bell, H.L., and A. V. Nebeker. 1969. Preliminary studies on the tolerance of aquatic insects to low pH. J. Kans. Ent. Soc. 42:230-236.
3. Berner, L. 1940. *Baetisca rogersi*, a new mayfly from northern Florida. Can. Ent. 62:156-160.
4. ———. 1950. The mayflies of Florida. Univ. Fla. Studies, Biol. Sci. Series 4:1-267.
5. ———. 1955. The southeastern species of *Baetisca* (Ephemeroptera: Baetiscidae). Quart. J. Fla. Acad. Sci. 18:1-19.
6. ———. 1977. Distributional patterns of southeastern mayflies (Ephemeroptera). Bull. Fla. State Mus., Biol. Sci. 22(1):1-56.
7. Bick, G.H., L.E. Hornuff, and E.N. Lambremont. 1953. An ecological reconnaissance of a naturally acid stream in southern Louisiana. J. Tenn. Acad. Sci. 28(3):221-231.
8. Biesecker, J.E. 1966. Stream quality in Appalachia as related to coal mine drainage. Circ. U.S. Geol. Surv. No. 526.

9. Brezina, E.R., R.C. Campbell, and J.R. Whitley. 1972. Effects of acid mine drainage on water quality of a reservoir. J. Water Poll. Cont. Fed. 4:1429.
10. Chaffee, D.L., and D.C. Tarter. 1979. Life history and ecology of *Baetisca bajkovi* Neave in Beech Fork of Twelvepole Creek, Wayne County, West Virginia (Ephemeroptera: Baetiscidae). Psyche 86(1):53-61.
11. Edmunds, G.F., S.L. Jensen, and L. Berner. 1976. The mayflies of North and Central America. Univ. of Minnesota Press, Minneapolis, Minn. 330 pp.
12. Gaufin, A.R. 1973. Water quality requirements of aquatic insects. EPA-600/3-72-004. Environ. Protect. Agency, Wash., D.C. 89 pp.
13. Hilsenhoff, W.L. 1970. Key to genera of Wisconsin Plecoptera (stonefly) nymphs, Ephemeroptera (mayfly) nymphs, Trichoptera (caddisfly) larvae. Dept. Nat. Res. Rep. No. 67(3):18-37.
14. Hoehn, R.C., and D.R. Sizemore. 1977. Acid mined drainage (AMD) and its impact on a small Virginia stream. Water Res. Bull. 13(1):153-160.
15. Hubbard, M.D., and W.L. Peters. 1978. Environmental requirements and pollution tolerance of Ephemeroptera. EPA-600/4-78-061. 461 pp.
16. Jewell, M. 1922. The fauna of an acid stream. Ecology 3:22-28.
17. Jones, D.C. 1951. Acid mine water, its control reduced pollution. Mechanization 15:10.
18. Kimmel, W.G., and D.C. Hales. 1973. Acute toxicity of low pH to aquatic insects. *In* Fish and Food Organisms in Acid Mine Waters of Pennsylvania. EPA Ecological Research Series, No. EPA-R3-73-032, pp. 125-158.
19. Lackey, J.B. 1938. The flora and fauna of surface waters polluted by acid mine drainage. Public Health Reports 53(34):1499-1507.
20. Lehmkuhl, D.M. 1972. *Baetisca* (Ephemeroptera: Baetiscidae) from the western interior of Canada with notes on the life cycle. Can. J. Zool. 50(7): 1015-1017.
21. Letterman, R.D., and W.J. Mitsch. 1978. Impact of mine drainage on a mountain stream in Pennsylvania. Environ. Pollut. 17:53-73.
22. Moon, T.C., and C.M. Lucostic. 1979. Effects of acid mine drainage on a southwestern Pennsylvania stream. Water, Air, and Soil Poll. 11:377-390.
23. Morris, W.R., D.L. Chaffee, and D.C. Tarter. 1980. Ecological life history of *Baetisca berneri* Tarter and Kirchner from a West Virginia stream (Ephemeroptera: Baetiscidae). Psyche 87(1-2):39-47.
24. Nemerow, N.L. 1971. Liquid Wastes of Industries: Theories, Practices and Treatment. Addison-Wesley Pub. Co., Reading, Massachusetts. 584 pp.
25. Nichols, L.E., Jr., and F.J. Bulow. 1973. Effects of acid mine drainage on the stream ecosystem of the East Fork of the Obey River, Tennessee. J. Tenn. Acad. Sci. 48(1):30-39.
26. Parsons, J.D. 1968. The effects of pH acid-strip mine effluents on the ecology of a stream. Arch. Hydrobiol. 65(1):25-50.
27. Parsons, J.W. 1952. A biological approach to the study and control of acid mine pollution. J. Tenn. Acad. Sci. 27:304-310.
28. Pescador, M.L., and W.L. Peters. 1971. The imago of *Baetisca becki* Schneider and Berner. Fla. Ent. 54(4):329-334.
29. ———. 1974. The life history and ecology of *Baetisca rogersi* Berner (Ephemeroptera: Baetiscidae). Bull. Fla. State Mus. Biol. Ser. 17(3):151-209.
30. Schneider, R.F., and L. Berner. 1963. A new southeastern species of *Baetisca* (Ephemeroptera: Baetiscidae). Fla. Ent. 46:183-187.
31. Tarter, D.C., and R.F. Kirchner. 1978. A new species of *Baetisca* from West Virginia (Ephemeroptera: Baetiscidae). Ent. News 89(9-10):209-213.
32. Tolbert, V.R., and G.L. Vaughn. 1979. Stripmining as it relates to benthic insect communities and their recovery. Proc. W.Va. Acad. Sci. 51(3):168-181.
33. Tomkiewicz, S.M., and W.A. Dunson. 1977. Aquatic insect diversity and biomass in a stream marginally polluted by acid strip mine drainage. Water Res. 11:397-402.

34. Traver, J.R. 1931. The ephemerid genus *Baetisca*. J.N.Y. Ent. Soc. 39:45-66.
35. U.S. Department of Interior. 1968. Stream pollution by coal mine drainage in upper Ohio River basin. Federal Water Pollution Control Administration. Washington, D.C. 110 pp.
36. Warner, R.W. 1971. Distribution of biota in a stream polluted by acid mine drainage. Ohio J. Sci. 71(4):202-215.

A Preliminary Study of the Distribution and Ecology of Myxomycetes in the Forests of West Virginia[1]

Steven L. Stephenson
Department of Biology
Fairmont State College
Fairmont, West Virginia 26554

Abstract

To obtain data on the distribution and ecology of Myxomycetes in the forests of West Virginia, field collections were made from four different study sites during the period from 1977 to 1981. Forty-two taxa representing 16 genera were identified, including several species not previously reported from the state. Although most of the species encountered in the present study are considered to be cosmopolitan, only six were found at all four sites.

Introduction

The myxomycete flora of West Virginia has received relatively little attention (Millspaugh 1913; Gilbert 1929, 1935), although these organisms are particularly abundant in temperate forests such as those which characterize much of the state (Martin and Alexopoulos 1969). Moreover, while brief notes relating to the ecology of Myxomycetes (e.g., choice of substrate) have traditionally been included in taxonomic treatments of the group, ecological studies of these organisms are few (Alexopoulos 1963, Eliasson 1981). This paper presents the results of an investigation which was undertaken to add to our knowledge of the distribution and ecology of Myxomycetes in the forests of West Virginia.

Collection Sites

The following is a brief description of the location and vegetation of the four sites used in the present study:

[1]This study was supported in part by funds provided by a Fairmont State Foundation Faculty Development Grant.

1) Coopers Rock State Forest in Monongalia County; elevation 2100-2200 feet (640 to 670 m); mixed hardwoods (black cherry, yellow poplar, red oak, and red maple).

2) Kumbrabow State Forest in Randolph County; elevation 3200-3700 feet (975 to 1128 m); northern hardwoods (yellow birch, red maple, red oak, and hemlock).

3) Mill Fall Run (a privately owned wooded area just off Route 54-4) in Marion County, about 3.5 miles (5.6 km) west of Fairmont; elevation 1100-1250 feet (335 to 380 m); mixed hardwoods (red oak, red maple, white oak, and beech).

4) Murphy Preserve (a 276-acre tract owned by the Nature Conservancy) in Ritchie County, about 3 miles (4.8 km) south of Pennsboro; elevation 900-1000 feet (275 to 305 m); mixed oak-hickory.

Materials and Methods

Field collections of Myxomycetes were made from the four study sites during the period of 1977-1981. Each site was usually visited one to several times per year. However, there were some years in which it was not possible to visit all four sites. All visits were made in late summer and autumn (August-November), the period of the year when the fruiting bodies of Myxomycetes are generally considered to be most abundant. On each visit, collections were made of all specimens encountered in a representative portion of the study site. In addition, field observations were made of relative abundance, general patterns of distribution, and choice of substrate of the taxa collected.

Specimens collected in the field were returned to the laboratory, where identifications were made using the descriptions and keys provided in 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.

The four sites were compared using Sorensen's Index of Similarity (1948), which has the formula $S = 2c/a + b \bullet 100$ where "a" is the number of species at one site, "b" is the number at a second site, and "c" is the number of species common to both sites. The index ranges from 0, if the two sites have no species in common, to 100 if all species are shared in common.

Results and Discussion

Forty-two taxa representing 16 genera were identified (Table 1). All of these are represented by specimens which had fruited in the field under natural conditions. Other studies of Myxomycetes have used moist chamber cultures (Gilbert and Martin 1933) to supplement field collections (Evenson 1961, Blackwell and Gilbertson 1980, Mitchel et al. 1980). This technique was not used in the present study, although it will be included in future research. Although most of the taxa reported in this study are considered to be cosmopolitan, only six species were found at all six sites. *Arcyria denudata*, *Trichia favoginea*, *Hemitrichia calyculata*, and *Metatrichia vesparium* were the most commonly encountered species and can be regarded as major elements in the late summer and autumn display of Myxomycetes in the forests of West Virginia. The two other species re-

Table 1. Occurrence of Myxomycetes in the Four Study Areas

Taxa	*Coopers Rock*	*Kumbrabow*	*Mill Fall*	*Murphy Preserve*
Arcyria cinerea		X	X	
Arcyria denudata	X	X	X	X
Arcyria stipata	X		X	X
Badhamia capsulifera		X		
Badhamia utricularis		X		
Comatricha nigra	X		X	
Comatricha nodulifera	X			
Comatricha pulchella			X	
Comatricha typhoides				X
Comatricha sp.		X	X	
Cribraria argillacea	X	X		
Cribraria intricata			X	
Cribraria sp.			X	
Diderma floriforme	X			
Fuligo septica			X	X
Lamproderma arcyrionema	X			
Lycogala epidendrum	X	X	X	X
Metatrichia vesparium	X	X	X	X
Oligonema flavidum	X		X	X
Hemitrichia calyculata	X	X	X	X
Hemitrichia clavata	X	X	X	
Hemitrichia serpula	X	X	X	X
Perichaena chrysosperma			X	
Physarum auriscalpium			X	
Physarum globuliferum		X	X	
Physarum lateritium	X			
Physarum viride	X		X	
Physarum penetrale				X
Stemonitis axifera		X	X	
Stemonitis fusca	X		X	
Stemonitis splendens			X	X
Stemonitis sp.			X	X
Trichia botrytis			X	X
Trichia decipiens	X			
Trichia favoginea	X	X	X	X
Trichia floriformis		X		
Trichia scabra	X	X		X
Trichia varia	X			
Trichia sp.	X			
Tubifera casparyi		X		
Tubifera ferruginosa	X	X		
Tubifera microsperma			X	
Totals	22	18	26	15

corded from all four sites (*Lycogala epidendrum* and *Hemitrichia serpula*) were generally much less abundant. Most taxa had low constancy values. Nineteen (45%) were collected at only one of the four sites, and 12 (29%) were recorded from just two sites. The majority of the taxa recorded from just one site were represented by a single collection, but several (e.g., *Comatricha typhoides* and *Cribraria intricata*) were collected a number of times and in different years at the site in question. Several of the taxa represented by a single collection (e.g., *Comatricha nodulifera* and *Tubifera casparyi*) are relatively uncommon and have not previously been reported from the state. These and other additions to the myxomycete flora of West Virginia will be considered in a future paper.

The majority of the specimens collected were found on rotten wood (59% of all collections), but fruiting bodies also occurred on dead bark (27%), mixtures of dead wood and bark (11%), and litter (3%). Approximately 11% of all collections were made from areas of wood or bark on which mosses were present. In about 11% of all collections, two or more species occurred in a small area on the same substrate. This would at least suggest that favorable microhabitats available for growth and fruiting are rather limited and that the requirements for different taxa do overlap.

Indices of similarity for the paired study sites are presented in Table 2. These data indicate that the Mill Fall Run and Murphy Preserve sites are the most similar, whereas the Kumbrabow State Forest and Murphy Preserve sites are the least similar. Since the latter sites occur at the highest and lowest elevations sampled and the former sites are the two which are closest in elevation, a composition gradient related to elevation is at least suggested. Cavender (1980), who studied the distribution of cellular slime molds (a group of organisms with an ecological role and habitat requirements somewhat similar to those of Myxomycetes) in the Southern Appalachians, found that these organisms respond to environmental factors produced by differences in elevation. However, such studies of Myxomycetes are lacking. Cavender also noted the greatest diversity (i.e., number of species) of cellular slime molds occurred at intermediate elevations (between 590 and 820 m for the sites he studied). As shown in Table 1, the numbers of taxa recorded from the four sites in the present study would support such a pattern (i.e., highest diversity at middle elevations) for Myxomycetes. In both cases, of course, the data are rather limited. 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 West Virginia.

Table 2. Indices of Similarity For the Four Study Sites

Paired study sites	*No. of shared species*	*Index of similarity*
Murphy Preserve/Mill Fall	12	59
Murphy Preserve/Coopers Rock	9	49
Murphy Preserve/Kumbrabow	7	42
Mill Fall/Coopers Rock	12	50
Mill Fall/Kumbrabow	11	50
Coopers Rock/Kumbrabow	10	50

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 Gregory W. Hott, Peggy A. Romeo, Gregory W. St. Pierre, Richard H. Wade, and my wife, Barbara, all of whom helped with the field work.

Literature Cited

1. Alexopoulos, C.J. 1963. The Myxomycetes II. Bot. Rev. 29:1-78.
2. Blackwell, M., and R.L. Gilbertson. 1980. Sonoran Desert Myxomycetes. Mycotaxon 11:139-149.
3. Cavender, J.C. 1980. Cellular slime molds of the southern Appalachians. Mycologia 72:55-63.
4. Eliasson, U. 1981. Patterns of occurrence of Myxomycetes in a spruce forest in south Sweden. Holarctic Ecology 4:20-31.
5. Evenson, A.E. 1961. A preliminary report of the Myxomycetes of southern Arizona. Mycologia 53:137-144.
6. Gilbert, F.A. 1929. A preliminary report of the slime molds of West Virginia. Proc. W.Va. Acad. Sci. 3:71-73.
7. ———. 1935. Additions to the slime-mold flora of West Virginia: I. Proc. W.Va. Acad. Sci. 8:38-39.
8. Gilbert, H.C., and G.W. Martin. 1933. Myxomycetes found on the bark of living trees. Univ. Iowa Stud. Nat. Hist. 15:3-8.
9. Martin, G.W., and C.J. Alexopoulos. 1969. The Myxomycetes. Univ. Iowa Press, Iowa City. 560 pp.
10. Millspaugh, C.F. 1913. The living flora of West Virginia. W.Va. Geological Survey, Wheeling. 491 pp.
11. Mitchel, D.H., S.W. Chapman, and M.L. Farr. 1980. Notes on Colorado Fungi IV: Myxomycetes. Mycotaxon 10:299-349.
12. Sorensen, T. 1948. A method of establishing groups of equal amplitude in plant sociology based on similarity of species content. Det Kong. Danske Vidensk. Selsk. Biol. Skr. (Copenhagen) 5:1-34.

Fall 1981 Mercury Levels in Water, Sediments and Fish in the Monongahela River Near Fairmont, West Virginia

Donald G. Kain, J. E. Fisher, and J. E. Schmidt
Division of Water Resources
WV Department of Natural Resources
1201 Greenbrier Street
Charleston, West Virginia 25311

Abstract

Water, sediment, and fish samples were collected from the Monongahela River System near Fairmont, West Virginia in October 1981. Water and sedi-

ments were collected at nine sites in the river, while fish were taken in five areas of the drainage.

Water, sediments, and fish were found to contain measurable amounts of mercury. Mercury levels of 0.1 ug/1 were found in two of nine water samples, with all other below this amount (analytical restrictions did not allow quantitative measurement of mercury below 0.1 ug/1). Measurable mercury levels in sediment samples ranged from 0.04-0.10 mg/kg. Fish samples contained up to 0.58 mg/kg mercury, with most samples far below this level.

Water sample analysis indicated that low to moderate levels of mercury exist in the Monongahela River. Levels in most fish tissue samples were considered low. In general, higher mercury levels were found in top predator species than in the suckers. Fillets typically contained more mercury per unit weight than whole fish of a given species. Mercury is likely to remain in the system for some time as it finds its way from the sediments into the water and aquatic organisms.

Introduction

In recent years there has been increased awareness and concern over mercury contamination of the environment. Mercury can be found in several forms, ranging from elemental to dissolved inorganic and organic species. The alkyl (methyl and ethylmercury) forms are the most toxic, followed in toxicity by metal mercury vapor, and inorganic mercury salts (Lambou 1972). Alkyl and metallic vapor forms have an affinity for nervous tissue and therefore produce bizarre, and sometimes permanent, neurological symptoms in victims.

Any form of mercury in the environment has the potential to become highly hazardous, as inorganic and organic mercury can be readily converted to methyl and dimethylmercury under naturally occurring conditions. Mercury has a strong tendency to accumulate in sediments and organisms, and its removal from the environment is a complex, long-term problem.

While a limited amount of mercury may be emitted from natural ore bodies, the problem is largely man-induced. Notable discharges result from chlor-alkali production, application of pesticides, fuel burning, waste incineration, ore refining, and paint manufacture and use. Typical point sources include chlorine plants, pulp and paper mills, hospitals, dental clinics, fossil fuel plants, and sewage treatment plants. Mercury can be discharged either directly into soil or water or released as vapor into the air to rain out or fall out elsewhere.

During the late sixties and early seventies fish from many states' waters were found to contain mercury levels in excess of the U.S. Food and Drug Administration's (FDA) interim action level of 0.5 mg/kg. These discoveries caused widespread alarm and brought about restrictions or closures of a number of sport and commercial fisheries across the country. Commercial fishing on the West Virginia portion of the Ohio River was banned in 1970 and remained closed until 1973, when mercury levels in fish dropped following a reduction of mercury discharges into the river. During the same period, officials in West Virginia became concerned over significant mercury levels in Monongahela River fish, although fishing has never been restricted in the system. The Monongahela River, along with other West Virginia waters, is presently monitored at least annually for an array of substances, including mercury.

In March 1981, personnel from Division of Water Resources of the West Virginia Department of Natural Resources (WVDNR) found substantial levels of mercury in the effluent from Westinghouse Electric Corporation's glass and lamp plant in Fairmont, West Virginia. As a follow-up in July 1981, members of Wildlife Resources Division (WVDNR) collected whole fish (4 channel catfish, 3 walleye, and 4 white sucker) from the Monongahela River near Westinghouse for analysis. Whole fish composite samples of each species were found to contain levels of mercury above the state criterion of 0.5 ug/g (0.5 mg/kg) (West Virginia Water Resources Board 1980). Thus, a more intensive investigation of the Monongahela River system near the Westinghouse site was conducted. In October 1981, WVDNR personnel collected water, sediment, and fish samples from the Monongahela River basin in an effort to determine the extent of mercury contamination. This report deals with the results of that investigation.

Area Description

The Monongahela River is formed by the confluence of the West Fork and Tygart Valley Rivers in Fairmont, West Virginia, and extends northward 128.7 mi to Pittsburgh, Pennsylvania. The basin is spread over the Appalachian Plateau and the Allegheny Mountains and drains a total of 7,340 mi^2. The Principal sub-basins are the West Fork, Tygart Valley, and Cheat River basins. The climate of the area is temperate with mild summers and cold winters. Principal economic activities are coal mining, timber production, and agriculture (West Virginia Department of Natural Resources 1976).

Water quality problems in the Monongahela Basin are primarily associated with coal mining operations and population centers. In the last 100 years, coal mining has caused the amount of acid, sediment, sulfates, iron, manganese, and hardness to increase in streams in the basin. The largest contributors of acidity in the basin are abandoned underground mines (West Virginia Department of Natural Resources 1980).

Population centers are generally confined to narrow valleys associated with streams that do not have the capacity to assimilate large waste loads. Thus, high levels of wastewater treatment are required.

This investigation was centered on the lower portion of the western half of the Monongahela Basin, including the West Fork River near Clarksburg, West Virginia, Tygart Lake, a 1750 acre impoundment at Tygart Valley River Mile 22.5, and the Monongahela River from Fairmont to Morgantown, West Virginia (Figure 1). This area is typically less rugged than the eastern half of the basin and is characterized by highly eroded rolling hills. Stream velocities and gradients are generally low. The cities of Clarksburg, Fairmont, and Morgantown are major industrial and urban centers. There is extensive water-based recreation in the study area, particularly in Tygart Lake and the Monongahela River. Sport fishing is very productive, with walleye, the black basses (smallmouth and largemouth), and channel catfish the most sought-after species.

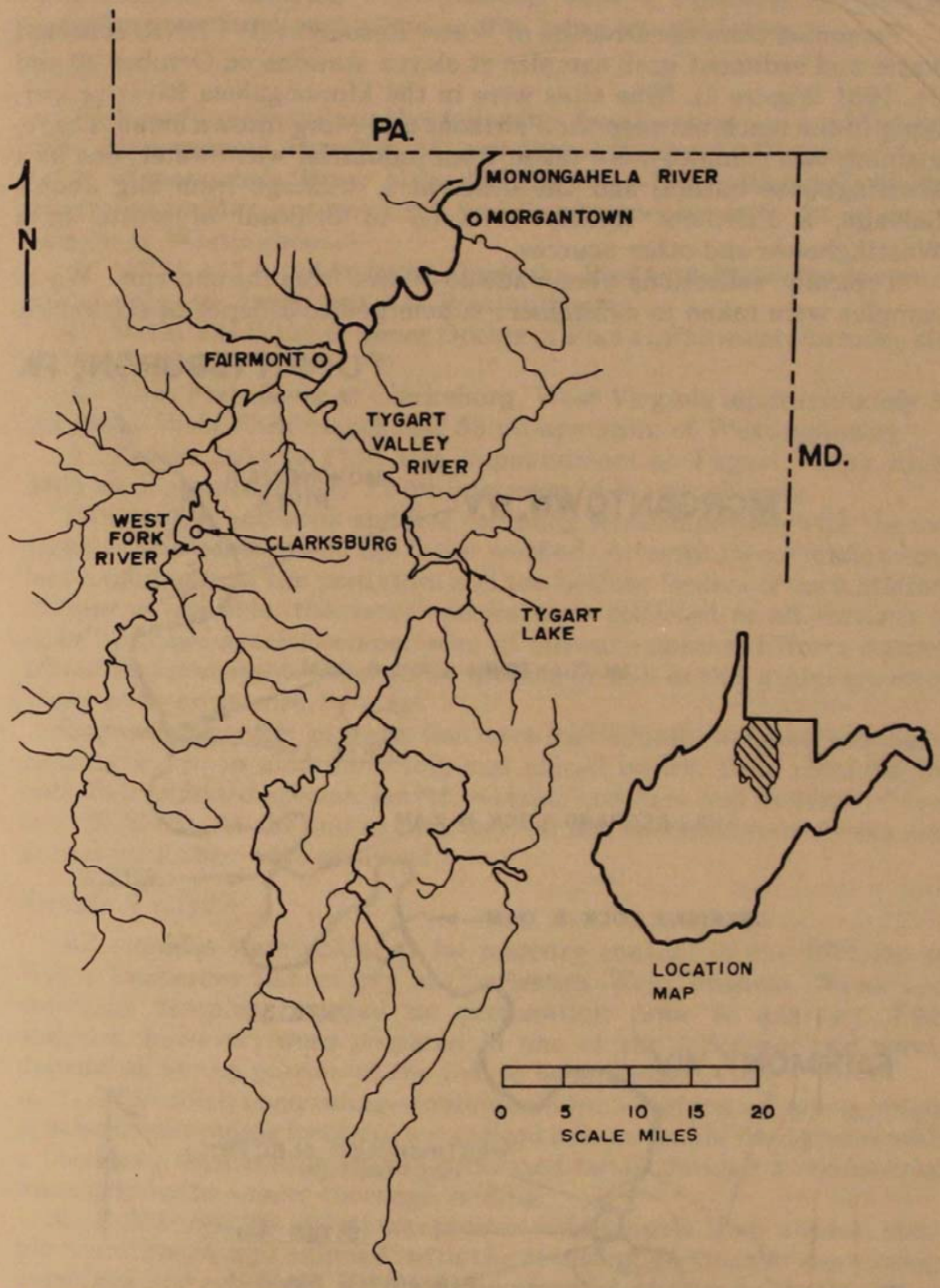


FIGURE 1. Map of Study Area for Fall 1981 Monongahela River Mercury Survey.

Materials and Methods

Sample Collection

Water, sediment, and fish samples were collected in October 1981 as follows:

Water and Sediment

Personnel from the Division of Water Resources (WVDNR) collected water and sediment grab samples at eleven stations on October 20 and 21, 1981 (Figure 2). Nine sites were in the Monongahela River proper, lying in the reach between the Fairmont and Morgantown areas. The remaining two samples were taken from industrial wastewater; one at a Westinghouse outfall, and the other at a drainage from Big John's Salvage, a Fairmont facility involved in disposal of waste from Westinghouse and other sources.

Typically, collections were made 25-50 feet from the shoreline. Water samples were taken in cubitainers submerged to a depth of six inches,

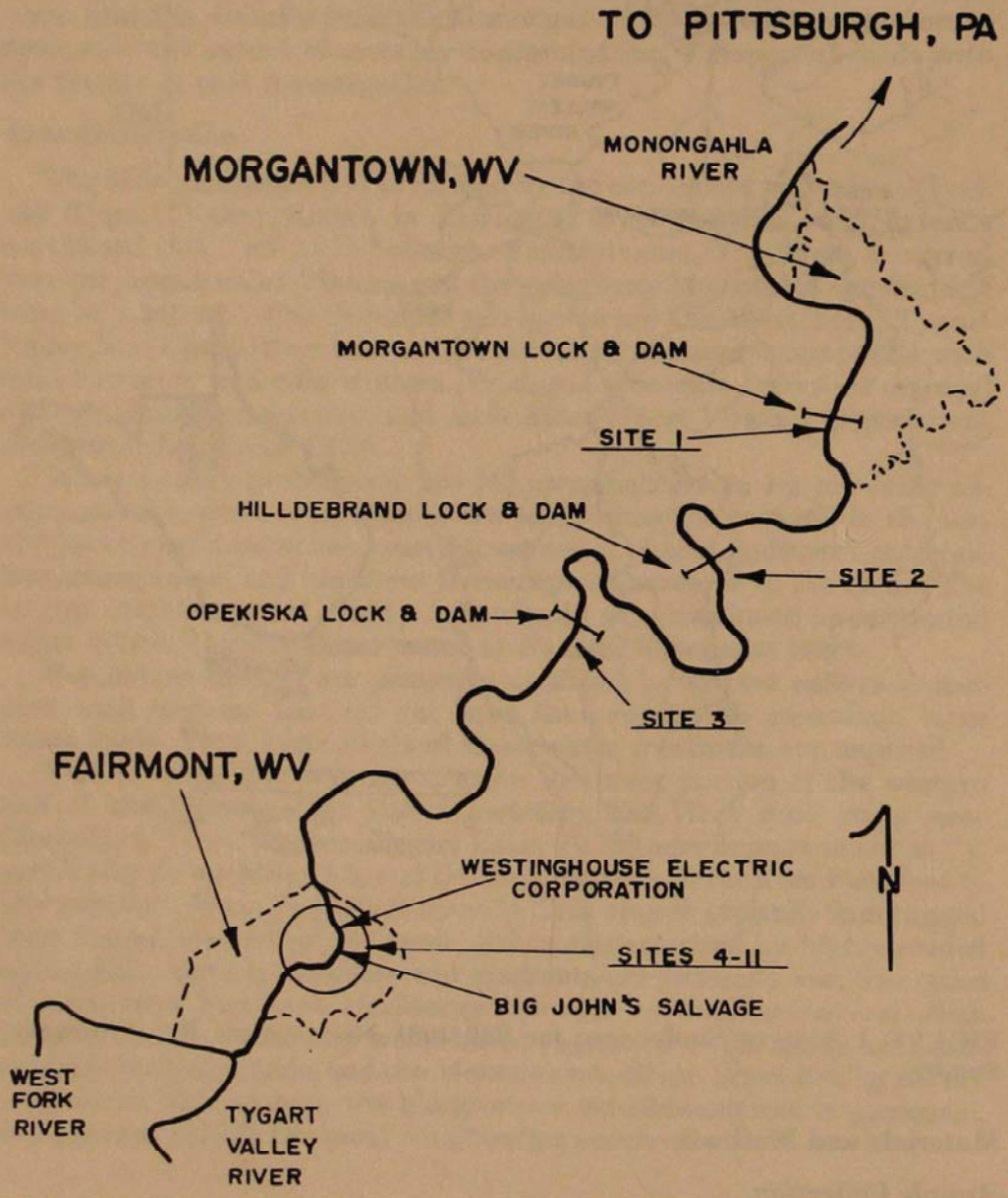


FIGURE 2. Water and Sediment Sample Sites for Fall 1981 Monongahela River Mercury Survey.

and sediment samples were grabbed with a Peterson Dredge. All samples were fixed with nitric acid to bring the pH below 2.

Fish

Fish were collected at the following five locations in mid-October 1981 by personnel from Wildlife and Water Resources Divisions:

1. Monongahela River Miles (MRM) 101.2-102.0: Westover Bridge upstream to Morgantown Lock and Dam (approximately 23 mi downstream of Westinghouse).
2. MRM 115.3-116.8: lower Opekiska Pool and Tailwater (approximately nine mi downstream of Westinghouse).
3. MRM 124.0-127.0: upper Opekiska Pool at Fairmont (includes site of Westinghouse Plant).
4. West Fork River at Clarksburg, West Virginia (approximately 31 mi above West Fork mouth and 35 mi upstream of Westinghouse).
5. Tygart Lake (a 1750 acre impoundment at Tygart Valley River Mile 22.5, approximately 27 mi upstream of Westinghouse).

Gill-netting and hook and line sampling were employed, with the majority of fish captured by the latter method. Attempts were made to collect a minimum of ten predators and ten bottom feeders of each station. Whenever possible, the same species were collected at all stations in order to make spatial comparisons of mercury uptake. Efforts concentrated on harvestable-sized game species, as fish in this group are most likely to be consumed by man.

Immediately after capture, fish were individually weighed and measured, wrapped in aluminum foil, and placed on ice. Data recorded for each fish included species, length, weight, and date and location of capture (Table 1). At the end of each day, all fish collected were frozen and stored until they were analzyed.

Sample Analysis

All samples were analyzed for mercury content in the Division of Water Resources Laboratory in Charleston, West Virginia. Water and sediment samples required no preparation prior to analysis. Fish samples, however, were prepared in one of the following two ways, depending on the portion of the fish to be analyzed:

1. Whole fish composites—individuals from a given sample (a single species from a single location) were sliced into workable sized pieces with a bandsaw, then combined and processed twice through a commercial meat grinder to assure thorough mixing.
2. Edible portion (fillet) composites—individuals from a given sample were filleted and skinned, with the resulting portions of flesh being combined and run twice through a commercial grinder as above.

Laboratory analysis was in accordance with the U.S. Environmental Protection Agency (EPA) recommended methods (U.S. EPA 1977). Water, sediment, and fish samples were digested using sulfuric acid, nitric acid, and potassium permanganate, then autoclaved. Total mercury was determined with an atomic absorption spectrophotometer by the cold vapor method. Analytical equipment in the Charleston Water Resources Lab allowed mercury measurements as low as 0.1 ug/1 in water and 0.04 mg/kg in sediment and fish.

Table 1—*Continued*

Largemouth Bass (fillets)	11.0	0.72
	10.2	0.54
	8.0	0.26
	8.5	0.34
Channel Catfish (whole)	14.5	0.92
	16.2	1.34
	16.3	1.38
	15.1	1.30
	10.7	0.32
MRM 115.3-116.8		
White Sucker (whole)	15.8	1.78
	14.7	1.38
	17.5	2.10
	13.9	1.08
MRM 124.0-127.0		
Walleye (whole)	15.5	1.25
	15.8	1.14
	14.8	0.92
	13.3	0.90
	14.8	1.00
Walleye (fillets)	14.4	1.12
	15.9	1.26
	16.4	1.30
	15.8	1.26
	16.0	1.24
Largemouth Bass (fillets)	10.2	0.50
	11.5	0.52
Spotted Bass (fillets)	11.4	0.70
	8.4	0.39
	7.9	0.33
	10.5	0.56
Channel Catfish (fillets)	15.0	0.92
	17.7	1.96
	18.9	2.20
	21.0	2.90
MRM 124.0-127.0		
Redhorse (fillets)	15.6	1.46
	15.0	1.28
	15.7	1.86

Table 1. Individual Lengths (in.) and Weights (lb.) of Fish Collected for Fall 1981 Monongahela River Mercury Survey

Location and Species	*Length*	*Weight*
MRM 101.2-102.0		
Walleye (whole)	14.7	1.10
	14.5	1.08
	14.8	1.17
	15.7	1.44
	14.2	0.98
Walleye (fillets)	16.2	1.62
	16.5	1.59
	17.4	1.98
	16.5	1.48
	15.6	1.12
Smallmouth Bass (whole)	10.8	1.07
	10.8	0.64
	9.7	0.43
	6.9	0.16
Smallmouth Bass (fillets)	12.2	1.02
	13.3	1.17
	13.0	1.20
	12.0	0.79
	14.0	1.36
MRM 101.2-102.0		
Channel Catfish (fillets)	17.8	2.05
	17.4	2.05
	17.2	1.88
	17.6	1.78
	17.0	1.80
MRM 115.3-116.8		
(Walleye (whole)	15.0	1.22
	15.5	1.14
	13.6	0.88
	14.1	0.98
	14.3	0.90
Walleye (fillets	16.0	1.32
	16.5	1.52
	16.5	1.64
	18.4	1.82
	18.0	1.86

Table 1—*Continued.* Individual Lengths (in.) and Weights (lb.) of Fish Collected for Fall 1981 Monongahela River Mercury Survey

Location and Species	*Length*	*Weight*
West Fork River		
Largemouth Bass (fillets)	13.2	1.25
	10.2	0.50
White Crappie (fillets)	10.1	0.50
	9.2	0.31
	9.7	0.44
Redhorse (whole)	12.2	0.75
	13.4	0.87
	11.6	0.63
	11.9	0.69
	11.2	0.63
Redhorse (fillets)	14.6	1.19
	16.2	1.56
	15.5	1.25
	14.3	1.00
	14.0	1.06
White Sucker (whole)	12.5	0.70
	15.1	1.22
	13.9	1.16
	15.7	1.30
	15.5	1.50
Tygart Lake		
Walleye (whole)	11.5	0.25
	11.2	0.20
	12.1	0.34
	11.3	0.21
	11.3	0.22
Walleye (fillets)	14.1	0.60
	14.1	0.63
	13.5	0.52
	12.9	0.41
	12.8	0.38

Results and Discussion

Measurable levels of mercury were found in water, sediment, and fish samples. A breakdown is shown below.

Water and Sediment

Only two of nine Monongahela River water samples contained measurable amounts of mercury (Table 2). These two samples each contained 0.1

ug/1 mercury, the lowest level which could be measured in the Water Resources Lab. Even though mercury in the two samples was above the West Virginia criterion of 0.05 ug/1, the samples were considered to be low in mercury content. The EPA has set a concentration of 0.20 ug/1 mercury for a 24-hour average (4.1 ug/1 maximum at any time) for the protection of freshwater aquatic life (Smith 1981). EPA has also issued an ambient water criterion of 0.144 ug/1 for the protection of human health from the toxic properties of mercury ingested through water and contaminated organisms, and a recommended level of 2.0 ug/1 for drinking water alone (U.S. EPA 1980). While the drinking water figure may appear abnormally high, it is based on evidence showing the majority of man's mercury in-

Table 2. Total Mercury in Water and Sediment Samples Collected in Monongahela River, October 20 and 21, 1981 (All Samples Taken in River Proper Unless Otherwise Noted)

		Total Mercury	
Pool	*Location*	*Water (ug/1)*	*Sediment (mg/kg)*
Morgantown	MRM 102.5	<0.1	<0.03
Hildebrandt	MRM 108.3	<0.1	<0.03
Opekiska	MRM 115.5 Immediately above dam	<0.1	<0.03
Opekiska	MRM 124.6 Left descending bank	<0.1	<0.04
Opekiska	MRM 124.6 Right descending bank	<0.1	0.07
Opekiska	MRM 124.8 Westinghouse outfall (not in river proper)	0.5	30.00
Opekiska	MRM 125.1 Left descending bank	<0.1	0.10
Opekiska	MRM 125.1 Right descending bank	0.1	0.05
Opekiska	MRM 125.6 Drainage—Big John's Salvage (not river proper)	2.4	4.40
Opekiska	MRM 125.7 Left descending bank	<0.1	0.05
Opekiska	MRM 125.7 Right descending bank	0.1	<0.03

take, especially of the more toxic forms, to be from the diet rather than from water (U.S. EPA 1980). All water samples collected in the Monongahela River had mercury levels below all of the action levels of EPA.

Based on the above state and Federal standards, it appears that fairly low levels of mercury exist in the Monongahela River near Fairmont. The presence of measurable mercury levels in some samples indicates that monitoring should continue. At this time there seems to be no threat to aquatic life or human health from mercury in Monongahela River water.

Water from discharges at Westinghouse Electric Corporation and Big John's Salvage contained 0.5 and 2.4 ug/1 mercury, respectively. These relatively high levels identify the two facilities as point sources of mercury contamination. This information will assist regulatory agencies in continued monitoring of mercury in the river.

Sediment samples from the Monongahela River contained mercury levels ranging from less than 0.03 to 0.10 mg/kg (Table 2), with the highest levels found in the vicinity of Big John's Salvage and the Westinghouse plant. It is likely that some mercury in these sediments will find its way into the water and aquatic organisms. Mercury in a river's sediments can create long lasting problems, since even in the absence of additional mercury entering the system, removal from the sediments is a very slow process (Lambou 1972). Monongahela River sediment mercury levels appear to be low to moderate. There are presently no state or EPA standards for mercury in river sediments.

Mercury levels from sediments in discharges from Westinghouse and Big John's Salvage, at 30.0 and 4.40 mg/kg, respectively, were considerably higher than those found in the river proper. These results further confirmed identification of these sites as point sources which should be closely monitored.

Fish

A total of 22 fish samples from five locations were examined. Mercury levels in these samples ranged from less than 0.03 to 0.58 mg/kg (Table 3). There was little variation in levels of mercury from site to site. In nearly all cases, however, fillets of a given species contained higher mercury concentrations than whole fish, indicating that fillet data in this investigation provided the most sensitive indication of mercury uptake. This finding is particularly important and useful when one is considering the threat to human health from mercury in fish.

In general, higher mercury levels were found in the top predator species such as walleye and the black basses, than in individuals from lower trophic levels, such as white sucker and redhorse. Other investigators (Steifel 1975, Vermont Fish and Game Department 1971) have reported similar trends, with predators, especially mature individuals, containing the highest mercury levels. In Vermont, walleye were found to consistently show high mercury levels when the substance was present, and for this reason were used as an indicator species, on the assumption that if walleye did not show high mercury levels then neither would other species (Vermont Fish and Game Department 1971). The limited number of fish collected in this investigation appeared to support this assumption, as walleye contained higher mercury levels than other species examined at each location. Although further study in this area is

Table 3. Total Mercury in Fish Tissue Composites from Samples Collected in Monongahela River Basin, October 10-18, 1981

Location	*Species*	*Whole or Fillet*	*No. of Fish*	*Mercury (mg/kg)*
MRM 101.2-102.0	Walleye	Whole	5	0.58
		Fillet	5	0.34
	Smallmouth Bass	Whole	4	0.08
		Fillet	5	0.15
	Channel Catfish	Whole	5	<0.03
		Fillet	5	0.05
MRM 115.3-116.8	Walleye	Whole	5	0.08
		Fillet	5	0.26
	Largemouth Bass	Fillet	5	0.15
	Channel Catfish	Fillet	4	0.10
	White Sucker	Whole	4	<0.04
MRM 124.0-127.0	Walleye	Whole	5	<0.04
		Fillet	5	0.21
	Black Bass*	Fillet	5	0.13
	White Sucker	Whole	5	<0.03
	Redhorse	Fillet	3	<0.03
West Fork River	Largemouth Bass	Fillet	2	0.10
	White Crappie	Fillet	3	0.11
	Redhorse	Whole	5	0.04
		Fillet	5	0.08
Tygart Lake	Walleye	Whole	5	0.14
		Fillet	5	0.27

*Largemouth (2) and Spotted (3) Bass mixed.

probably needed, validation of a species' suitability as an indicator of mercury (or any other) contamination allows investigators to select a target species which can lead to substantial savings in time and effort both in field collections and laboratory analyses.

The levels of mercury found in fish tissue were generally low, with only one sample (0.58 mg/kg) exceeding the state standard of 0.5 mg/kg (West Virginia Water Resources Board 1980). All fish samples were well below the present 1.0 mg/kg standard set by FDA (U.S. Food and Drug Administration 1978). Overall, fish in the Monongahela River appear to be safe for human consumption from a mercury standpoint, as the most highly contaminated fillets (0.34 mg/kg) examined contained mercury levels substantially below both state and FDA standards.

Mercury data from fish tissue analyses are especially meaningful in determining the extent of contamination in a system. A large portion of total mercury in fish is highly toxic methylmercury, with fish being the predominant source of methylmercury exposure to humans (U.S. EPA

1980). Mercury levels in fish, particularly in the edible portion, therefore, are much more relevant than those in water and sediments when the objective is to protect human health. Fish data can also provide information on water column mercury levels in bodies of water where mercury is undetectable by conventional water analysis. Mercury levels are higher in a given fish species than in the water from which the fish came, often by a known factor (U.S. EPA 1980). The high levels in fish are readily measured and, when adjusted by the correct factor, can approximate mercury levels in the body of water. It is easy to see, therefore, why many states place such an emphasis on fish tissue analysis.

The Monongahela River supports a productive sport fishery, particularly for walleye and the black basses. A large number of these fish are undoubtedly caught for human consumption. Overall, the fish in the river appear to be safe for human consumption from a mercury standpoint, and there is no reason to expect this status to change. As with water and sediment, fish in the Monongahela River should continue to be monitored to assure that human health and biological integrity are not threatened.

Conclusion and Summary

The Monongahela River and its aquatic life appear to contain low to moderate levels of mercury. Based on state and Federal standards, there seems to be no immediate threat to aquatic life or human health from mercury in the system. At least two point sources have been identified and are being monitored. It is likely that some additional mercury is entering the system from natural sources and from fallout and rainout of elemental mercury vapor. This continuing input, along with leaching of existing mercury from the river's sediments, indicates that low to moderate levels of mercury are likely to remain in the system for some time.

Literature Cited

1. Lambou, V.W. 1972. Report on the problem of mercury emissions into the environment of the United States to the Working Party on Mercury, Sector Group on Unintended Occurrence of Chemicals in the Environment, OECD. U.S. Environmental Protection Agency. Washington, D.C. 81 pp.
2. Smith, J.N. 1981. Water quality criteria; correction. Federal Register 46(156):40919.
3. Steifel, R.C. 1975. Mercury as a factor in the fisheries environment. Ohio Department of Natural Resources, Division of Wildlife. Columbus, Ohio. 45 pp.
4. U.S. Environmental Protection Agency. 1977. Interim methods for the sampling and analysis of priority pollutants in sediments and fish tissue. Environmental Monitoring and Support Laboratory. Cincinnati, Ohio. 54 pp.
5. U.S. Environmental Protection Agency. 1980. Ambient water quality criteria for mercury. Office of Water Regulations and Standards, Criteria and Standards Division. Washington, D.C. 217 pp. See Smith (1981) for corrections.
6. U.S. Food and Drug Administration. 1978. Administrative guidelines manual. Guideline 7408.09. Unavailable, information in U.S. EPA (1980).
7. Vermont Fish and Game Department. 1971. Results of mercury testing conducted by the Vermont Fish and Game Department in 1970. Lake, Pond, and Stream Investigation. F-12-R-3. 39 pp.
8. West Virginia Department of Natural Resources. 1976. Basin water quality

management plan for the Monongahela River Basin. Division of Water Resources. Charleston, West Virginia. 556 pp.
9. West Virginia Department of Natural Resources. 1980. Water quality status assessment, 1977-1979. Division of Water Resources, Charleston, West Virginia. 107 pp.
10. West Virginia Water Resources Board. 1980. West Virginia administration regulations, Chapter 20-5 and 20-5A, Series I, II and III. Charleston, West Virginia. 149 pp.

Psychology and Sociology Section

Self-Reported Assertive Responding in Student Nurses

Debra B. Hull
Department of Psychology
Wheeling College
Wheeling, West Virginia 26003
and
John H. Hull
Department of Psychology
Bethany College
Bethany, West Virginia 26032

Abstract

Senior level student nurses completed an assertiveness questionnaire, rating their degree of discomfort and response probability in a variety of specific situations frequently encountered in nursing. Data analyses showed that the degree of difficulty nurses have behaving assertively is not the same in all situations, but depends upon the type of assertive response required and the person to whom it is directed. These findings provide additional evidence that assertiveness is not a trait, but is situation-specific, and provide important implications for assertiveness training programs for nurses.

Assertiveness training for nurses has been focused upon in recent nursing literature (Donnelly, 1979; Herman, 1978). Typically, such training has been designed to provide a wide range of assertive skills within and beyond a nurse's normal work setting. If assertiveness is a situation-specific response (e.g., Hull & Hull, 1978; Rich & Schroeder, 1976), then nurses should not be expected to have equal difficulty responding assertively in all situations, and programs could be geared more efficiently to those specific situations in which nurses have difficulty behaving assertively. This study assesses self-reported assertive behavior among student nurses in a variety of specific situations frequently encountered in nursing

(Chenevert, 1978). Situations differ in the type of assertiveness required, and the target of that assertiveness.

Method

Subjects

Subjects were 30 Caucasian female senior student nurses enrolled in a diploma-granting hospital nursing program in West Virginia.

Procedure

In a group setting, each subject completed a questionnaire adapted from one written by the West Virginia School of Nursing, Division of Continuing Education, following the model developed by Gambrill and Richey (1975). Each of seven types of assertiveness: giving praise, receiving praise, making a request, refusing a request, giving criticism, receiving criticism, asking for a behavior change—was crossed with each of six targets of assertiveness: family member, patient, peer, subordinate, supervisor, physician—for a total of 42 situations. For each situation, subjects rated their degree of discomfort in making an assertive response from 1—extremely uncomfortable, to 4—comfortable, then rated their response probability from 1—never, to 5—always. Subjects were asked to conceal their discomfort ratings as they made their response probability ratings.

Results

Pearson product-moment correlation coefficients computed between subjects' total discomfort scores and response probability scores for both type of assertiveness and target of assertiveness were .79 and .78, respectively. Since the relationships between discomfort and response probability were so strong, each pair of discomfort/probability scores was collapsed into one "difficulty of assertiveness" score for further analysis.

A repeated measures analysis of variance for type of assertiveness ratings yielded a statistically significant effect of type of assertiveness, $F(6,174) = 45.23, p < .001$. Subsequent Newman-Keuls tests showed that giving praise was rated significantly easier than any other type of assertiveness, while giving criticism and asking for a behavior change, while

Table 1. Newman-Keuls Summary Table for Type of Assertiveness and Target of Assertiveness*

Type of Assertiveness	*Target of Assertiveness*
giving praise	family member
receiving praise	patient/peer/subordinate
making a request	supervisor
refusing a request/receiving criticism	physician
giving criticism/asking for a behavior change	

*Items on different lines differ significantly ($p < .05$) from one another. Assertiveness difficulty is least for items at the tops of the lists, and most for items at the bottoms of the lists.

Relationship Contexts and Coital Attitudes of College Students

Richard J. Venjohn
Department of Family Resources
West Virginia University
Morgantown, West Virginia 26506

Abstract

The need to resolve fertility problems (e.g., unplanned pregnancies) has stimulated personal and professional interest in understanding fertility-related behaviors. In the present study we hypothesized that behavioral intentions would be significantly different among assigned relationships contexts because of normative and personal beliefs (i.e., expected rewards and punishments) for exhibiting coital behavior within a particular relationship. College students were asked to complete a questionnaire measuring attitudinal and normative beliefs and behavioral intentions for having coitus while in an assigned relationship context (i.e., married, single, cohabiting, or engaged) during the coming year. The results supported the hypotheses that attitudinal and normative beliefs and behavioral intentions were significantly different. The predictive model used also appeared to accurately predict behavioral intentions and to be a useful heuristic framework from which to study determinants. Other suggestions for future research and application of the finding were discussed.

Introduction

Efforts to delineate the sociological and psychological determinants of coital behavior among college students have had limited success. One model in particular, the Fishbein Model, has been able to successfully predict coital behavior by identifying and measuring the determinants of behavioral intentions.

The Fishbein Model combined two predictor variables, social norm and the evaluation of behavioral consequences, to predict behavioral intentions. Behavior is viewed as a function of behavioral inention (BI) which is predicted from the combination of the two predictor variables. The attitudinal predictor (Aact) is the person's evaluation of the consequence of performing a particular behavior. The normative predictor (SN) is the person's perception of significant others' attitudes about his performing the particular behavior (e.g., coitus). In explaining the model Fishbein and others (Fawcett, 1970; Fishbein, 1967, 1974; Smith, 1969) have noted the potential influence of the social situation on which behavior occurs to modify these predictors and subsequent behavioral intentions. Research using the model has been successful in predicting coital behavioral intentions (Fishbein, 1966) but has failed to identify the influence of social situations (e.g., relationship situation) on these determinants.

The present study proposes that a particular type of relationship situation (i.e., assigned relationship context: being married, single, en-

not differing significantly from each other, were rated as significantly more difficult types of assertiveness than the others. The repeated measures analysis of variance for the targets of assertiveness yielded a significant effect of assertiveness target, $F(5, 145) = 65.21, p < .001$. Subsequent Newman-Keuls tests showed that assertive responses directed toward family members were rated significantly easier than those directed toward anyone else, with those directed toward physicians rated significantly more difficult than those directed toward anyone else. Table 1 summarizes the results of the Newman-Keuls tests for both analyses.

Discussion

Clearly, the degree of difficulty student nurses report for behaving assertively depends upon the type of assertiveness required and the person to whom the assertiveness is directed. Besides providing additional evidence in support of assertiveness as a situation-specific behavior rather than as a generalized trait (e.g., Galassi & Galassi, 1980; Hull & Hull, 1978; Rich & Schroeder, 1976), this study has implications for assertiveness training programs for student nurses. While situations would undoubtedly differ somewhat from person to person, and from student nurses to graduated nurses working professionally, it appears that nurses in general could benefit from assertiveness training designed specifically to teach them to give criticism and ask for behavior changes, particularly with physicians. Such training should involve direct participation by physicians to some degree, since traditionally nurses have not been expected to behave assertively with physicians (Donnelly, 1979). Future research should develop the most efficient ways by which this training could be accomplished.

References

1. Chenevert, M. 1978. *Special techniques in assertiveness training for women in health professions.* C.V. Mosby. St. Louis. 118 pp.
2. Donnelly, G.F. 1979. RN's assertiveness workbook. *RN* 42: January, 78-81; February, 54-57; March, 36-39; April, 30-33; May, 34-37; June, 40-43; July, 48-51; August, 32-35; September, 48-51; October, 28-31.
3. Galassi, M.D., and J.P. Galassi. 1980. Similarities and differences between two assertion measures: The College Self-Expression Scale and the Rathus Assertiveness Schedule. *Behavioral Assessment* 2:43-57.
4. Gambrill, E.D., and C.A. Richey. 1975. An assertion inventory for use in assessment and research. *Behavior Therapy* 6: 550-561.
5. Herman, S.J. 1978. *Becoming assertive: A guide for nurses.* D. Van Nostrand. New York. 189 pp.
6. Hull, D.B., and J.H. Hull. 1978. Rathus Assertiveness Schedule: Normative and factor analytic data. *Behavior Therapy* 9: 673.
7. Rich, A.R., and H.E. Schroeder. 1976. Research issues in assertiveness training. *Psychological Bulletin* 83:1081-1096.

gaged, or cohabiting) influences the normative and attitudinal predictors of coital behavioral intentions. This influence will be attributed to cultural and personal attitudes about having coitus within a particular relationship.

Method

Approximately 300 undergraduates enrolled in marriage and family relationship courses at a large midwestern university were asked to participate in the present study. Two hundred and forty-seven of the subjects agreed to participate and completed the questionnaires. Thirty-seven of the subjects completed an additional questionnaire which elicited salient consequences and referents for performing certain behaviors.

There were three instruments: an Informed Consent Form, the Salient Consequence and Referents Survey, and the Behavioral Intention Survey (Venjohn, 1979). The three instruments were modeled after questionnaires previously used to test the Fishbein Model (Jaccard and Davidson, 1972; and Fisher, 1978). The scores for the intention to have sexual intercourse and for social attitudes ranged from very likely (+3) to very unlikely (−3). The scores for the students attitude about having sexual intercourse ranged from very good (+3) to very bad (−3).

The Informed Consent Form and the Salient Consequence and Referents Survey and the Behavioral Intention Survey were distributed at the same time in six marriage and family relationship courses. These six classes were used because of their availability and compatibility with the experimental procedures.

Results

The following sections describe findings pertinent to each of the following hypotheses.

Hypothesis 1: Coital behavioral intentions (BI) may be predicted from attitudes about the personal consequences of the act (i.e., Aact) and social norms (i.e., SN).

The Fishbein model is based on the contention that behavioral intention is a function of attitude toward the act (Aact) and subjective norms (SN) concerning the behavior in question. To ascertain the ability of the particular attitudinal and normative components to predict coital behavioral intentions, multiple regression coefficients for Aact and SN on BI were computed. The multiple correlation for Aact was significant ($p < .01$)' with an $r = .91311$.

The results supported the hypothesis that the method of measurement (i.e., Aact and SN) successfully predicted behavioral intentions.

A major objective of this study is to assess the influence of assigned relationship contexts on coital intentions. The relationship was defined by the description of the hypothetical situation (i.e., being married, single, engaged or cohabiting). These types of relationships were expected to influence behavioral intentions to the degree that the relationship context influences the determinants of behavioral intentions (i.e., Aact, SN). Therefore, if determinant scores differ among assigned relationships, BI should be influenced by these differences.

Hypothesis 2: Aact will be significantly different among assigned relationships for coital behaviors.

To measure the influence of the relationship context on the attitudinal predictors a one-way analysis of variance compared the Aact's among the assigned relationships for coital behavior. The attitudinal components did vary significantly among the types of relationships (Aact: $F = 17.4268$, $P < .01$).

Hypothesis 3: SN will be significantly different among assigned relationships for coital behaviors.

A one-way analysis of variance compared the normative components (SN) across relationships for coital behaviors. Subjective normative beliefs (SN) varied significantly among the types of relationships for coital behavior ($F = 44.3429$, $p < .01$).

Hypothesis 4: BI will be significantly different among the assigned relationships for coital behavior.

Since the social and personal beliefs (i.e., Aact and SN) about performing certain behaviors vary across types of relationships the present study contends that the intention to perform these behaviors should also vary across relationship contexts. In a one-way analysis of variance BI did vary significantly across the assigned types of relationships for coital ($F = 13.73$, $p < .01$) behavior.

Discussion

In the present study the research findings supported all four hypotheses. The Fishbein Model appeared to accurately predict behavioral intentions and to be a useful heuristic framework for investigating determinants of these intentions. A situational factor, the assigned type of relationship was observed to influence the model's attitudinal and normative predictors and behavior intention scores. The following is a discussion of the interesting aspects and the most salient potential applications of the findings as well as suggestions for future research.

The Fishbein Model's apparently successful prediction of behavioral intentions supported its use as a framework by which to study the influence of relationship on the determinants of fertility-related behaviors. Relationship context was observed to influence normative and attitudinal components of behavioral intentions.

A few methodological issues need to be clarified and emphasized. Most importantly, the population sample and the experimental design limit the generalizability of the results. The scores of the types of relationships are the responses of college students to hypothetical situations. The present study did not attempt to explain or describe fertility-related behaviors among married, engaged, single or cohabiting individuals. Its objective was to measure the influence of the relational context on coital intentions and the determinants of these intentions. Any generalizations should be limited to the discussion of the influence of the assigned relationships on social or personal beliefs about or on the prediction of fertility-related behavioral intention.

In the present study two propositions were tested and supported: the utility of the Fishbein Model as a framework in understanding and predicting behavioral intentions, and the importance of the dyadic relationship in the decision to have coitus. Now it is necessary to duplicate this success with individuals who are actually married, single, cohabiting, and

previous papers the literature within the journals of sociology and criminology were surveyed (Warner, 1981b), and later, eight relatively unexplored "arenas of rural crime" were described for which there is research and published material, and in which criminal laws are clearly violated, but for which there is almost no comment within the discipline of criminology (Warner, 1981a). It is argued that the discipline of criminology has largely limited its work to those events which take place within the city limits, and that the discipline is still so governed by a Gemeinschaft-Gesellschaft view of the social world that it is hardly able to justify a serious study of deviance in the bucolic pastures of rural America.

The focus of this paper is on crime within the coal mining industry. It was stimulated by an essay published in 1932 (Yoke) in which the observation was made that crime rates in mining counties of West Virginia are higher than in agricultural counties, and by a comment made by Kenneth Polk (1967:140):

> Logging counties and mining counties have also been found to have relatively high crime rates, in spite of the non-urban classification of the counties.

The stories presented here are nothing new to an audience whose home is West Virginia. But the stories will be examined from a different perspective. These stories are given as a constructive criticism of the discipline of criminology, to point out that there exists a rich literature and, unfortunately, a substantial history of crime in the mining industry which has been entirely overlooked by the discipline whose job it is to study the etiology of crime. The guiding light is an essay written by Edwin Sutherland when he made his famous presidential address to the American Sociological Society in 1939, where he pointed to what was until that time another unexplored arena of criminological investigation, the arena of white collar crime (Sutherland, 1940). With this background, let us now explore those dark caverns, the mines, into which the light of criminological investigation has seldom penetrated.

Bloodletting in Appalachia.[1] Those familiar with the history of West Virginia know the stories of the four mine wars which witnessed numerous murders, ambushing, terrorism, vandalism, violations of civil liberties and federal labor laws, and outright warfare between armies of miners and armies of "deputies" mobilized to protect the mines. The first war broke out in 1912 on Cabin and Paint Creeks, South of Charleston, where 7,500 miners, working in some 96 mines, went on strike in April of that year, demanding recognition of their union, the rights of free assembly and free speech, an end to "blacklisting," and an end to compulsory trading at company stores. They also demanded the legally controlled weighing of their tons of coal. The owners brought in more than 200 Baldwin-Felts strikebreakers to evict the miners and their families from company housing, and "scabs" were brought in to mine the coal. With union funds the miners purchased 1,000 rifles and 50,000 rounds of ammunition. "Mother Jones" inspired the miners to "kill every goddamned mine guard" and to "blow up the mines" (Lee, 1969:27). The strike lasted one year, leaving dozens of men dead. Martial law was declared three times during the "war."

engaged in order to test the ability of the model to predict and explain behavior as well as behavioral intentions, to measure the relative influence of referents and consequences for each type of assigned relationship, and to compare the differences among the actual relationships.

One aim of social and behavioral sciences is the application of knowledge to avoid unwanted personal consequences (e.g., unplanned conceptions). As one delineates the influence of behavioral determinants, educational programs and methods can be developed. If a person understands how his behavioral decisions are affected by his relationship he can better control his environment to achieve personal goals. Being able to delineate differences among relationship contexts would allow mental health professionals to modify and to develop programs to influence and guide individuals in a particular relationship.

Literature Cited

1. Fawcett, J.T. 1970. Psychology and population. The Population Council. New York.
2. Fishbein, M. 1966. Sexual behavior and propositional control. Paper presented at the meeting of the Psychonomic Society.
3. Fishbein, M. 1967. Attitude and the prediction of behavior. In M. Fishbein (Ed.), Readings in attitude theory and measurement. Wiley, New York.
4. Fishbein, M., and I. Ajzen. 1974. Attitude toward objects as predictors of single and multiple behavioral criteria. Psychological Review. 81:59-74.
5. Fisher, W.A. 1978. Affective, attitudinal, and normative determinants of contraceptive behavior among university men. Doctoral Dissertation, Purdue University.
6. Jaccard, J.J., and A.R. Davidson. 1972. Toward an understanding of family planning behavior: An initial investigation. Journal of Applied Social Psychology, 2:228-235.
7. Reiss, I.L. 1973. Heterosexual permissiveness inside and outside of marriage. Morristown, N.J.: General Learning Press.
8. Smith, M.B. 1969. Social psychology and human values. Chicago: Aldine Publishing Co.
9. Venjohn, R.J. 1979. Situational, attitudinal and normative determinants of coital, contraceptive and conceptive behavioral intentions: An integration of the Fishbein Model. Doctoral Dissertation, Purdue University.

Crime in the Mines

John R. Warner, Jr.

Department of Sociology and Anthropology
West Virginia Wesleyan College
Buckhannon, West Virginia 26201

This paper is one of a series of essays written by this author on the topic of rural crime, and is the third such paper read before this body. In

Besides that first "war" there were three other mine wars: one in 1920 and 1921 in Mingo and McDowell Counties; another in Logan County in 1921 where the famed Sheriff Don Chafin ruled the county with an iron fist and drove out all efforts to unionize the mines; and a long war in Marion and Monongalia Counties which lasted from 1924 to 1929.

Hell in Harlan.[2] West Virginia was not alone the scene of mine violence. The history of Harlan County, Kentucky, is a fascinating and tragic story of warfare between mine owners and those who sought to unionize the mines. Here coal companies used violence, intimidation, murder, ambush, dynamite, and mayhem to control elections, keep unions out, and to keep miners silent. The most famous incident in the sordid history of Harlan County is remembered as the "Battle of Evarts" where thugs killed four striking miners on May 5, 1931. However, the miners were not above the use of violence to obtain their ends. More than once did Governor "Happy" Chandler bring in the National Guard to establish peace in Harlan County. The seeds of violence planted in those early years of unionization ripened into the vehicle of union tyranny by which UMW President W. A. "Tony" Boyle governed the miners for a decade beginning in 1963, and it was those loyal miners from District 19 who schemed with Boyle in the plot to kill Joseph "Jock" Yablonsky on New Year's Eve, 1969 (Gaventa, 1980).

John L. Lewis.[3] In all of the history of American Labor there are few names equal to that of John L. Lewis. As president (1919-1960) of the UMW he brought union membership to its greatest strength, led the successful fight to unionize the miners in West Virginia and eastern Kentucky, challenged—unsuccessfully—Samuel Gompers for the presidency of the American Federation of Labor, then led the struggle to create the new Congress of Industrial Organizations (CIO). He was instrumental in influencing Congress to pass the National Industrial Recovery Act in 1938, the Act which assured workers the right to organize for collective bargaining.

But Lewis was not above an act of crime if such seemed expedient to protect or strengthen the union. Convinced that miners in Illinois had made a poor decision at the ballot box in 1932, Lewis was evidently involved in misplacing the ballots. To protect the union he sacrificed democracy.

In the late 1940's Lewis, convinced that to save his union he must also save the bituminous coal industry, began to work cooperatively, and secretly, with the mine owners, and the industry witnessed the transformation of one of the owners' most bitter enemies into a friend of management. He began to make secret deals with industrial leaders which, while seemingly necessary at the time, led the union down a path of deceit, fraud, a disregard for contracts and for the law and, frankly, out-and-out crimes against the miners and the American people.

When Horace Ainscough received the first UMW pension check in September, 1948, that miner spoke, perhaps, for all miners in America. "God bless the day John L. Lewis was born" (Hume, 1971:30). Those who know where John L. led the miners in the next twelve years might not in unison be able to say that prayer with Mr. Ainscough.

In 1946 John L. took advantage of the "coal boom" to extract from

the mines a per-tonnage royalty on coal mined in union mines, to be paid into a welfare and retirement fund for miners and their families. With that royalty he built ten new UMW hospitals and paid miners $100 per month when they retired. But again secret deals were made with the industry. The UMW purchased the National Bank of Washington in 1948, and through the bank made loans to struggling mines. Lewis deposited nearly $30 million of UMW Welfare Funds in the Bank's checking account, drawing *no interest*! With the money saved by paying no interest Lewis "forgave" loans which the companies could not repay. Lewis also allowed small union mines to default in Welfare Fund payments, knowing that if he forced payment they would have to close or would leave the union. Later, when Fund resources grew slim, he cut off miners from Fund benefits if the companies for which they worked were in arrears. Not realizing that they had been sold out by Lewis, these workers struck back at the small mine owners, dynamiting and vandalizing the mines with whose owners Lewis had made the secret deals. Under his leadership the UMW purchased controlling interest in two coal companies. Such was the leadership of John L. Lewis.

W. A. "Tony" Boyle. While the long presidency of John L. Lewis is marked with grandeur as well as deceit, UMW president "Tony" Boyle represented only the latter. Space prevents us from detailing the demagoguery of this mediocre union leader, but we will mention here only that his control of union elections and convention voting violated the principles of the U.S. Constitution and the law as set forth under Landrum-Griffen and Taft-Hartley Acts. As mentioned above, he conspired successfullly to assassinate Joseph Yablonsky in 1969.

Coal Mine Health and Safety.

> "I'm so glad it come all of a-sudden, and he didn't have to suffer like so many I've knowed."—Coal miner's widow (Caudill, 1976:88).

The history of coal is one of death and mutilation. Since the first records were kept in 1838, more than 130,000 miners have lost their lives in mine accidents in the U.S.A., and several hundred thousand others have been disabled (U.S., 1980). Death rates in the mines of this nation are higher than in any other Western coal mining industrialized nation in the world (McAteer, 1971). Twenty-five mine disasters have claimed the lives of more than one hundred men (Hume, 1971).

The history of mine safety and health legislation is one of callous disregard for the welfare of men working in the mines. To suggest that this nation did anything less than exploit the miners who extracted energy from the earth would be to turn away from the truth. Yet this is not a story of crime in the usual sense, for with few exceptions no criminal laws were broken. The story of coal mine legislation is a tale of a license to kill with the sanction of the law. The federal government has passed seven mine health and safety laws since 1910, but most have been vague, with little power of enforcement, and the penalties, where applicable, have been weak. For that reason the death rate in American mines in 1971 was six times higher than that of mines in the Netherlands. In 1978 federal mine inspectors issued 80,343 notices of health and safety violations, but it is no crime to send men to their death (U.S., 1980?).

Guyandotte River at Man, West Virginia. With it would go 125 human lives and 1,000 homes. Four thousand people would be left homeless, and more than $50 million of property would be destroyed.

Oldie Blankenship, a fifty-five year old coal miner, watched his wife, Edith, as she was swept to her death. He heard her last words, "Oldie, Lord have mercy on us!" Seventeen year-old Steve Albright rushed into his house at Loredo, grabbed his mother, she grabbing her nine-month-old Kerry Lee. But they were too late. Neighbors saw the water engulf the three, and they saw the mother try in desperation to throw the infant up the side of the hill as water pulled her under. Her toss fell short. Shirley Adkins could not swim, but she rode a mattress to safety. Goldie Sipple pulled herself ashore, her lungs filled with mud. Friends watched her choke for three hours on the oil and sludge, crying, "God, why won't you let me die?" before sweet death lifted her soul (Nugent, 1973).

That "Act of God," as Pittston Coal called it, was not the first, nor will it be the last such collapse, because the laws which govern such destruction are not adequately enforced.

A committee appointed by West Virginia Governor Arch Moore studied the disaster and concluded that:

> Without stiff penalties—or perhaps even the possibility of criminal prosecution—many observers wondered if the profit-oriented industrial giants would ever feel compelled to spend the time or money required to eliminate hazards like the one at Buffalo Creek (Nugent, 1973:174).

The grand jury returned no true bills. The Bureau of Mines found 900 other such dangerous gob piles in the coal fields of Appalachia. Yet 20 months later, in October, 1973 ABC television reported that "in hollow after hollow, small towns and villages sit directly in the path of waters damned up by huge piles of coal slag dumped by neighboring coal operations" (Stern, 1976:171).

The Sounds of Silence. Now the question is raised, why has the discipline of criminology remained silent on the crimes of the coal industry? We have studied street gangs in Boston and Chicago, murderers in Philadelphia, drug addicts in San Francisco, delinquents with a poor self-concept in Columbus. We have filled our textbooks with illustrations of traditional crimes in urban places. But with one exception (Shover, 1980) we have not examined this significant arena of rural crime. It is missed because it is rural, but also because the crimes of industry have, until the last decade, generally been overlooked, in spite of Sutherland's presidential address in 1939.

The discipline of criminology has been a conservative discipline, following Tappan (1947):

> Crime is an intentional act in violation of the crminal law (statutory and case law), committed without defense or excuse, and penalized by the state as a felony or misdemeanor.

Because the coal industry was able to buy the offices of sheriff and judge in the early years of unionization, the tyranny of Sheriff Don Chafin and the Baldwin-Felts dectectives was beyond the purview of our

Black Lung.

> With each gulp into oxygen starved lungs the microscopic bits of coal and silica poured in to coat the alveoli. Day after day the black film accumulated, inexorably reducing the capacity of the doomed lungs to function. Men slowed and stopped. Suddenly young men looked middle-aged, and the middle-aged looked old and exhausted. By the early 1960's the Appalachians contained a quarter of a million ruined coal miners, and an industrial army of incapacitated and forgotten workers (Caudill, 1976:145-46).

More than a quarter of a million miners in America have been disabled by the miners disease, pneumoconiosis, or "black lung." Harry Caudill (1976:145) explains the cause of black lung: "Coal digging was profitable and dust abatement costly, so the former was pushed and the latter was ignored." The same might be said of the destruction of the land, or "terracide," as Caudill describes it.

My Land is Dying.[5]

> Here the scent was altogether different; jumbled mounds of loose earth, slabs of bluish slate, half-buried trunks of dead trees, pools of stagnant, acid-yellowed water, and raw cliffs of sandstone newly scored; a litter of mechanical relics, already rusting, from the bulldozers, trucks, and power shovels whose work, completed, had left this desolation behind (Caudill, 1971:18).

Harry Caudill, perhaps the most able spokesman for Appalachia, stood atop a Kentucky hill with Dan Gibson, coffin maker. They looked across the ruins of a land once described for its beauty by John James Audubon. Caudill listened to the old man, who had seen the virgin forests cut down and the great machinery rape the soil to extract coal from the richest source of energy on Planet Earth. "My land is dying," mourned the old man (1971:17-18).

The devastation of the environment has exacted a massive toll in this nation. It took its greatest toll along the banks of a small and, until early in the morning hours of February 26, 1972, unknown creek in Logan County, West Virginia.

Buffalo Creek. The great "gob" pile and three retaining dams built without the aid of an engineer and in violation of federal law impounded 135 million gallons of water. Heavy rains in late February brought the water to the very crest of the third retaining dam on the Middle Fork Hollow above Buffalo Creek. Officials of Pittston Coal Company, owners of the dam, knew of the danger which threatened the lives and homes of some 5,000 residents who lived below the water, but they failed to act. Below is a description of the morning of February 26, 1972:

> The clock stopped exactly at 8:01 a.m. in Ossie Adkins house. His was the house closest to the great gob pile. Ossie saw the fifty foot wall of water knifing down the valley, and the stream pouring out as the water hit the smouldering fires deep in that pile. Miraculously, Ossie escaped to tell his story. In the next three hours 135 million gallons of black, slimy water would roll the seventeen miles down to where Buffalo Creek enters the

discipline. Because coal mine roof falls and explosions, black lung, Kentucky waste lands, and gob piles are governed by administrative, but not criminal, laws, they too are considered improper subjects for study. Because the region of Appalachia has largely been ignored by mass media or, when portrayed, the image follows popular stereotypes, the death of miners has not attracted the penetrating light of the discipline.

The conclusions here are a *paraphrase* of the words with which Edwin Sutherland concluded his presidential address, a set of propositions (Sutherland, 1940):

1. Rural criminality is real criminality.
2. Rural criminality takes a variety of forms which differ from crimes of urban life.
3. The theories of criminologists which follow a Gemeinschaft-Gesellschaft typology (things are pretty bad in town) cannot be considered adequate where modern industry extends its tentacles into the deepest recesses of rural America.
4. Theories which fail to take into account the power of great industries to write the very laws by which they are governed are politically reactionary and reflect poor scholarship.
5. There's quite a bit going on outside of town. Criminologists of the world, come out and see us.

Endnotes

1. From the title of the book by Lee (1969).
2. From the title of the book by Titler (1972).
3. Material on Lewis is documented in Hume (1971), Finley (1972), and Alinski (1970).
4. Material on Boyle is documented in Hume (1971), Finley (1972), and Armbrister (1975).
5. From the title of the book by Caudill (1971).

References

1. Alinski, Saul. 1970. *John L. Lewis: An unauthorized biography.* New York: Vintage Press.
2. Armbrister, Tevor. 1975. *Act of Vengeance: The Yablonski murders and their solution.* New York: Saturday Review Press/E.P. Dutton & Co., Inc.
3. Caudill, Harry M. 1971. *My land is dying.* New York: E.P. Dutton & Co., Inc.
4. ———. 1976. *The watches of the night.* Boston: Little, Brown and Company.
5. Finley, Joseph E. 1972. *The corrupt kingdom: the rise and fall of the United Mine Workers.* New York: Simon & Schuster.
6. Gaventa, John. 1980. *Power and powerlessness: quiescence and rebellion in an Appalachian valley.* Urbana: University of Illinois Press.
7. Hume, Brit. 1971. *Death and the mines: rebellion and murder in the United Mine Workers.* New York: Grossman Publishers.
8. Lee, Howard B. 1969. *Bloodletting in Appalachia: The story of West Virginia's four major mine wars and other thrilling incidents of its coal fields.* Morgantown: West Virginia University Press.
9. McAteer, J. Davitt. 1971. *Safety in the mines: a look at the world's most hazardous occupation; a comparative study of coal mine health and safety in Europe and the United States.* Washington, D.C.: Center for Study of Responsible Law.

10. Nugent, Tom. 1973. *Death at Buffalo Creek: The 1972 West Virginia flood disaster.* New York: W. W. Norton & Company, Inc.
11. Polk, Kenneth. 1967. Juvenile delinquency in non-metropolitan areas. In the President's Commission on Law Enforcement and Administration of Justice, *Task Force on Juvenile Delinquency and Youth Crime.* Washington, D.C.: U.S. Government Publishing Office.
12. Shover, Neal. 1980. The criminalization of corporate behavior: federal surface coal mining. In Gilbert Geis and Ezra Stotland (eds.), *White-collar crime: theory and research.* Beverly Hills: Sage Publications.
13. Stern, Gerald M. 1976. *The Buffalo Creek disaster: the story of the survivors' unprecedented lawsuit.* New York: Random House.
14. Sutherland, Edwin H. 1940. White collar criminality. *American Sociological Review 5.* February.
15. Tappan, Paul W. 1947. Who is the criminal? *American Sociological Review 12.* February.
16. Titler, George J. 1972. *Hell in Harlan.* Beckley, WV: BJW Printers.
17. U.S. Department of Labor: Mine Safety and Health Administration, 1980. *Annual report and achievements: Fiscal Year 1978, Part 1.* Washington, D.C.: U.S. Government Printing Office.
18. ———. 1980? MSHA. Washington, D.C.: U.S. Government Printing Office, (Pamphlet).
19. Warner, John R., Jr. 1981a. Arenas of rural crime. *Proceedings of the West Virginia Academy of Science 53.*
20. ———. 1981b. Rural crime, rural criminals, rural delinquents. *Juvenile justice in rural America.* U.S. Department of Justice. Washington, D.C.: Government Publishing Office. Also presented before the West Virginia Academy of Science in 1980.
21. Yoke, H.L. 1932. Crime in West Virginia. *Sociology and Social Research 16.*

Stress-Reduction Through Stress-Lessening Lifestyle—Portable Equipment as an Aid—A Review

Albin R. Gilbert
Department of Psychology
West Virginia Wesleyan College
Buckhannon, West Virginia 26201
and
Richard Coppola
Laboratory of Psychology
National Institute of Mental Health
Bethesda, Maryland 20205.

Abstract

Rosenman, Friedman, Jenkins, Strauss, and others examined persons suffering from cardiovascular and other stress-related disorders regarding their life-

stress they suffer by their work. This argument impressed Friedman and Rosenman so deeply that they initiated a research project of their own.

They sent questionnaires to 150 businessmen of San Francisco, asking them to check what particular phenomenon or complex of habits they believed had preceded a heart attack in a friend of theirs. Seventy percent of these men believed that indulgence in excessive competitive drive and deadline meeting were the outstanding characteristics exhibited by their coronary-stricken friends. Twenty-eight percent of these overdetermined persons had seven times as much coronary heart disease as the uni-motivationally living persons.

Next, Friedman and Rosenman surveyed 100 internists who treated coronary patients. The majority of them also thought that the phenomena most frequently found to have preceded the heart attack in the patients they had treated was the indulgence of these patients in excessive competitive drive and meeting deadlines.

Here is another investigation in the fundamental importance of lifestyle as one of the causative factors of coronary disease. The fact that fewer American white females than males are susceptible to coronary disease is also regarded by the mentioned authors as evidence for lifestyle, and not for the serum cholesterol level to be the primary cause of coronary disease.

The most penetrating research into motivational overdetermination as an essential cause of coronary disease was performed by Friedman and Rosenman by developing the stress-provoking lifestyle in rats. "Following deliberate damage to rat's hypothalamus, the emotional center of the brain, the affected animal instantaneously exhibited the rat-equivalent of the human type A behavior pattern, meaning the motivationally overheated lifestyle." Our success in experimentally inducing a facsimile of this lifestyle in the rat, was followed by emergence of the most dreaded of all coronary biochemical derangements.

Friedman conducted with colleagues a mass experiment to re-educate 600 men, who had already had a heart attack, to change their "type A behavior" to "type B behavior." The subjects were told that their "type A behavior" has impoverished various aspects of their original personality. In order to reform their lifestyle they were taught to walk, eat, and talk at a slower pace.

Conversion of stress-provoking into stress-lessening lifestyle. Tremendously important is the finding of Rosenman and Friedman (1977) that "type A behavior" (the stress-provoking lifestyle) can be converted into "type B behavior" (the stress-lessening lifestyle) *by training.*

What effects do we expect from this change in lifestyle? On a simplistic level we expect a better chronic cardiovascular state. This is certainly the most obvious manifestation of a healthy individual. Much of the work on coronary disease indicates that getting cardiovascular parameters into a healthy range is important for a better prognosis. We expect reduced cardiovascular changes as well as fewer autonomic nervous reactions. These smaller reactions would indicate a saving of psychophysical energy.

As a particular mechanism of aiding someone involved in reorganizing his lifestyle, Gilbert proposes keeping a record of "backslidings,"

styles. They found these lifestyles characterized by a high drive for achievement, competition, and a strong sense of time-urgency. They labeled this stress-provoking lifestyle "type A behavior." Persons of the contrasting stress-lessening lifestyle were found to be relatively unambitious and uncompetitive, as well as under less pressure of time. Persons of this lifestyle were called "type B."

Physiologically, Friedman and Rosenman found that as a rule "type A" persons had seven times as much heart disease than "type B" persons. The Friedman and Rosenman school proposes a novel therapy for cardiovascular and other stress-related disorders by aiding patients in converting their "stress-provoking lifestyle" into "stress-lessening lifestyles."

The present authors propose to monitor the effectiveness of this self-training by having the subjects use portable equipment which measures electromechanically certain physiological parameters, explained in this paper. Our technique is a pioneering attempt to aid persons suffering from coronary heart disease and other stress-related disorders, and to aid even healthy persons, beset by excessive stress, to develop stress-lessening lifestyle.

The influence of stress upon man's health has been investigated systematically since the early 1900s. Hans Selye (1936) defined stress as, "a syndrome produced by various nocuous agents."

The relation between occupational stress and stress-related disorders. We are interested here in the occupational category of stress. To illustrate, the National Institute of Occupational Safety and Health has probed into jobs in terms of their provoking morbid stress. Thus, air traffic controllers were found to experience 5.6 times more hypertension than aviation workers (Rose, Jenkins, and Hurst, 1978).

The stress-provoking and stress-lessening lifestyle. Friedman and Rosenman (1959), Rosenman, Friedman, Strauss *et al.* (1964) and Jenkins (1976) studied white middle-class men who have a high drive for achievement, competition, and who live under the pressure of deadlines. The research team labeled these persons as having "type A behavior." By contrast, the team investigated relatively unambitious and uncompetitive, as well as less time-pressed persons, calling them "type B behavior." These terms have become household words all over the world like many innovative terms coined by Freud and Jung. The incidence of clinical coronary artery disease was found to be seven times greater in "group A" than in "group B" (Rosenman, Friedman, Strauss *et al.*, 1964).

Stress-provoking lifestyle underlying certain professions. Friedman and Rosenman (1974) have seen scores of coronary patients for well over a decade and initially treated them routinely. Then, prior to writing a review on the role of dietary cholesterol in coronary heart diseases, they found that many studies suggested that neither the cholesterol nor the fat content of various diets could always explain the coronary heart disease. They suspected other factors playing a part.

When investigating the dietary habits of males and their wives from the San Francisco Junior League they found a lower incidence of heart disease in the females than in the males, although the dietary intakes were exactly the same. The wives affirmed that the reason for the greater susceptibility to heart disease of their husbands lies in the

that is, failure to maintain a uni-motivational state, i.e., to pursue always only one motive at a time. This means that we will also be maintaining a direct cognitive variable.

While biofeedback techniques usually monitor only one variable or indicate only a desired change of direction in a variable, the more comprehensive monitoring proposed here will allow for recognizing "patterns of response." More than a specific variable, a particular pattern of change in physiological variables indicate the underlying (or over-riding, as the case may be) cortical state.

The physiological variables that we monitor. We propose to monitor the following physiological variables that are important in daily living: Blood pressure, heart rate; temperature (temperature in the limbs and in the forehead); galvanic skin response; electroencephalic variables, such as dominant rhythm and laterality; sleep variables, including sleep stages (latency, percentages).

The possibility of some degree of control over each of these variables has been shown in various biofeedback or other clinical studies (Transcendental Meditation; Zen, Yoga; Autogenic Training; Progressive Relaxation, Hypnosis with suggested deep relaxation).

Measurements, particularly with portable equipment, will have to be interpreted in a relative sense. If an individual has a "type A" lifestyle and tries to convert it into "type B," blood pressure and heart rate will decrease; the warmth in the limbs and coolness in the forehead will increase; the dominant rhythm and laterality of his brainwaves will change (alpha waves increase in intensity and frequency); the sleep variables, including sleep stages, will change (oxygen consumption decreases). Comparative measurements of these parameters, particularly with the aid of a portable belt, will be performed.

Monitoring the lifestyle change by portable equipment. Psychologists have begun to model electromechanical devices monitoring physiological and psychological changes (Schwitzgebel, 1969). Dr. Coppola, working in the psychological laboratory of National Institutes of Health and Dr. Gilbert (1960, 1979), a student of lifestyle, are designing a belt-worn and other portable equipment. The equipment is aimed at continually monitoring a *pattern* of physiological (and the previously mentioned cognitive variable of Gilbert) as a guide to how well one is adjusting to the conversion of stress-provoking to stress-lessening lifestyle. The purpose is to monitor progress as well as provide the trainees with an indication that their adopted lifestyle is having direct effect.

Schwitzgebel (1969) reports that at least 50 different devices are being used experimentally for psychotherapy. As early as 1904 a device consisting of a quilted pad and an electric buzzer was used for the treatment of bedwetting. In 1938 W. M. Mowrer constructed a more sophisticated device of this sort, ever since widely used. Sears Roebuck lists it in its catalog. Portable electric shock devices are available to suppress smoking, nail biting, drug addiction, and obsessional thoughts.

The apparatus we are designing is a portable belt. It is not uncomfortable nor restrictive of normal activities. It is different for males and females. The belt's circuitry is planned to monitor the physiological responses and Gilbert's recording of "backslidings" (see above) of the wearer.

The required transducers for these variables include skin electrodes for the first four variables (explained above), and a pushbutton and microphone for the recording of the "backslidings." Unobtrusive electrodes using self-adhesive collars with fine wire are necessary.

Preprocessing for the variables is accomplished by amplification for the heart and EEG signals, a thermocouple circuit for the temperature, and a bridge network for the skin conductance measurement. In each case the output we want from this stage is the actual variable we wish to monitor.

The recording of the data is simplified by using a microprocessor to further encode the variables and to indicate changes and patterns. In this way the amount of data to be recorded is greatly reduced, since only the salient features are noted. The recording media are either an incremental digital recorder, or direct semiconductor, or bubble memory. Additionally, a microcassette audiorecorder is utilized for recording additional "cognitive" variables as noted by the subject.

Current technology renders all of these requirements into practical reality. While several monitoring and biofeedback devices are currently marketed, none encompasses the spectrum of variables that are required for our desired application. However, each part of such a device as proposed here is available; and integrating all these features into one small package is well within the capability of present day engineering practice. While initially the cost for the equipment required for this program may be high, volume production would bring the price for such equipment comparable to what many spend for other more dubious forms of relaxation.

Treatment of stress-related disorders by developing a stress-lessening lifestyle already spreading. The treatment of stress-related disorders by developing a stress-lessening lifestyle (not yet aided by belt-worn equipment proposed by the present authors) is already spreading. Thus, the Beth Israel Hospital in Boston treats patients suffering from high blood pressure, chronic pain, arthritis and other afflictions by urging them to educate themselves to the "type B lifestyle," which reduces stressful living.

At the Center for Health Enhancement and Education Research at the University of California at Los Angeles, patients are admitted for a 24-day intensive improvement of their mode of lifestyle.

The Psychosomatic Medicine Clinic in Berkeley, California, sets its sight on total lifestyle change.

Conclusion

We have presented a review of research into the relationship of stress-related disorders and stress-provoking lifestyle, and the technique of converting the latter into the former as a therapy of those disorders. We have reported that some medical institutes are already treating stress-related disorders in this way. This therapy will be enhanced by the portable equipment which is being designed by Dr. Coppola.

We think it is no science fiction to envisage people acquiring and maintaining a stress-lessening lifestyle in the near future; and we venture to visualize that the monitoring of this desirable lifestyle training will help to usher in an era of lifelong self-management of lifestyle.

Special Publication Section

Physics, Philosophy, and Pseudoscience: Perspectives on the Creation-Evolution Controversy

Stephen G. Brush
Department of History
Institute for Physical Science and Technology
University of Maryland
College Park, Maryland 20742

(Invited lecture at the 57th Annual Meeting of the West Virginia Academy of Science, Davis & Elkins College, April 3, 1982)

Judging by the program of today's meeting, I would guess that most of you are biologists and teachers concerned with the threat to biology courses presented by the creationist movement. But, as the title of this lecture suggests, my own interest is in the areas of physics and the philosophy of science. In fact, my formal education in biology ended with a high school course more than 30 years ago. Why, then, should I be concerned with the creation/evolution controversy?

There are seven aspects of the controversy that interest me: the First Amendment issue, academic freedom, the effect on biology courses, the effect on earth science and astronomy courses, the relation to physics, philosophy of science, and history of science. In my discussion I will take the legal definition of creationism as given by the recently-overturned Arkansas law (Act 590 of 1981—see Table 1), and I will use Henry Morris's book *Scientific Creationism* as an indication of how it would actually be presented in public school science classes.[1]

(1) *First Amendment*

It was clearly established in the Arkansas trial that "creation science" is a thinly-disguised presentation of the tenets of one particular religious doctrine, the *Genesis* account of the Judeao-Christian Bible. Thus any law mandating that creationism be taught in public schools would be a violation of the constitutional prohibition of the establish-

Literature Cited

1. Friedman, M., and Rosenman, R.H. 1959. Association of specific overt behavior pattern with blood and cardiovascular findings. Jour. Amer. Med. Assoc. 169:1286.
2. Friedman, M., and Rosenman, R.H. 1974. Type A behavior and your heart. Fawcett Crest, New York, 319 pp.
3. Gilbert, A.R. 1960. The concept of lifestyle, its background, and its psychological significance. Jahrb. fuer Psychol., Psychother. und Mediz. Anthrop. 7:97-107.
4. Gilbert, A.R. 1979. Appraisal of personal lifestyle. In Anthropologische Aspekte der Psychologie (Anthropological aspects of psychology). D. Ruediger and H. Perrez, Eds., Otto Mueller, Salzburg, 223 pp.
5. Jenkins, C.D. 1976. Recent evidence supporting psychological and social risk factors for coronary disease. N. Engl. J. Med. 294:1033.
6. Rose, R., Jenkins C., and Hurst, M. 1978. Health change in air traffic controllers. Psychosom. Med. 40:143.
7. Rosenman, R.H., Friedman M., and Strauss R. *et al.* 1964. A predictive study of coronary heart disease. Jour. Amer. Med. Assoc. 189:15.
8. Rosenman, R.H., and Friedman, M. 1977. Identifying type A behavior. J. Psychosom. Res. 21:323.
9. Schwitzgebel, R.L. April 1969. A belt from big brother. Psychol. Today.
10. Selye, H. 1936. Syndrome produced by diverse nocuous agents. Nature, London. 138:32.

Table 1. Definitions of "Creation-Science" and "Evolution-Science" in Arkansas Act 590

(a) "Creation-science" means the scientific evidences for creation and inferences from those scientific evidences. Creation-science includes the scientific evidence and related inferences that indicate:

(1) Sudden creation of the universe, energy, and life from nothing;
(2) The insufficiency of mutation and natural selection in bringing about development of all living kinds from a single organism;
(3) Changes only within fixed limits of originally created kinds of plants and animals;
(4) Separate ancestry for man and apes;
(5) Explanation of the earth's geology by catastrophism, including the occurrence of a world-wide flood; and
(6) a relatively recent inception of the earth and living kinds.

(b) "Evolution-science" means the scientific evidences for evolution and inferences from those scientific evidences. Evolution-science includes the scientific evidence and related inferences that indicate:

(1) Emergence by naturalistic processes of the universe from disordered matter and emergence of life from nonlife;
(2) The sufficiency of mutation and natural selection in bringing about development of present living kinds from simple earlier kinds;
(3) Emergence by mutation and natural selection of present living kinds from simple earlier kinds;
(4) Emergence of man from a common ancestor with apes;
(5) Explanation of the earth's geology and the evolutionary sequence by uniformitarianism; and
(6) An inception several billion years ago of the earth and somewhat later of life.

---

ment of a state religion.[2] Subsequent revisions which attempt to conceal this religious basis by eliminating certain key words ("flood" and "kinds") do not make it constitutional, according to the Attorney General of Maryland; in any case the teaching materials now available are inescapably tainted with religious content.

(2) *Academic Freedom*

The requirement for "balanced treatment" means more than just giving equal time to creationism and evolution; it means that they must be presented as if they were equally-valid alternatives. A teacher who gave an objective discussion of the evidence for and against both theories, as currently accepted by the scientific community, could not avoid conveying the conclusion that creationism has no scientific validity, and would thus be in violation of the law. The Arkansas law requires the teacher to pretend that creationism is a viable scientific model even if he knows this is not the case; hence it violates his or her academic freedom.

(3) *Biology*

In my opinion the real thrust of the creationist movement is not so much to put creationism into public schools as to take evolution out. Un-

less they control the public schools and monitor classrooms on a day-to-day basis, creationists would not benefit by having their doctrines taught by skeptical teachers to skeptical students. Consider for example the creationist explanation of the presence in the sky of stars millions of light years away. If we see them *now*, doesn't that mean they existed millions of years ago, thereby contradicting the creationist doctrine that the universe was created only a few thousand years ago? Creationists argue that God created their light *en route* to us so as to make it appear that they existed earlier.[3] This is a modern version of the "Omphalos" (navel) theory which states that Adam and Eve were created with navels to make it appear that they were born in the usual way.[4] I suspect most students would realize that this is not an acceptable scientific explanation, and would quickly lose all respect for creationism if this argument were presented to them.

The more likely result of the present controversy is that many schools will take the easy way out and teach neither creationism or evolution. This would put us back in the situation we had after the Scopes Trial, when evolution was almost completely wiped out of U.S. high school biology courses, until it was restored in the 1960s. Biology was taught as a collection of facts and descriptions to be memorized, with no theory to provide a unifying explanatory framework. I was a victim of this prohibition of theory—my high school biology course was so boring that I never wanted to take any more courses in the subject. There is a real danger that this will happen again, as textbook publishers and school boards decide to play it safe by playing down evolution.[5]

(4) *Earth Science and Astronomy*

Although most of the public controversy has been about Darwinism, a strict interpretation of the Arkansas law would have a greater impact on the earth science/astronomy courses now taught in high schools than on the biology courses. This is because "evolution-science" is defined to include generally-accepted theories in geology and astronomy (see items (5) and (6) in Table 1). It is possible to restrict evolution to a single chapter in a biology text (even though this may make the rest of the book rather uninteresting), but the same cannot be done with earth science and astronomy. All of historical geology, plate tectonics, and theories of the early development of the earth depend on a time scale established by radioactive dating which is rejected by creationists. Not only the big bang cosmology but, as we have already seen, the very existence of stars millions of light years away is called into question by the creationists.

According to one educator who is familiar with earth science curricula, Rick Duschl at the University of Maryland, more than 60% of the material in a typical textbook would be defined as "evolution science" and thus would have to be balanced by creationist material.[6] This means that *at least 30% of the present content of such a course would have to be eliminated to make room for material considered to be of no scientific value by nearly all scientists.*

(5) *Physics*

Creationists have attempted to use physics against evolution, by claiming that the Second Law of Thermodynamics forbids the development of complex forms of life by natural processes. But in fact they not

melanism, development of strains of organisms resistant to antibiotics, etc.)—and "macroevolution" which takes place over a long period of time and therefore cannot be *directly* observed. The creationists then *incorporate microevolution into their own model* (see Table 1, item a-3) while defining "evolution-science" as including only macroevolution, not microevolution! (Table 1, item b-3.) Of course there is no reason why scientists should accept this peculiar definition of evolution.

The second argument is that the theory of evolution cannot be logically falsified because it merely interprets events that have happened in the distant past rather than attempting to predict what will happen in the future. This objection goes back to the doctrine of the philosopher Karl Popper, that a theory is not scientific unless it makes predictions that can be tested and possibly found incorrect. Popper wanted to establish a criterion of demarcation between science and pseudoscience. Theories in a pseudoscience (he mentioned Marxism and psychoanalysis as specific examples) are so flexible that they can explain anything, hence they can never be tested. Popper himself used to argue that Darwinian evolutionary theory is not a falsifiable hypothesis but a "metaphysical research programme."[9] Later he recanted this view and decided that Darwin's theory is indeed a legitimate scientific hypothesis, but creationists ignore his change of mind.[10]

The problem with Popper's original criterion was that he defined "prediction" so narrowly that not only evolutionary biology but geology and astronomy would fail to be defined as scientific. Any attempt to deal with phenomena that take place over a large domain of space or time, and therefore cannot be brought into the laboratory for controlled tests, would have to be called pseudoscience since it could not generate predictions of specific future events. Since we do generally consider geology and astronomy to be sciences, we must either broaden our concept of "prediction" or use another criterion for being "scientific."

There are several good treatments of the scientific status of evolution available, the most recent being that of Philip Kitcher who gives a thorough analysis of the creationist objections and shows that they are groundless.[11] Rather than get into a discussion of the testability of biological theories, I would like to address the more general claim put forward by creationists; that any theory of *origins* is in principle untestable and therefore not scientific. This claim provides the rationale for arguing that since neither creationism nor evolution (in the broad sense defined in Table 1) can be proved or disproved, both should be presented so that students may choose whichever they prefer.

Although the claim sounds plausible at first, it fails as soon as one recognizes that two well-known theories of origins have in fact been tested; one of them was dramatically confirmed, the other refuted (or at least abandoned by its major advocate). It is interesting to note that creationists reject both theories without even considering the evidence for and against them.

The first example is the "big bang" theory of the origin of the universe as developed by George Gamow and his students in the 1940s. They predicted that the electromagnetic radiation produced in the original explosion would have cooled off over a period of several billion

only ignore the generally-accepted version of the Second Law, they are quite willing to discard other well-established physical theories when it suits their purposes.

According to Morris, the Second Law states that "every system left to its own devices always tends to move from order to disorder."[7] This oversimplified version ignores important qualifications. The system must be *closed* to the flow of matter and energy, otherwise the Law in its original form does not apply at all. For a system in thermodynamic equilibrium, the most stable state is *not* the one with highest disorder or entropy, except at very high temperatures; it is the one with lowest *free energy*, $F = E - TS$ (where E = energy, T = temperature, S = entropy). As one lowers the temperature, the state with lowest energy (usually an ordered crystalline arrangement of the molecules) will be favored. Thus the formation of snowflakes from water vapor, a familiar natural process which involves a transition from disorder to order, is perfectly consistent with the Second Law. In general, interatomic forces can result in the spontaneous formation of complicated molecules (including organic molecules) under appropriate conditions.

The most flagrant contradiction of creationism and physics arises from the attempt to evade the results of radioactive dating. Since I have discussed this problem in considerable detail in a recently-published article,[8] I will mention only a few highlights. First, creationists claim that radioactive decay constants might have varied enough in the past to produce an error of a factor of a million in the estimated age of the earth (they say the earth is only a few *thousand* years old, while scientists say it is a few *billion*). Yet their alleged evidence for such variation collapses under close examination. Second, in order to explain theoretically how such a variation in decay rate could have occurred, creationists rely on a theory by H. C. Dudley which postulates that radioactive decay is not a random process but depends on the coupling of the nucleus to a surrounding ethereal medium. As Dudley himself admits, this theory requires us not only to reject Einstein's theory of relativity (in order to revive a 19th-century ether) but also to postulate "hidden variables" at a subquantum level, contrary to the principles of quantum mechanics.

Thus, in order to save their theory and back up their objections to evolution, creationists have rejected or seriously distorted the basic principles of thermodynamics, nuclear physics, relativity, and quantum mechanics. Presumably if any state passed a law requiring the teaching of creationism in public schools, the universities and other teacher-training institutions in that state would be expected to offer courses in "creationist physics" as well as "creationist biology" and "creationist geology." This might be rather difficult since those "sciences" lack any empirical basis and for the most part have no coherent theoretical structure.

(6) *Philosophy of Science*

The Arkansas law includes the phrase "evolution cannot be experimentally observed, fully verified, or logically falsified." This reflects two standard creationist arguments, both fallacious but for rather different reasons. The first is that one can distinguish between "microevolution" —which can in fact be experimentally observed (e.g., industrial

years and should now be present as a background radiation at a temperature a few degrees above absolute zero. This prediction was confirmed by Penzias and Wilson in 1965 and is generally regarded as a crucial piece of evidence in favor of the big bang cosmology.

The second example is the theory of the origin of the moon advocated by Harold Urey and others in the 1960s. Urey argued that the moon was formed elsewhere in the solar system and captured by the earth, and that it has preserved on its surface a record of events that occurred billions of years ago. This, in his view, was the major justification for an extensive program of manned lunar exploration—that we could learn something about early solar-system history. But the Apollo program produced evidence that contradicted the detailed predictions of Urey's theory, and he eventually abandoned it in favor of the idea that the moon was spun off from the earth in a fission process.[12]

Many scientists think that creationism is unscientific because it is untestable, and this view is reflected in Judge Overton's decision.[2] At the same time they argue that the major tenets of creationism have been refuted. Is there an inconsistency here? Not if one distinguishes between creationism as a set of propositions and creationism as an activity of particular people. I would argue that creationism *was* a science in the 18th century, that it was decisively refuted in the 19th century, but that its 20th-century advocates behave unscientifically when they ignore the refuting evidence. In other words, creationism is testable, it has been tested, and it has been refuted. It can only be advocated as a pseudoscience.

But there is one last chance for creationists to show that their doctrine is a testable scientific hypothesis. Frank Tipler of Tulane University has worked out a consistent cosmological theory based on the hypothesis that the Universe began in 4004 B.C. with the explosion of numerous black holes.[13] Tipler's theory is also a variant of the "Omphalos" theory, but one which has testable consequences. In particular, it says that if we look out into space a distance of about 6000 light years we should see some evidence of these black hole explosions which created the Universe. There must be about 10^6 black hole explosions per second occurring at 6000 light years, with the number of explosions in the direction of the galactic center being about twice the number occurring in the opposite direction. Furthermore, the theory asserts that no black hole explosion can occur closer to the Earth than 6000 light years.

These are fairly definite numerical predictions, so if theorists knew exactly what a black hole explosion looked like, we could test this theory by simply looking for the predicted explosions. Unfortunately, calculating what a black hole explosion would look like involves understanding elementary particle physics at energies higher than our accelerators can reach. Thus, more research in elementary particle physics is needed before a definite test can be performed. However, on the basis of our current limited knowledge, we can guess that observations with a very sensitive gamma-ray telescope, probably placed in a space shuttle, are required. Testing the theory could be very expensive. But those who really believe in "creation-science" should be willing to pay the price to prove that their theory is a testable scientific hypothesis—and, of course, willing to take the risk that it will be disproved. Some aspects of the theory

should be appealing to the Moral Majority; it relies on the principle of "cosmic censorship" which prevents anyone from observing the "naked singularities" that result from black hole explosions. I suggest that Jerry Falwell should immediately start raising money from fundamentalists to finance this exciting program of theoretical and observational research on the creation of the Universe.

(7) *History of Science*

I am sometimes asked why I bother to get involved in the creation-evolution controversy, since scientists consider it a waste of time to argue with people who will never change their opinions in the face of contrary evidence. One answer might be that my own field, the history of science, is being misused to provide arguments for creationism. For example, creationists are intensely embarrassed by the fact that no reputable modern scientists support their theories, and so they claim that great scientists of the past were creationists. Morris recently published a list of scientists who had founded various disciplines and made great discoveries, and were allegedly creationists; the British physicist William Thomson, Lord Kelvin, appears on this list four times.*14* But Lord Kelvin actually repudiated creationism; he was a "theistic evolutionists" in modern terms.*15* Thus, as an historian of science, I can show that creationists are unreliable in their claims.

A more substantial reason for my interest in creationism is that it represents a reincarnation of a pre-modern worldview, and an opportunity to view a rerun of a famous 19th-century debate. The 1860 confrontation of Bishop "Soapy Sam" Wilberforce and T. H. Huxley is not just something to read about in a history book: I can observe and probe the Wilberforce mentality when a creationist speaker comes to my own campus. The idea that the universe was created for the benefit of man is not just an historical curiosity; it lives again in the writings of Henry Morris.*16*

Moreover, it is a challenging problem for historians to explain why creationism has been revived at this particular time. My view is that creationism is correlated with a complex of ideas and values which might be identified with a generalized cultural romanticism—a conservative, holistic viewpoint opposed to individualism and scientific rationality, always present but becoming dominant every 50 or 60 years.*17* Others (such as Lynda Ewen, at this meeting) point to connections with an economic crisis. Such explanations do not imply that we must accept the periodic recrudescence of creationism as inevitable, but they may help us to understand the nature of such movements so that we can deal with them more effectively.

Notes

1. Henry Morris (editor), *Scientific Creationism*, San Diego, CA: Creation-Life Pubs., 1974.
2. William Overton, "Creationism in Schools: The Decision in McLean versus the Arkansas Board of Education." *Science*, 215(1982):934-43.
3. Henry Morris, *The Remarkable Birth of Planet Earth*, Minneapolis, MN: Dimension Books, 1972, pp. 61-62.
4. F.C. Haber, *The Age of the World, Moses to Darwin*, Baltimore, MD: Johns

Hopkins Press, 1959, pp. 246-50; Martin Gardner, *Fads and Fallacies in the Name of Science*, 2nd ed., New York: Dover Pubs., 1957, pp. 124-27.

5. Gerald Skoog, "Topic of Evolution in Secondary School Biology Textbooks: 1900-1977" *Science Education*, 63 (1979):621-40.
6. Duschl's estimate is based on *Investigating the Earth* by Matthews et al., 3rd ed., New York: Houghton, Mifflin & Co., 1978, and the teacher's manual which outlines a teaching schedule for this text, an outgrowth of the original Earth Science Curriculum Project, sponsored by the American Geological Institute.
7. *Scientific Creationism*, p. 25.
8. S. G. Brush, "Finding the Age of the Earth: by Physics or by Faith?" *Journal of Geological Education*, 30(1982):34-58. The arguments given in this paper are sufficient to refute the latest creationist attack on radioactive dating: Theodore W. Rybka, "Consequences of time dependent nuclear decay indices on half lives," *Impact* No. 106, Institute for Creation Research, April 1982.
9. K. Popper, *Unended Quest*, La Salle, IL: Open Court, 1976, pp. 167-80.
10. K. Popper, "Natural Selection and the Emergence of Mind," *Dialectica*, 32(1978):339-55; "Evolution," *New Scientist*, 87(1980):611. R. E. Kofahl and H. Zeisel, "Popper on Darwinism," *Science*, 212(1981):873. W. J. Broad, "Creationists limit scope of evolution case," *Science*, 211(1981):1331-32.
11. Philip Kitcher, *Abusing Science*, Cambridge, MA: MIT Press, 1982.
12. S. G. Brush, "Nickel for your thoughts: Harold Urey and the Origin of the Moon," *Science*, 217(1982):891-98.
13. Frank J. Tipler, "Did the Universe begin in 4004 B.C.?" preprint, Departments of Mathematics and Physics, Tulane University, New Orleans, LA. 1982.
14. Henry Morris, "Bible-Believing Scientists of the Past," *Impact* No. 103, Institute for Creation Research, January 1982; see also *Men of Science, Men of God* (San Diego, CA: Creation-Life Pubs., 1982).
15. Address to the British Association for the Advancement of Science, 1871; reprinted in Kelvin's *Popular Lectures and Addresses*, and extracted in *Victorian Science*, edited by George Basalla, William Coleman and Robert H. Kargon (Garden City, NY: Anchor Books, 1970), pp. 101-28.
16. Morris, *op. cit.* (note 3) and elsewhere.
17. S. G. Brush, *The Temperature of History: Phases of Science and Culture in the Nineteenth Century*, New York: Burt Franklin & Co., 1978; "The Chimerical Cat: Philosophy of Quantum Mechanics in Historical Perspective," *Social Studies of Science*, 10(1980):393-447.

Minutes of the Annual Business Meeting
West Virginia Academy of Science
Room 413, Science Center
Davis and Elkins College
Elkins, West Virginia 26241

April 3, 1982 9:30 a.m.

President Nunley called the meeting to order.

Minutes of the 1981 Business Meeting were read by the secretary. Dr. Buckalew moved, Dr. Blaydes seconded, that the minutes be accepted. Motion passed.

Dr. Pauley gave the Treasurer's Report. Dr. Blaydes moved, Dr. Phillips seconded that the report be accepted. Motion passed. A copy of the report is attached.

President Nunley reported on the Executive Committee Meeting and reported the go-ahead to print the Index for Volumes 1-50 of the Proceedings. The Index will be Volume 51 number 4.

One death noted during the preceeding year, that of Dr. Eugene R. Arnold of Fairmont State College.

The nominating committee consisting of Joe Glencoe, Roy Clarkson, and Tom Meadors nominated Dr. B. Das Sarma of West Virginia State College for President-Elect 1982-83. Dr. Swiger moved, Dr. Phillips seconded that the nominations committee report be accepted. Motion passed. Nominations from the floor were called for. There were no nominations from the floor. The secretary was instructed to cast a unanimous vote for Dr. Das Sarma as President-Elect of the Academy for 1982-83.

The Academy was invited to have its 1983 Annual Meeting on the Glenville State College Campus on the suggested dates of April 15 and 16 1983. Motions to accept the invitation and suggested dates were passed.

Dr. Karl Fezer presented three proposed resolutions on the creation-evolution teaching controversy. Both typing and editing corrections were made on the resolution. Dr. Fezer moved, Dr. Swiger seconded that the amended resolution be accepted by the Academy. Motion passed with no dissenting votes. These resolutions are to be sent to Governor Jay Rockefeller, Dr. Roy Truby, the State Superintendent of Schools, Mr. Si Galperin, State Senate Education Committee Chairman, and Mr. Lyle Sattes, State House of Delegates Education Committee Chairman, to be used and distributed as they see fit. The corrected copy of the resolution is given below.

tionism is independent of biblical creationism, which they admit is religious, is demonstrably false. The consistently poor scholarship of their attempts to defend scientific creationism suggests that their dominating principle can be accepted on faith but is not compatible with scientific standards of reasoning. It is clear that scientific creationism and science are two distinct systems of thought. It should be noted that other religions, including other varieties of Christianity, are also distinct from science, but are compatible with it.

Scientific creationists have defined the issue in such a way that their point of view on one side is contrasted with all other points of view lumped together on the other side, even though some of these other points of view also consider themselves creationist. Their demand that public schools devote equal time and resources to scientific creationism is in effect a demand that their religion be accorded special status and that schools purchase large quantities of books from their publishing houses, even though these books demonstrably represent poor scholarship. It is an attempt to win by legislative decree what they have been unable to win through scholarly argument. Proposals for equal-time legislation are unwise.

Be it resolved that the West Virginia Academy of Science endorses and adopts the AAAS (American Association for the Advancement of Science) resolution on Forced Teaching of Creationist Beliefs in Public School Science Education. This resolution, adopted by the AAAS Board of Directors and AAAS Council in January, 1982, reads as follows:

> *Whereas* it is the responsibility of the American Association for the Advancement of Science to preserve the integrity of science, and
> *Whereas* science is a systematic method of investigation based on continuous experimentation, observation, and measurement leading to evolving explanations of natural phenomena, explanations which are continuously open to further testing, and
> *Whereas* the Association respects the right of people to hold diverse beliefs about creation that do not come within the definitions of science, and
> *Whereas* Creationist groups are imposing beliefs disguised as science upon teachers and students to the detriment and distortion of public education in the United States,
> *Be it resolved* that because "Creationist Science" has no scientific validity it should not be taught as science, and further, that the AAAS views legislation requiring "Creationist Science" to be taught in public schools as a real and present threat to the integrity of education and the teaching of science, and
> *Be it further resolved* that the AAAS urges citizens, educational authorities, and legislators to oppose the compulsory inclusion in science education curricula of beliefs that are not amenable to the process of scrutiny, testing, and revision that is indispensable to science.

Dr. Fezer was commended for the effort he made in assembling the resolutions.

The Academy expressed its thanks to Bob Urban and to Davis and Elkins College for a job well done in hosting the 1982 meetings. The meeting was adjourned at 10:10 a.m.

Creation—Science Resolutions (as corrected and approved)

Be it resolved that the West Virginia Academy of Science adopts the following position statement on the relation between science and religion, and on their places in science classrooms in public schools.

In the modern world, science is one important way of organizing human experience. That there are other important ways is evident from the existence of diverse religions and other nonscientific systems of thought.

Our nation requires well-trained scientists and scientifically literate citizens who understand the values and limitations of science. Therefore, science courses should not only convey the important conclusions of modern science, but should also help students to understand the nature of scientific thought, and how it differs from other modes of thought.

Teachers are professionally obligated to treat all questions as objectively as possible. Questions regarding the relation between science and various religions may arise. To the extent that a teacher feels competent to do so, he or she should be free to respond to such questions. It is appropriate to show why science limits itself to ways of reasoning that can only produce naturalistic explanations. However, teachers and students should be free to challenge the presuppositions of science and to question their adequacy as a basis for a religion or world view. Ideas offered seriously by students deserve a serious response. They will never be ridiculed by teachers with high professional standards. Furthermore, teachers should make it clear that students will be evaluated on their understanding of the concepts studied, and not on their personal beliefs regarding those concepts.

Dogmatic assertions are inconsistent with objective consideration of any subject. Science is always tentative and does not pretend to offer ultimate truth. Nevertheless, there is an overwhelming consensus among scientists that the earth is several billion years old, that living organisms are related by descent from common ancestors, and that interpretation of all available evidence by *scientific* standards renders contrary claims highly implausible.

"Scientific creationism," which does challenge these conclusions, is a point of view held only by those who insist that the principle of biblical inerrancy and perspicuity must take precedence over all scientific considerations. This viewpoint is religious. Their claim that scientific crea-

Be it resolved that the West Virginia Academy of Science commends the Education Committees of the West Virginia Senate and West Virginia House of Delegates for withholding support of "equal time for creation science" legislation (Senate Bill 40 and House Bill 1391) during the 1982 Legislative Session. "Scientific creationism" is not science and cannot be taught as such. Rather, it is a tenet of religious faith disguised as science. Furthermore, the Academy opposes all legislative efforts to mandate specific components in public schools curricula, or any specific balance between such components.

WEST VIRGINIA ACADEMY OF SCIENCE
ANNUAL TREASURER'S REPORT

1981

April 2, 1982
WVAS Annual Meeting
Davis and Elkins College
Elkins, West Virginia

January 1, 1981 to December 31, 1981

CASH RECEIPTS

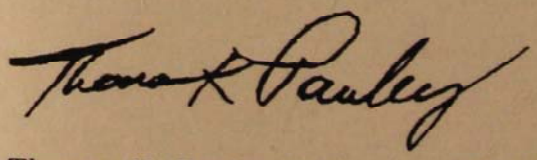
Balance on hand January 1, 1981		$ 7,694.96
Dues	$ 1,135.00	
Institutional Memberships	600.00	
Proceedings Sales	3,301.50	
Contributions	99.00	
Annual Meeting	371.00	
Page Charges	616.10	
Interest on Savings	471.89	
TOTAL RECEIPTS FOR THE YEAR	$ 6,594.49	
TOTAL RECEIPTS AND BALANCE ON HAND		$14,289.45

CASH DISBURSEMENTS

Printing (McClain)	$ 5,867.05	
Printing (Printech)	25.05	
Contributions	430.10	
Annual Meeting Expenses	446.44	
Postage	110.13	
Secretarial Help	20.00	
Supplies	53.71	
Miscellaneous	84.93	
TOTAL DISBURSEMENTS	$ 7,037.41	
RECEIPTS LESS DISBURSEMENTS	[$439.92]	
CASH ON HAND DECEMBER 31, 1981		$ 7,252.04

(Savings $820.19)
(Checking $2,431.85)
(Certificate of Deposit $4,000.00)

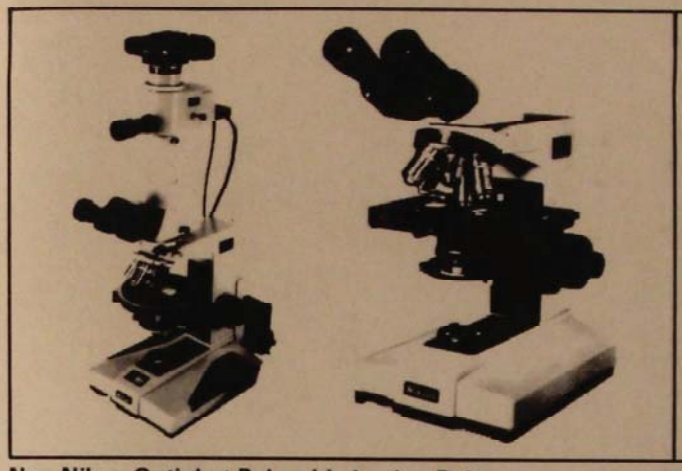
Respectfully submitted,



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, 1981 to December 31, 1981, and find them to be correct.

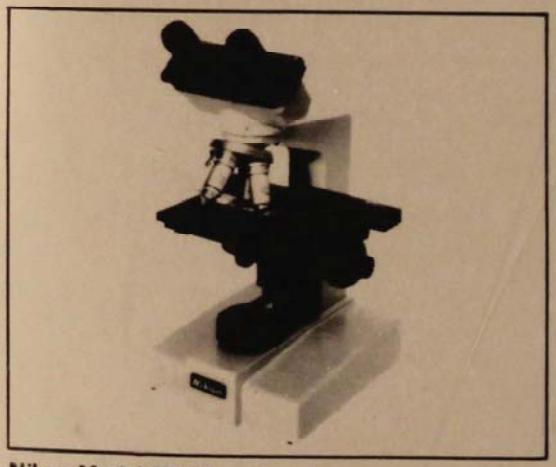
Richard L. Banks Loy R. Phillips David A. McCoun



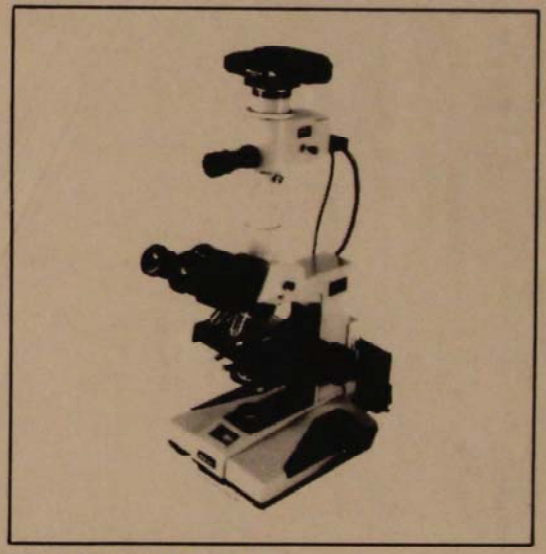
New Nikon Optiphot-Pol and Labophot-Pol polarizing microscopes:
These two surprisingly affordable microscopes utilize exclusive strain-free CF optics to deliver polarizing images of remarkable contrast, brightness and clarity. The sturdy stand and stage assemblies are so well designed that sharp focus is maintained even during manipulation or adjustment. Once centered, the objectives remain in perfect alignment without drift.

Nikon Labophot laboratory microscope:
New Nikon CF optics, plus sealed roller-bearing coaxial coarse and line focusing. Built-in Koehler-type/halogen illumination. High-eyepoint eyepieces with individual diopter adjustment. Completely new ultra-rigid body. Accepts many accessories plus Nikon photomicrography system.

Extend your vision with Nikon



Nikon Model SC laboratory / student microscope:
Newly designed flat-field optical system in quadruple rotating nosepiece. Wide-field high-eyepoint eyepieces, interpupilary and diopter adjustments. Tamper resistant design with special lock-in features. Substage rack and pinion gearing. Coaxial low-position stage controls. Priced to fit the most modest budget.



Nikon Optiphot research microscope:
New CF optics for unequalled brightness, color fidelity. Coaxial coarse and line focusing on roller bearings. True Koehler illumination system needs no adjustment during magnification changes. Removable 5-place nosepiece. Five body tube alternatives. Totally compatible with Nikon photomicrography system.

Preiser Scientific

PREISER

900 MacCorkle Avenue, S.W. Charleston, West Virginia 25303 Telephone: 304 / 344-4031

10101-D Bacon Drive
Beltsville, Maryland 20705
Telephone: 301 / 937-5150

804 N. Miami Boulevard
Durham, North Carolina 27703
Telephone: 919 / 688-5583

1500 Algonquin Parkway
Louisville, Kentucky 40201
Telephone: 502 / 636-3307

94 Oliver Street
St. Albans, West Virginia 25177
Telephone: 304 / 727-2902