ISSN: 0096-9222

PROCEEDINGS of the PENNSYLVANIA ACADEMY OF SCIENCE

Founded on April 18, 1924

VOLUME 58
Issue No. 1
1984

SHYAMAL K. MAJUMDAR, Ph.D., EDITOR
DEPARTMENT OF BIOLOGY
LAFAYETTE COLLEGE
EASTON, PA. 18042

60th Annual Meeting
Seven Springs Resort
Champion, Pennsylvania

SHYAMAL K. MAJUMDAR, Ph.D., *Editor*
Department of Biology
Lafayette College
Easton, Pennsylvania 18042

EDITORIAL COMMITTEE

Adam Anthony, Ph.D. — The Pennsylvania State University, University Park, Pennsylvania
Digamber S. Borgaonkar, Ph.D. — Wilmington Medical Center, Wilmington, Delaware
A. Ralph Cavaliere, Ph.D. — Gettysburg College, Gettysburg, Pennsylvania
Robert S. Chase, Ph.D. — Lafayette College, Easton, Pennsylvania
Robert F. Denoncourt, Ph.D. — York College of Pennsylvania, York, Pennsylvania
John J. Dropp, Ph.D. — Mount Saint Mary's College, Emmitsburg, Maryland
Richard W. Faas, Ph.D. — Lafayette College, Easton, Pennsylvania
Walter C. Farrell, Ph.D. — The University of Wisconsin-Milwaukee, Milwaukee, Wisconsin
Henry N. Fremount, Dr. PH. — East Stroudsburg University, East Stroudsburg, Pennsylvania
Bernard Fried, Ph.D. — Lafayette College, Easton, Pennsylvania
Warren J. Guy, Ph.D. — Lafayette College, Easton, Pennsylvania
Barry B. Hunter, Ph.D. — California University, California, Pennsylvania
Laylin K. James, Ph.D. — Lafayette College, Easton, Pennsylvania
Robert J. Lowry, Ph.D. — The University of Michigan, Ann Arbor, Michigan
Carolyn F. Mathur, Ph.D. — York College of Pennsylvania, York, Pennsylvania
Kenneth E. Michel, Ph.D. — Slippery Rock University, Slippery Rock, Pennsylvania
Mark S. Monmonier, Ph.D. — Syracuse University, Syracuse, New York
Howard S. Pitkow, Ph.D. — Pennsylvania College of Podiatric Medicine, Philadelphia, Pennsylvania
Hayden N. Pritchard, Ph.D. — Lehigh University, Bethlehem, Pennsylvania
Herbert P. Riley, Ph.D. — University of Kentucky, Lexington, Kentucky
Timothy W. Robbins, Ph.D. — National Environmental Sciences, Lancaster, Pennsylvania
Leonard M. Rosenfeld, Ph.D. — Thomas Jefferson University, Philadelphia, Pennsylvania
George A. Schnell, Ph.D. — State University College, New Paltz, New York
George C. Shoffstall, Jr., Ph.D.—Western Pennsylvania Hospital, Pittsburgh, Pennsylvania
William F. Skinner—The Pennsylvania Power and Light Co., Allentown, Pennsylvania
Louis T. Stableford, Ph.D. — Lafayette College, Easton, Pennsylvania
George C. Stephens, Ph.D. — George Washington University, Washington, DC
Guy L. Steucek, Ph.D. — Millersville University, Millersville, Pennsylvania
Roy Tasker, Ph.D. — Bucknell University, Lewisburg, Pennsylvania
Henry H. Vallowe, Ph.D. — Indiana University of Pennsylvania, Indiana, Pennsylvania
Thomas O. Wright, Ph.D. — Allegheny College, Meadville, Pennsylvania
William J. Yurkiewicz, Ph.D. — Millersville University, Millersville, Pennsylvania
Donald E. Zappa, Ph.D. — Vector Corporation, Pittsburgh, Pennsylvania

SUBSCRIPTIONS. Correspondence concerning subscriptions, purchase of single copies and back issues and related business should be addressed to the Treasurer, Ernest H. Braue Jr., Department of Chemistry, Pennsylvania State University, Mont Alto Campus, Mont Alto, PA 17237. Subscription price for non-member is $20.00 per volume. Checks should be made payable to the Pennsylvania Academy of Science. Foreign subscribers are requested to remit by international money order or a draft on a New York bank.
ADDRESS CHANGE. Notice of change in address should be received by the Secretary, Howard S. Pitkow, Department of Physiology, Pennsylvania College of Podiatric Medicine, Eighth at Race Street, Philadelphia, PA 19107, at least 40 days previous to the publication date. Lost copies, owing to change of address, cannot be supplied unless adequate notice has been given.
MISSING COPIES. Claims for missing copies should be sent to the Treasurer within 90 days of publication date. Such claims will be allowed only if the Academy or the printing company is at fault.
MEMBERSHIPS. Application is invited from persons with interest in the biological, medical, physical and/or social sciences. Applications are obtainable from the Secretary. Annual dues in the Academy are (a) Active members (scientist)—$15.00, (b) Associate member (non-scientist)—$15.00, (c) Student Member—$7.00, (d) Sustaining member—$20.00, (e) Institutional member—$25.00, (f) Life member—$200.00. Dues are payable in U.S. Currency.
MANUSCRIPTS. Papers submitted for publication will normally have been presented at the spring meeting of the Academy. Two copies of manuscripts in completed form must be submitted to the Section Chairman for transmittal to the Editor at the time of presentation of papers. Manuscripts submitted at other times and correspondence relating to publication in the *Proceedings* should be addressed to the Editor, Daniel Klem, Jr., Department of Biology, Muhlenberg College, Allentown, PA 18104. Submission of the manuscript is a representation that it has not been published, copyrighted or submitted for publication elsewhere. The PAS, the editorial committee members and the editor assume no repsonsibility for opinions and/or statements expressed by authors.
See "Suggestions to authors" in this issue of the *Proceedings*.
REPRINTS. Reprints of papers in the *Proceedings* are obtainable only from the authors or their institutions.
NEWS AND NOTES. Announcements about meetings, personnel changes and other items of interest to the Academy should be sent directly to the Editor of the Newsletter, Kurt Schreiber, Duquesne University, Pittsburgh, Pennsylvania 15219.
Copyright 1984 by the Pennsylvania Academy of Science, Inc.

ISSN: 0096-9222

PROCEEDINGS of the PENNSYLVANIA ACADEMY OF SCIENCE

VOLUME 58
Issue No. 1
1984

SHYAMAL K. MAJUMDAR, Ph.D., EDITOR
DEPARTMENT OF BIOLOGY
LAFAYETTE COLLEGE
EASTON, PA. 18042

60th ANNUAL MEETING
PENNSYLVANIA ACADEMY OF SCIENCE
MARCH 30 - APRIL 1, 1984
SEVEN SPRINGS RESORT
CHAMPION, PENNSYLVANIA

Printed by

TYPEHOUSE
481 Memorial Parkway
Phillipsburg, NJ 08865
(201) 454-1155

ISSN: 0096-9222

CONTENTS

President of the Academy—Dr. George C. Shoffstall, Jr. 3
Program of the 60th Annual Meeting 4
The Honorable Governor Richard Thornburgh's Greetings 5
The Pennsylvania Academy of Science President's Address 6
Executive Committee Meeting 7
Academy Business 11
Executive Council Meeting 23
BIOLOGY: Lectin Interactions with Biomembranes: A Survey—*Darryl L. Landis and William J. Yurkiewicz* 29
BIOLOGY: An Aging Scheme for the Pine Vole, *Pitymys pinetorum scalopsoides*—*Tyrone R. Cornbower and Gordon L. Kirkland, Jr.* 37
BIOLOGY: A Survey of the Furbearers of the Codorus Drainage, York County, Pennsylvania—*Gordon L. Kirkland, Jr. and Edwin C. Gillman* 42
BIOLOGY: Correlation of Blood Glucose and Cholesterol with Social Rank and Testosterone Repalcement in Male Hamsters *(Mesocricetus auratus)*—*Fred J. Brenner and Sharon K. Bradley Wirtz* 47
BIOLOGY: A Survey of the Mammals of the Wattsburg Fen Natural Area—*Steven J. Ropski and Kenneth W. Andersen* 53
BOTANY: Vascular Riffle Flora of Appalachian Streams: The Ecology and Effects of Acid Mine Drainage on *Justicia americana* (L.) Vahl—*Michael Koryak and Rosemary J. Reilly* 55
BOTANY: Effects of Edge, Age, and Cover Type on Wildlife Microhabitats in Even-Aged Forest Stands in Central Pennsylvania—*Richard H. Yahner and Jeffrey W. Grimm* 61
BOTANY: Growth Rates of Norway Spruce *(Picea abies)* from 46 Diverse Seed Sources Studied in Maryland's Appalachian Region—*John B. Genys, Dan M. Harman and Kent B. Fuller* 67
ENTOMOLOGY: The Influence of Phorid and Sciarid Populations on Mushroom Yield at Commercial Mushroom Farms in Pennsylvania—*D. L.Rinker, R. J. Finley, P. J. Wuest, R. Snetsinger, R. Tetrault and D. J. Royse* 70
GEOGRAPHY: Trends in the Distribution of Black and White Populations During the Seventies—*George A. Schnell* 73
GEOGRAPHY: Maps in *The New York Times,* 1860-1980: A Study in the History of Journalistic Cartography—*Mark Stephen Monmonier* 79
GEOLOGY: Pressure Solution Shortening in the Martinsburg Slate, New Jersey—Eric Erslev and Carol Mann 84
PHYSIOLOGY: Interaction of Metallic Ions with Red Blood Cells and Stroma—*Robert Weisbrod, David Zercher, Gerald Hess and Ray H. Crist* 89
BIOLOGY: Preliminary Study of the Ectomycorrhizal Distribution of White Oaks in Eastern Pennsylvania Forests—*L. Mineo, S. K. Majumdar, G. Rall, J. Francis, A. Segal and A. Mrowca* 92
RESEARCH NOTE: *Oreochromis aureus* (Steindachner: Cichlidae), An Exotic Fish Species, Accidentally Introduced to the Lower Susquehanna River, Pennsylvania—*William F. Skinner* 99
RESEARCH NOTE: Sex, Age, and Dressed Weights of Hunter-Killed Sika and White-Tailed Deer from Assateague Island, Maryland—*Ronald R. Keiper, Joel Stephens and David Baldwin* 101
RESEARCH NOTE: Long Term Profits: A Difference Equation Model—*R. F. Melka* 103
Abstracts 107
Pennsylvania Academy of Science Constitution 121
Suggestions to Authors 125

DR. GEORGE C. SHOFFSTALL, Jr., PRESIDENT PENNSYLVANIA ACADEMY OF SCIENCE 1984 - 1986

Dr. George C. Shoffstall, Jr., President of the Pennsylvania Academy of Science (1976-78 and 1984-86) came to The Western Pennsylvania Hospital from The Pennsylvania State University where he was Assistant to the Dean in the College of Science (1966-80). Dr. Shoffstall served as President (1981-82) of The National Association of Academies of Science being elected at its Annual Meeting in Toronto, Canada. He was also named a Fellow in the American Association for the Advancement of Science and is currently serving on the AAAS Council (1984-86).

Active at the national and state levels, Dr. Shoffstall holds a doctorate in radiation biology from The Pennsylvania State University. Named an Outstanding Educator in 1975, Dr. Shoffstall is listed in *American Men and Women in Science, Who's Who in the East, Who's Who in Training and Development, Community Leaders of America, 11th ed.,* and the *1981 Directory of Distinguished Americans.*

Along with the American Association for the Advancement of Science and the Pennsylania Academy of Science, his memberships include the Association for the Advancement of Medical Instrumentation, American Society for Training and Development, National League for Nursing, Pennsylvania League for Nursing, Pennsylvania Association for Medical Education and Smithsonian Associates.

60th ANNUAL MEETING
MARCH 30 - APRIL 1, 1984

Time and Place Chairman
Dr. William Uricchio, Carlow College

Program Chairman
Robert F. Denoncourt, York College of Pennsylvania

EXHIBITORS

American Optical Instrument Div.
Carolina Biological Supply Co.
Connecticut Valley Biological Supply
Fisher Scientific Company
Sargent-Welch Scientific Company

FRIDAY, MARCH 30, 1984

1:00 P.M.—Executive Council Meeting ..... Directors Room #2
4:00-7:00 P.M.—Exhibits ..... Five Seasons Room
4:30-7:00 & 8:00-9:00 P.M.—Registration and Room Check-In ..... Main Hotel Lobby
6:00-8:00 P.M.—Dinner ..... Tyrol Room
8:00-9:30 P.M.—SYMPOSIUM ..... Sunburst Forum
ENDANGERED SPECIES
Fred Brenner, Chairperson
9:45 P.M.—Wine & Cheese Social ..... Dupre Room

SATURDAY, MARCH 31, 1984

7:00-8:15 A.M.—Breakfast ..... Oak Room
8:15 A.M.-3:00 P.M.—Registration ..... Dupre Lobby
8:15 A.M.-1:30 P.M.—Exhibits ..... Five Seasons Room
8:30-9:45 A.M.—PAS BUSINESS MEETING & ELECTION OF OFFICERS ..... Snowflake Forum
10:00-11:00 A.M.—Geography (papers #8-11) ..... Fox Den
10:00 A.M.-Noon—Botany (papers #16-23) ..... Sunburst Forum
10:00-11:45 A.M.—Aquatic I (papers 24-30) ..... Snowflake Forum
11:15 A.M.-12:15 P.M.—Engineering (papers #12-15) ..... Fox Den
10:30 A.M.-Noon—Poster Session (papers #1-3) ..... Five Seasons Room
1:15-2:15 P.M.—PLENARY SESSION ..... Sunburst Forum
Speaker: Dr. Nicholas Short
Topic: "Remote Sensing from Space—The New Approach to Managing Our Earth's Resources"
2:15-5:30 P.M.—EXHIBITS ..... Five Seasons Room
2:30-4:45 P.M.—Poster Session (papers #4-7) ..... Five Seasons Room
2:30-3:45 P.M.—Behavioral Science (papers #31-35) ..... Fox Den
2:30-3:45 P.M.—Instructional Applications (papers #36-40) ..... Sunburst Forum
2:30-3:45 P.M.—Aquatic II (papers #41-45) ..... Snowflake Forum
4:00-5:15 P.M.—Medical/Physiology (papers #46-50) ..... Fox Den
4:00-5:15 P.M.—Ornithology (papers #51-55) ..... Sunburst Forum
6:00-7:00 P.M.—Social Hour ..... Five Seasons Room
7:15-8:45 P.M.—DINNER ..... Alpine Room
8:45 P.M.—PLENARY SESSION ..... Sunburst Forum
Dr. Nicholas Short
"A Pictorial Tour of the World's Great Scenery from Space"

SUNDAY, APRIL 1, 1984

7:30-9:00 A.M.—Breakfast ..... Oak Room
8:30-10:00 A.M.—Registration ..... Dupre Lobby
8:30-10:30 A.M.—Exhibits ..... Five Seasons Room
9:00-11:20 A.M.—Biochemistry/Cell Biology (papers #61-67) ..... Fox Den
9:00-10:40 A.M.—Mammalogy (papers #68-72) ..... Sunburst Forum
9:00-11:00 A.M.—Geology (papers #73-78) ..... Snowflake Form
10:30 A.M.—Executive Council Meeting ..... Directors Room #2
By 1:00 P.M.—ROOM CHECK-OUT ..... Main Hotel Lobby

COMMONWEALTH OF PENNSYLVANIA
OFFICE OF THE GOVERNOR
HARRISBURG

GREETINGS:

As Governor of the Commonwealth of Pennsylvania, I am pleased to extend hearty congratulations to the members of the Pennsylvania Academy of Science on the occasion of the Academy's 60th anniversary.

Scientific advancement is vitally important to the progress of the Keystone State, especially in this time of advanced technology and increased automation. For the past 60 years, the Pennsylvania Academy of Science has promoted an interest in science and scientific research, and it is, indeed, fitting that we recognize the worthwhile purpose of the Academy in meeting the unique challenges of science and its vital role in improving the quality of life for us all.

On behalf of all Pennsylvanians, I offer best wishes for many more successful years for the Pennsylvania Academy of Science.

Dick Thornburgh
Governor

DR. GEORGE C. SHOFFSTALL, JR.
President, Pennsylvania Academy of Science

PRESIDENT'S EDITORIAL

"The best use of a journal is to print the largest practical amount of important truth—truth which tends to make mankind wiser, and thus happier." Horace Greeley stated that. Dr. Shyamal K. Majumdar enforced that.

As Editor of the PAS *Proceedings*, Dr. Majumdar was outstanding. His relentless efforts brought excellence to the *Proceedings.* With his editorial expertise and professional acumen, Dr. Majumdar certainly earned international respect for his work in bringing to the world the same quality of editorship in our PAS textbooks, i.e., *Energy, Environment, and the Economy* and *Pennsylvania Coal.* The later under joint editorship with PAS Past-President E. Willard Miller. Soon to follow are three volumes on "Nuclear, Hazardous and Solid Wastes" which, too, will enhance the Academy's presence in the scientific community. He is indeed a fine person who did a fine job as editor of the *Proceedings* and has earned the respect of us all.

Thank you Dr. Majumdar.

PRESIDENT'S MESSAGE

Having served as President of the National Association of Academies of Science (1981-82), the Pennsylvania Academy of Science (1976-78), currently serving as a member of the AAAS Council (1983-86), and again as the President of Pennsylvania Academy of Science (1984-86), I have noted many emerging issues in science and technology which have sought or are continuing to seek answers. Themes such as: limited financial support for R&D; how to stimulate and encourage private sectors to implement new technologies which will increase productivity and international competitiveness of U.S. industry; crises in science and math education; industry/government/academia relations; membership declines; were only a few of the focal points on any agenda. One issue, chronically discussed, is the lack of technological literacy among the citizenry. Moreover, the 1983 Council for the Understanding of Technology in Human Affairs notes that the paramount issue in science and technology education today is the enhancement of scientific literacy for the populace.

Ironicaly, we are living in an increasingly visual culture. People who originally got much of their general information from speaking, reading or listening to radio, are now getting their facts from TV and computer screens. Broadly speaking, new networks and combinations of computers, data bases, telephones, satellites, and cable transmission systems are rapidly evolving. Accordingly, some observers believe this new revolution in technology could ultimately have the same impact on our world as did the Industrial Revolution.

The scientific community, by virtue of its analytic mystic and its science-techno jargon, is viewed consciously or unconsciously as the one responsible group for creating the immense technological problems confronting society today. TV sitcoms and tabloid journalism have been blamed in creating this hiatus. The real problem is that educated, intelligent, inquisitive people are consistently unable to bring informed judgement to bear on questions connected, in almost any way, to science and/or technology. Interestingly, it is viewed at the national level, that academies of science have a role in ameliorating and dispelling these beliefs—real or contrived—but this will require financial support from their states in order to help accomplish this mission.

By charter, the Pennsylvania Academy of Science is accorded a powerful voice in the Commonwealth of Pennsylvania regarding its scientific affairs. Certainly, in its sixty (60) years of existence, the Academy can retrospectively reflect on its many accomplishments—to cite a few: the *PAS Proceedings*—in no other publication is there such a wealth of information concerning the scientific affairs of this state; the Pennsylvania Junior Academy of Science—the PJAS has grown in it first fifty (50) years to be considered one of the finest in America; regional symposia—the PAS has hosted a plethora of highly acclaimed symposia on such topics as TMI, Radioactive and Hazardous Wastes, Endangered Species, etc; textbook publications—its publications on *Energy, Environment, and the Economy, Pennsylvania Coal,* and forthcoming textbooks on *Radioactive, Hazardous, Liquid and Solid Wastes Disposal* are classics.

Ergo, it would appear from a science policy perspective that the PAS has found a niche in the scientific community and to this end we are committed. However, to continue our accomplishments and venture into new horizons, long range planning is essential to establish direction, focus on actions, heighten communication and to insure growth and stability.

It is inevitable that new sources of income and long range financial support must be sought. Tradition should *not* be the adversary of innovation! Moreover, if the PAS is to continue serving the Commonwealth of Pennsylvnania and to fulfill its goals in the scientific community effectively, then old members must be encouraged and new members must be actively sought to grow with the Academy. Truly, it is incumbent upon all academy members to solicit among your professional peers membership into your organization. Membership must be sought from every conceivable sector of the scientific, engineering and technological community if the PAS is to play a leadership role in its scientific expertise during its next sixty (60) years.

MINUTES OF THE PENNSYLVANIA ACADEMY OF SCIENCE EXECUTIVE COUNCIL MEETING FRIDAY, MARCH 30, 1984 SEVEN SPRINGS, CHAMPION, PA

I. Old Business:

The 60th annual meeting of the Pennsylvania Academy of Science convened on March 30, 1984 at 1:05 p.m. in the Directors' Room No. 2. President Stanley Zagorski presiding.

Members present were: Stanley J. Zagorski, George Shoffstall, Kurt Schreiber, Shyamal Majumdar, Robert Halma, Bruce Martin, Ernie Braue, Michael Buckholtz, William Uricchio, Fred Brenner, Sherman Hendrix, Carl Oerlein, Sister Gabrielle, Ted Zeigenfus, George Boone, Carolyn Mathur and Viola Yakstis.

A. Minutes of October 27, 1983 meeting held at the Marriott Hotel, Monroeville, Pennsylvania were sent to the members by mail. Stanley Zagorski asked for acceptance of the minutes. Bill Uricchio made a motion and George Shoffstall seconded that the minutes be accepted. Motion carried.

B. Constitutional revisions were made and reprinted in booklet form and passed out to the members. The new revisions are noted by an asterisk. A copy of the revisions is attached in the back of the booklet.

C. The subject of Disposition of House Bill 56 has come up once more. George Shoffstall, Stanley Zagorski,and Sister Gabrielle have all spoken to people in Harrisburg and have not received a definite answer as to when we can expect the money which the above-noted people have fought for so long. It seems that it is politically motivated and will take some time before we can expect results.

Dr. Shoffstall stated that he has spoken with certain individuals in Harrisburg, people of the Appropriations Committee, etc. Promises were made and hopefully, they will be kept. The new officers will try to use a new approach on this subject.

D. Revisions were made of Brochures with dues changes. These were distributed at this meeting; 1,500 were printed and hopefully, will be distributed to people who will bring in new members.

E. Marketing of Coal Book—Bob Halma stated that he has contacted the Literary Marketplace which is the handbook for publishers to find out what firms would market books, advertise books and sell books and also would do with academic type books. Sent letters to these publishers, and they want mailing lists and would not take say 500 books for selling. They all want cash up front before they do anything for us.

Dr. Majumdar sent some complimentary books to different literary journals and expects some answers from them.

Very good suggestions were given on this subject by Dr. Uricchio, Dr. Majumdar, Mr. Zagorski and Bob Halma. All these suggestions will be taken into consideration and a decision will be made.

F. Office space in Harrisburg. Dr. Shoffstall stated that there is a possibility and feasibility of having an office next to the Governor's Mansion in Harrisburg, Pennsylvania. The price tag on this office is $150 to $200 a month. Sister Gabrielle and George have looked at many places in Pittsburgh and they were all found to be too expensive for our budget. People who have this place are promotors in the complex. We can have access to the Board Room (on short notice) for meetings and we will have our private telephone line which will answer to "Pennsylvania Academy of Science". Mail that will be sent to this address will be kept bundled and sent to whomever is designated to receive this mail. The address in Harrisburg is: 2101 North Front Street, Harrisburg, Pennsylvania, 17110. Stanley asked that a motion on this item be postponed until the new business on this particular item comes up.

II. New Business.

A. Reports of Officers and Committees

1. President—S. Zagorski

The President of the Pennsylvania Academy of Science has had a very busy, active twelve months since his last report to the Executive Committee. In addition to the day-to-day correspondence and communications on behalf of the Academy he has met with members of Hammermill Company, traveled to Harrisburg to meet with members of Governor's Energy Council, promotion of the Coal Book, wrote to Senators, the Governor, Lt. Governor and members of the House on the House Bill 56; met with people of the Pennsylvania Department of Environmental Resources; gone to Pittsburgh to meet with the President-Elect to discuss the agenda for this meeting; had a telephone conversation with Program Chairperson of PSTA, etc.

2. President-Elect—G. Shoffstall

The President-Elect and Executive Secretary has actively served on, and/or chaired, numerous committees germane to the enhancement of the Academy and the promulgation of the philosophies therein. Moreover, with the concurrence of President Zagorski, the President-Elect has pursued missions, objectives, programs, memberships and resource strategies

of the Academy as deemed necessary.

3. Immediate Past-President—Dr. Martin

The Immediate Past President has actively served the Academy during 1983-1984 by pursuing activites assigned by the President in keeping with the goals and philosophies of the Academy for the promotion of Science in the Commonwealth.

4. Secretary—D. Ostrovsky

The mailing list has been kept up-to-date and everything has been done to make the transition to a new corresponding secretary as easy as possible.

Before proceeding with Reports of officers and committees, the President read some favorable letters he received from certain organizations, etc.

He also mentioned that Dr. Ostrovsky has sent a letter of resignation. The President has accepted his resignation with regret.

5. Recording Secretary—V. Yakstis

During the past year, the recording secretary has been busy transcribing tapes of meetings, typing the new revised constitution and taping minutes of the October meeting and the Spring meeting.

6. Treasurer—M. Buckholtz

Mike presented his lengthy report to the members. The organization has a total of $70,509.68 assets. His report will be published in its entirety in report of Annual Business Meeting. Mike has stated that Dr. Oerlein donated to the Academy stock in the Cleveland Illuminating Company and that made the net worth of the stock close to $3,500.

Since Mike is going out of office, the President thanked Mike and Ernie Braue for a job well-done.

7. Editor of Proceedings—Dr. Majumdar

Dr. Majumdar reported that the Volume 57, No. 1 of the proceedings was published in October 1983. The No. 2 issue will be published in April 1984. *Pennsylvania Coal* was published in July 1983. There were 312 books sold. The third book *Hazardous and Toxic Wastes* was published in March 1984. *Solid and Radioactive Wastes* are being edited as of this meetings.

There is a slight storage problem for the books that have not yet been sold. There is also a Pennsylvania Environmental Council; one office in Pittsburgh and one in Pennsylvania that perhaps could help us to market some of our latest books.

Dr. Majumder and Dr. Miller were thanked for their efforts on the newest publication of PAS. It was well done and authoritative.

8. Editor of the Newsletter—Dr. Schreiber

Five issues were published of the Newsletter with a total of 68 pages. This rate of publication will continue for the coming year. A suggestion was given by Dr. Schreiber to change to a May publication date which means a timely report could be given to the membership about the activities and actions of the annual meeting. This action will be voted on in the New Business category.

The August issue will contain the full details of the fall symposium. The October issue will contain the call for papers and would also be a last minute reminder of the Fall Symposium.

9. Director of the Pennsylvania Junior Academy of Science—C. Myers

Was not present but his report was given to Mr. Zagorski to pass out. He stated in his report that his fifth year as State Director of PJAS is coming to a close. He reported on the state meetings, activities of the regions, and general report of the Director for the year.

The President of the PAS is disturbed by the absence of the Director of PJAS. Regardless of reason an alternate should have been sent to represent him. The reprimand of State Director will be taken to the Directors meeting on Sunday night, April 1, 1984. The Director has not been present at three meetings and Constitution calls for him to attend all meetings of PAS.

10. Historian—R. Halma

Historian reviewed book jobbers and marketing firms in the *Literary Marketplace.* Several firms, in turn, responded to Dr. Majumdar but none were willing/interested in acting as an agent without "up front" money.

Contact was also made with several firms about producing PAS desk calendars.

11. Membership—G. Boone

Membership Chairman reported that he undertook a drive to increase our number of Life Members. They are 15 in total. Approximately 700 calls for paper posters were mailed in October. Approximately 700 membership posters were mailed in January. Inquiries were received from college science students seeking information on memberships.

12. Director of the Pennsylvania Talent Search—Dr. Schreiber

The 43rd Annual Science Talent Search was conducted by the Science Service in Washington, D.C. this January. 44 entries were from Pennsylvania. The 1984 Pennsylvania Science Talent Search is just in the process of being completed.

13. Fund Raising—Sister Gabrielle

Sister stated that the House Bill 2537 was changed to House Bill 56. Took four students to the American Academy of Science in Detroit. This year the students will present papers in New York. Sister, Dr. Shoffstall and Dr. Majumdar will attend the X Session of the AAAS meeting in New York City. She reported that she sold 100 Coal Books at $30.00 a book. Two organizations donated $500 toward the jubilee celebration: Spectroscopy and Analytical Chemists.

Sister reported that we may receive money from the Appropriations Committee in Harrisburg sometime in June.

14. Convention Committees:

a. General Chairperson—Dr. Schreiber and Dr. Martin.

Dr. Schreiber reported that this year we have 79 people presenting papers and we had only 6 Exhibitors, as opposed to 100 paper presentations last year and 11 exhibitors couple of years ago. Dr. Shoffstall interjected that the same declining trend is happening in other states this year. Perhaps we could establish new ways of attracting people to these presentations.

b. Program chairpersons—R. Denoncourt—C. Mathur

Total of 78 papers were scheduled for presentation. This represents 20% decrease over 1983. Membership is asked to encourage the presentation of good research and submission of manuscripts. The Friday evening Symposium on Endangered Species chaired by Fred Brenner is ready for presentation. The Saturday afternoon presentation by Dr. Nicholas Short "Remote Sensing from Space—The New Approach to Managing our Earth's Resources" will also be an informative presentation to all.

c. Time and Place chairman—W. Uricchio

60th Annual meeting of PAS is taking place today, March 30, and April 1. Senior Academy is meeting alone with Junior Academy following on Sunday, Monday and Tuesday.

The 61st annual meeting will take place at Host Farm in Lancaster, Pa. on Sunday, April 21 to Tuesday, April 23, 1985. This is a joint meeting.

Chairman is continuing to evaluate various reports and convention centers for future meetings.

We will get an extra meal next year at Host Farms. Same package as this year.

d. Symposium—F. Brenner

The 1984 Annual Meeting Symposium is on Endangered Species. All speakers were asked to bring complete manuscripts to the meeting. The symposium chairman would like to develop a book on this theme with S.K. Majumdar and F.J. Brenner as co-editors.

e. Exhibitor chairman—T. Ziegenfus

Sent 41 letters to scientific supply houses and/or textbook companies. Only 7 replies were received. Five companies are exhibiting at this meeting.

Given that the 61st PAS/PJAS meeting, April 21-23, 1985 will be held at Host Farms, Lancaster, PA. Dr. Ralph Cavaliere will serve as co-chairperson of the Exhibits Committee.

f. Registration and local arrangements—K. Schreiber. Report was given earlier on this subject.

15. Research Grants—Sherman Hendrix

The Grants committee has received six applications for funds to support secondary school student research. Three of these were funded. One proposal was returned by the committee for being too vague, one is pending and one was withdrawn by the applicant.

16. Advisory Council—No report.
17. Auditing—No report as yet.
18. Special awards—no report.
19. Industrial Relations—no report.

B. Fall Symposium 1984 -

Fred Brenner suggested that we continue with the Fall Symposium. We should continue with Endangered Species. PSTA also wants us to continue our affiliation with them and have a fall symposium. Symposium seems to be an agreeable issue with everyone present, and pursue the issue of Endangered Species. Dr. Uricchio made the motion to have the symposium and have Fred Brenner chair it. Seconded by Sherman Hendrix. Motion carried.

C. Nomination Report—Bruce Martin -

Nominations and renominations sought at this meeting are, President-Elect, Treasurer, Assistant Treasurer, Corresponding Secretary and Editor of the Proceedings. Nominating Committee sought the nominees for offices in the fall of 1983 in the following three newsletters with the help of Dr. Schreiber, and in December concluded the slate of candidates to be presented before the membership in Spring of 1984. The following is the entire slate of candidates: President, two-year term, Dr. Shoffstall, President-Elect, two-year term, Dr. Shyamal Majumdar, Immediate Past President, two-year term, Stanley Zagorski, Corresponding Secretary, two-year term, Dr. Pitkow, Treasurer, two-year term, Ernest Braue, Assistant Treasurer, Sherman Hendrix, Editor of Proceedings, four-year two candidates, Daniel Klem, Jr. and Leonard Rosenfield. The officers to be placed before the membership are: President-Elect, Treasurer, Assistant Treasurer, Corresponding Secretary and Editor of the Proceedings. By constitution the offices of President and Immediate Past President are assumed by the incumbent president, etc. and are not voted on by the membership. Elected officers will assume their positions immediately following the Annual Business Meeting. To complete the executive offices of the Academy, the following are confirmed as continuing until the expiration of their terms: Historian -four-year term, Bob Halma; Editor of the Newsletter, four-year term, Kurt Schreiber, Director of PJAS, Clarence Myers, three-year term, expires in 1985 and Recording Secretary, Vi Yakstis, 1985. Two positions expire next year. Ballots will be available for voting. George Boone made a motion to accept the aforementioned slate of candidates to be presented to the membership. Sherman Hendrix seconded. Motion carried.

D. Alternate Meeting Place for Fall Meeting 1984.

Letter was received from New York inviting us to have one of our meetings there, but the Executive Council opposes such a switch since we are the Pennsylvania Academy of Science and wish to have our meetings in the State of Pennsylvania. Mr. Zagorski will reply to this invitation.

E. Fall Meeting with PSTA and or the Pennsylvania Wildlife Society.

Since we have already voted to be affiliated with the Pennsylvania Wildlife Society at our Fall meeting, they are now requesting from us to have a joint meeting with them in the spring. The Wildlife society is planning their meeting in April 1985 and if they do not meet with the Academy they will meet at the State College area. Fred Brenner will pursue this issue with the Wildlife Society for a joint meeting sometime in spring of 1986.

F. Resource Office for Low Level Radioactive Waste (letter).

President Zagorski read a letter from Penn State concerning the above-mentioned topic. Letter given to the interested parties.

G. Annual Register of Grant Support letter

Response to this letter will be negative.

H. Responses from State Legislators on the Publication of the Coal Book Steve Sventy, from the Pittsburgh area, promised to help us, and has been helping us. After sending 400 books to the legislators, we received only three replies about the Coal Book, all favorable.

I. Honorary Membership

Nothing new to report

J. Motions and New Proposals

The President read another letter from Marine Science Consortium. They are asking if they could use our letter as a vehicle for recruitment, to publicize their college workshops, etc. The letter will be answered by the President.

Two more letters were received: one from the Governor and the other from the Lt. Governor, why they could not attend the meeting. Governor sent a letter of congratulations to the PAS and PJAS, copies of which were distributed to the membership and the same will be done at the PJAS meeting on Sunday.

Correspondence also was received from Rosemary Kuhn, President of PSTA stating the fact, she will attend the meeting of PAS this spring.

K. A suggestion was made earlier in the meeting about changing the Newsletter publication from April to May and from July to August. This is now made in a form of motion and has been seconded. Discussion ensued. Motion carried.

Sherman Hendrix was appointed Chariman of the Ad Hoc committee to pursue The Environmental Energy Council and coordinate same. Dr. Majumdar and Dr. Brenner agreed to help him.

A suggestion was made to Carolyn Mathur as chairman of the 1985 Annual Meeting to include a workshop at the Host Farms meeting, to attract more exhibitors. A workshop may prove more interesting and conductive to our meeting. This will be in conjunction with paper presentation, or alone. Carolyn was asked to survey this idea and it has been, at this time, tabled until the fall meeting.

Items for follow-up:

1. Carolyn will pursue what we suggested in regard to workshop program.
2. Office space in Harrisburg. Dr. Schreiber made a motion that we go for the office space in Harrisburg, brought up by Dr. Shoffstall earlier in the meeting. Dr. Majumdar seconded. Motion passed. Dr. Shoffstall was given the authority to go ahead with renting the space in Harrisburg. The rent is $2,000 a year. The PAS will pay half and Sister Gabrielle will write to Mrs. Castro to pay the other half. Motion made by Dr. Schreiber to appropriate money from our treasury if we cannot get any grants or funds from anywhere else. Dr. Boone seconded the motion. Motion carried.

L. Other:

The President stated that Sister Gabrielle received gifts of $500 each from the Spectroscopy Society and Society for Analytical Chemists to use for the 60th anniversary program. Stan presented a memento to everyone of the Executive Council as a remembrance of the 60th Anniversary of PAS.

No further pressing business to discuss. The meeting was adjourned at 4:36 p.m. Motion was made by Dr. Schreiber and seconded by Dr. Boone for adjournment. Motion carried.

Respectfully submitted,
Viola Yakstis, Recording Secretary

MINUTES OF THE ANNUAL BUSINESS MEETING SATURDAY, MARCH 31, 1984 SEVEN SPRINGS, CHAMPION, PA

The 60th Annual Business Meeting of the Pennsylvania Academy of Science was opened by the President, Stanley J. Zagorski at 8:35 a.m. in the Snowflake Forum Room. The President greeted and welcomed the members.

I. Old Business

A. The President stated that the Minutes of the October Meeting were approved by the Executive Council which met last night in the Directors Room. The October meeting was held at the Marriott in Monroeville, Pennsylvania. President asked for approval of the minutes.

B. Constitutional Revision. The minutes also approved the change in the Constitution as to Emeritus and Honorary memberships. Constitutional revisions will now be implemented and they will be for your review in the Proceedings.

C. Disposition of House Bill 56. House Bill 56 is now in the Appropriations Committee. For your information, House Bill 56 is an allocation to the Pennsylvania Academy of Science in the amount of $150,000, and in support of the Junior Academy of Science to help defray the cost of publications and running of the Academy itself. It has its third reading and at this particular time is being held in the House Appropriation Committee in Harrisburg. We should know very shortly whether that bill will be passed or not. If you have any friends in the house, please write to them on behalf of the Academy.

D. The approval last year of dues changes can be found in the brochure which was just published. All of you have been informed via the Newsletter also of the increase in dues of $5.00. These are all the items that were on the Old Business item.

II. New Business

A. Reports of Special Officers and Committees

1. REPORT OF THE PRESIDENT—Stanley J. Zagorski

The President of the Pennsylvania Academy of Science has had a very busy, active 12 months since his last report to the Executive Committee. In addition to the day-to-day correspondence and communications on behalf of the Academy, the following special duties must be reported.

April 26, 1983: The President met with members of Hammermill Paper Company's corporate research division to discuss their involvement in the forthcoming publications of the Academy on Solid, Hazardous and Radioactive Wastes, and to seek a possible contribution. Telephone calls to Lord Corporation and Zurn Industries were also made.

May 23 and 24, 1983: Traveled to Harrisburg to meet with members of the Governor's Energy Council regarding the release of the PAS publication on Pennsylvania Coal. While in Harrisburg, met with numerous House members and Senators lobbying for House Bill 56.

June 27 and 28, 1983: Traveled to Harrisburg for the official release and promotion of the Pennsylvania Coal book by Governor Richard Thornburgh and Lt. Governor William Scranton. Again lobbied for House Bill 56. Met with K. Leroy Irvis, Majority leader, and other representatives of state government to seek financial support for the Academy.

July-August, 1983: Wrote to Senators, the Governor, Lt. Governor and members of the House again requesting support for House Bill 56. Also wrote and called many industrial leaders seeking financial support for the PAS publication on coal, and for future publication on Hazardous, Solid and Radioactive Wastes.

September 9, 1983: Traveled to Harrisburg to meet with Mr. Lazarchik and Mr. Galida of the Pennsylvania Department of Environmental Resources to discuss a joint effort in publishing the three volumes on Hazardous, Solid and Radioactive Wastes, and also to seek financial support. Two weeks later, in late September, a list of twelve prominent industries and their leadership was provided to the PAS by the DER for possible contributions toward publication costs of the three volumes on Hazardous, Solid and Radioactive Wastes.

September 30, 1983: The President traveled to Pittsburgh to meet with the President-Elect to discuss the agenda for the fall meeting, as well as future plans of the Academy.

October 5 and 6, 1983: Lengthy telephone conversation with the Program Chairperson of P.S.T.A. regarding reservations, meeting rooms, etc., for the fall meeting. Final arrangements were made for the fall meeting.

October 12, 1983: On behalf of the Academy, mailed a letter describing the Academy, PAS brochures and a copy of coal book to the twelve industrial leaders provided by the DER. Included in the letter was a request for financial support for the publication of the three volumes on Hazardous, Solid and Radioactive Wastes.

October 24 and 25, 1983: Follow-up telephone calls were made to all twelve of the industrial leaders to ascertain arrival of publication and materials, and to establish formal contact with individuals involved.

October 26, 1983: 1. Symposium Report

a. The President mailed out notices to 80 newspaper, TV, and radio stations concerning news release about the Fall Symposium on Radioactives Wastes.

b. The President also appeared on Channel 12, NBC TV, and was interviewed concerning the Symposium.

November 1983: Follow-up letters were sent to the twelve industrial leaders to follow-up the October letters. The President received donations from two of the twelve. Letters were also sent to members of the Senate and House of Representatives encouraging them to support House Bill 56. The Bill will be brought to the floor for a vote in March.

February 23, 1984: The President traveled to Pittsburgh to meet with the President-Elect concerning the agenda for the Spring meeting.

2. REPORT OF THE PRESIDENT-ELECT AND EXECUTIVE SECRETARY - Dr. George C. Shoffstall

The President-Elect and Executive Secretary has actively served on, and/or chaired, numerous committees germane to the enhancement of the Academy and the promulgation of the philosophies therein. Moreover, with the concurrence of President Zagorski, the President-Elect has pursued missions, objectives, programs, membership and resource strategies of the Academy as deemed necessary.

A representative listing of activities are as follows:

...Worked directly and indirectly with Dr. S.K. Majumdar in seeking authors and publication materials for PAS's new textbook on "Pennsylvania Coal".

...Spoke with legislators regarding continued funding for PAS/PJAS. It should be noted that current House Bill 56 has been in the *Committee on Appropriations* since 7 June 1982. This Bill is to continue Commonwealth support in the dissemination of scientific information throughout the State and to continue to encourage and support the youth of Pennsylvania in scientific research.

...Served as Chairperson of the PAS Symposium Planning Committee in formulating content and seeking speakers for the symposium on "Hazardous and Solid Wastes Management" presented at the fall joint meeting of PAS and PSTA in Monroeville, Pennsylvania.

...Represented PAS at the PJAS Advisory Board meeting in Whitehall.

...Attended the fall Organizational Meeting for PJAS Region 7 at St. Francis Academy in Castle Shannon.

...Represented the Academy at the PAS/PJAS Directors' Meetings at Host Farms, Lancaster and at Seven Springs, Champion, Pennsylvania.

...Serving as Chairman on the Governor's School for the Sciences, I along with Past-President Sr. M. Gabrielle Maze, attended the closing exercises and banquet for the first Pennsylvania School for the Sciences at Carnegie-Mellon University.

...Served as Program Organizer, Planner and Presider for an International Symposium on "The Crises in Science and Mathematics Education: Perspectives From the National, State and Local Levels" held at the 149th annual meeting of the AAAS in Detroit, Michigan, 29 May 1983.

...Wrote the introduction to the newest textbook publication of the PAS—"Pennsylvania Coal".

...Currently serving on the Editorial Committee of the PAS's forthcoming multi-volumes textbooks on "Solid and Liquid Wastes: Management and Methods"; Nuclear and Hazardous Wastes: Management, Treatment and Transportation".

...Was elected to serve on Council of the American Association for the Advancement of Science until 1986.

3. REPORT OF IMMEDIATE PAST PRESIDENT—Dr. Bruce D. Martin

Activities: April 1983 – March 1984

The Immediate Past President has actively served the Academy during 1983-84 by pursuing activities assigned by the President in keeping with the goals and philosophies of the Academy for the promotion of Science in the Commonwealth.

1. Attended meetings of concern to the Academy including:
   April 10-12—Academy Annual Meeting, Lancaster, Pennsylvania
   June 28—Official release of *Pennsylvania Coal*, Governor's Office, Harrisburg
   May 4—Advisory Board meeting, Region VII, PJAS, Pittsburgh
   May 11—PJAS Annual Meeting, Region VII, Pittsburgh
   October 5—Advisory Board Meeting, Region VII, PJAS, Pittsburgh
   February 18—Planning meeting of the PAS at Seven Springs Resort in preparation for the Annual meeting.
2. Member, Advisory Board for the three volume series on Solid, Hazardous and Radioactive Wastes.
3. Wrote letters supporting HB 56 to local state representatives.
4. Chaired Nominating Committee, with Justice J.P. Flaherty and Sister M. Gabrielle Maze for the 1984 election of officers. Each issue of the Newsletter contained the call for nominees. The report of the Nominating Committee is attached.

4. REPORT OF THE TREASURER AND ASSISTANT TREASURER—Michael L. Bucholtz and Ernest H. Braue, Jr.

Dr. Braue passed out the reports of the treasurer's activities. After the reports were passed out Michael L. Bucholtz proceeded to explain the different items of the treasurer's printed report. He explained the deficit this year because of the publication of the new books which the Academy had undertaken to write and publish.

PENNSYLVANIA ACADEMY OF SCIENCE
Balance Sheet
December 31, 1983

ASSETS

Cash:		
Checking account		$ 3,443.91
Savings accounts		
Darbaker Savings Account	$ 3,037.13	
Zappa Endowment Fund	4,021.33	
		7,058.46
Savings Certificates:		
Life Membership		200.00
Investments:		
Prudential-Bache	$23,174.26	
Merrill-Lynch	15,813.06	
IDS	10,970.99	
Great Western Savings	4,877.00	54,825.31
Equipment (net of depreciation)		4,982.00
TOTAL ASSETS		$70,509.68

LIABILITIES AND NET WORTH

NET WORTH	$70,509.68

PENNSYLVANIA ACADEMY OF SCIENCE
Statements of Income and Net Worth
For the year ended December 31, 1983

REVENUE:		
Printing and Publications	$10,922.85	
Dues	10,277.00	
Annual Meeting	9,482.75	
Interest & Dividends	6,020.31	
Grants	6,000.00	
Publications Endowment	4,600.00	
Gifts	3,112.46	
Library Subscriptions	2,131.88	
Advertisements	200.00	
Miscellaneous	58.28	$ 52,805.53
EXPENDITURES:		
Printing & Publications	$42,009.88	
Meeting expenses	11,718.36	
Travel	3,691.85	
Salaries	1,429.81	
Awards	1,637.10	
Supplies	1,676.05	
Postage	1,837.88	
Depreciation	1,053.00	
Professional Services	556.00	
Taxes	250.36	
Dues	69.00	
Miscellaneous	33.63	65,962.92
EXCESS EXPENDITURES OVER REVENUE		**$(13,157.39)**

NET WORTH, JANUARY 1, 1983		**$83,667.07**
NET WORTH, DECEMBER 31, 1983		**$70,509.68**

EXHIBIT "A"—Receipts and Disbursements of the Pennsylvania Academy of Science for the period of January 1, 1983 to December 31, 1983

		1983	1982	1981
RECEIPTS:				
Membership dues				
Institution	$ 50.00			
Student	357.00			
Sustaining	530.00			
Life	2,000.00			
1980	10.00			
1981	120.00			
1982	370.00			
1983	3,410.00			
1984	3,430.00			
Total Membership Dues		$10,277.00	$ 6,145.00	$ 4,610.00
Library Subscriptions				
Vol. 55	$ 87.50			
Vol. 56	387.50			
Vol. 57	1,206.25			
Vol. 58	450.63			
		$ 2,131.88	$ 3,000.00	$ 2,131.25
Gifts				
Darbaker	$ 1,102.406			
Reading Anthracite Co.	1,000.00			
Pittsburgh Conference	500.00			
Joan Elliot	500.00			
Mr. Rosenfield	10.00			
		$ 3,112.46	$ 2,423.61	$ 1,908.00
Grants				
Governor's Energy Council	$ 5,000.00			
AAAS	1,000.00			
		$ 6,000.00	$39,398.00	$ 800.00
Interest and Dividends				
Prudential-Bache	$3,080.29			
IDS	960.99			
Merrill-Lynch	1,450.21			
Zappa	292.47			
Darbaker	220.90			
Other	15.45			
		$ 6,020.31	$ 7,103.57	$ 6,299.75
Publications-Books				
Pennsylvania Coal	$5,925.13			
Energy, Environment & the Economy	1,397.72			
Toxic Waste	500.00			
		$ 7,822.85	$ 1,887.60	$ —0—
Publications Endowment		$4,600.00	$ —0—	$ —0—
Page Charges		3,100.00	3,975.00	3,100.00
Annual Meeting		8,582.75	14,954.15	9,000.97
Advertisements		200.00	—0—	—0—

Exhibitors Fees		900.00	900.00	260.00
Miscellaneous Income		58.28	—0—	70.00
TOTAL RECEIPTS		**$52,805.53**	**$79,786.93**	**$28,179.97**
EXPENDITURES:				
Printing				
Proceedings	$10,998.00			
Newsletter	910.91			
		$11,908.91	$11,413.23	$ 9,699.97
Postage		1,837.88	554.56	873.65
Wages		1,429.81	1,236.05	1,280.95
A.A.A.S. Dues		69.00	70.50	113.50
Travel Expenses for Officers		3,691.85	4,280.62	2,010.84
Awards				
Darbaker Award	150.00			
Oerlein Award	300.00			
Research Grant	1,187.10			
		$ 1,637.10	$ 1,540,00	$ 1,130.00
Professional Services				
Auditing & Income Tax	100.00			
Legal	206.00			
Transcribing & Indexing	250.00			
		$ 556.00	$ 260.00	$ 100.00
Supplies & Petty Cash		$ 1,676.05	$ 1,107.56	$ 808.61
Meeting Expenses				
Spring	11,015.60			
Fall	702.76			
		$11,718.36	$15,035.89	$ 8,996.46
Office Rent		$ —0—	$ 199.00	$ 957.00
Insurance		$ —0—	$ 95.00	$ —0—
Publications				
Pennsylvania Coal	$29,460.97			
Energy, Economy & the Environment	—0—			
Toxic Waste	640.00			
		$30,100,97	$11,951.70	$ 511.00
Taxes		$ 250.36	$ —0—	$ —0—
Miscellaneous		$ 33.63	$ 26.05	$ —0—
Equipment Purchased	$ 3,800.00			
Depreciation		$ 1,053.00	$ 359.50	$ —0—
TOTAL EXPENDITURES		$65,962.92	$48,129.66	$26,481.98

Exhibit "B"—Accounts for the Pennsylvania Academy of Science, Inc. for the period of January 1, 1983 to December 31, 1983

I. Checking Accounts			
Erie:			
Balance, December 31, 1982		$ 679.86	
Deposits		87,248.86	
Disbursements		85,188.76	
Balance, December 31, 1983			$ 2,739.96
Mount Alto:			
Balance, December 31, 1982	$ 435.06		
Deposits	11,000.00		
Disbursements	10,731.11		
Balance, December 31, 1983			$ 703.95
II. Darbaker Account			
Balance, December 31, 1982		$ 2,816.23	
Interest		220.90	
Balance, December 31, 1983			$ 3,037.13
III. Zappa Endowment Fund			
Balance, December 31, 1982		$ 3,728.86	
Interest & Deposit		292.47	
Balance, December 31, 1983			$ 4,021.33
IV. Merrill-Lynch Ready Assets Trust			
Balance, December 31, 1982		$26,478.09	
Deposits:			
8/16	$ 6,000.00	$ 6,000.00	
Disbursements:			
1/24	$10,000.00		
3/21	4,877.00		
6/23	2,000.00		
7/11	1,000.00		
Interest		$17,877.00	
		1,211.97	
Balance, December 31, 1983			$15,813.06
V. Prudential-Bache			
Balance, December 31, 1982		$47,093.97	
Disbursements			
7/11	$27,000.00	$27,000.00	
Dividends		3,080.29	
Balance, December 31, 1983			$23,174.26
VI. Savings Certificates-Life Membership			
Balance, December 31, 1982		$ 200.00	
Interest		15.45	
Disbursements		15.45	
Balance, December 31, 1983			$ 200.00
VII. IDS Bond Fund			
Balance, December 31, 1982		$ —0—	
Deposits:			
2/3		10,000.00	
Dividends		960.99	
Balance, December 31, 1983			$10,960.99

VIII. Great Western Savings & Loan			
Balance, December 31, 1982		$ —0—	
Deposits:		4,877.00	
Balance, December 31, 1983			$ 4,877,00

FINANCIAL REPORT
FOR THE 59th ANNUAL PAS SPRING MEETING
LANCASTER, PENNSYLVANIA
APRIL, 1983

REVENUE:		
Registration	$ 8,582.75)	
Exhibitor's Fees	900.00	
TOTAL REVENUE		$ 9,482.75
EXPENSES:		
America's Host Farm Resort	$ 8,093.69	
Transportation	827.10	
Dr. Uricchio's Expenses	63.20	
Travel to arrange meeting	560.80	
Honorarium	500.00	
Refreshments	459.18	
Photography	200.00	
Plaques and Pens	175.13	
Program Expense	136.50	
TOTAL EXPENSES		$11,015.60
EXPENSES OVER REVENUE		$(1,532.85)

Pennsylvania Academy of Science
Lafayette College
Easton, Pennsylvania

I have examined the balance sheets of the Pennsylvania Academy of Science as of December 31, 1983, and the related statements of revenues and expenditures for the year then ended. My examination was made in accordance with generally accepted auditing standards and, accordingly, included such tests of the accounting records and such other auditing procedures as were considered necessary in the circumstances.

In my opinion, the financial statements referred to above present fairly the financial position of the Pennsylvania Academy of Science at December 31, 1983, and the revenues and expenditures for the year then ended, in conformity with generally accepted accounting principles applied on a consistent basis.

Dennis C. Steele, Auditor

Erie, Pennsylvania
February 23, 1984

5. REPORT OF THE EDITOR OF THE PROCEEDINGS—Shyamal K. Majumdar, Ph.D.

The Proceedings, Volume 57, #1 was published in October, 1983, following the same editorial style as in the past. The issue no. 2 of volume 57 is expected to be published in April, 1984. An Editorial Committee has been appointed consisting of the Editor and thirty-two members. The members are specialists in various fields (see Vol. 57, #1 Issue for names and their affiliation). In 1983, forty-six manuscripts were received for publication consideration, of which 35 were accepted and published. Every paper was read and evaluated by one or more reviewers in whose field the paper lies.

The book *Pennsylvania Coal: Resources, Technology and Utilization* (edited by S.K. Majumdar & E. Willard Miller) was published in July, 1983 as a special publication of the Pennsylvania Academy of Science. As of this writing 312 Coal Books were sold (18 books, $5.00/book to PAS members) at a price of $9668.98.

The third book, *Hazardous and Toxic Wastes: Technology, Management and Health Effects,* edited by S.K. Majumdar and E. Willard Miller was published in March, 1984 (Hardbound, pages XXII, 442, ISBN: 0-9606670-2-4, $35.00). The book is co-sponsored by the Pennsylvania Department of Environmental Resources, and it contains 27 chapters and an introduction by Nicholas DeBenedictis, Secretary, Pennsylvania DER.

Dr. Miller and I are editing two other volumes on *Solid and Radioactive Wastes*. The Pennsylvania Academy of Science plans to publish the books under the sponsorship of the Pennsylvania Department of Environmental Resources.

The Editor expresses his appreciation to the members of the Editorial Committee for their generous assistance in reviewing the manuscripts, to the contributors for their excellent cooperation, and to Professor Robert S. Chase, Head, Department of Biology, Lafayette College for his generosity in allowing the department to absorb certain expenses (telephone and secretarial) incurred by the Editor's office. The Editor is deeply grateful to many other members and non-members of the PAS who helped in the evaluation of the manuscripts submitted for publication in the *Proceedings*.

Dr. Majumdar explained about our subscriptions to libraries all over the world. He also encouraged all members to take advantage of buying the new books that were published by the Academy especially the Coal Book.

A member of the Academy expressed his feelings as to the Coal Book and he stated that this is the only Coal Book that we have as a reference in Pennsylvania and it is very impressive and should be in all the schools of the state of Pennsylvania. We highly recommend this book.

6. REPORT OF THE EDITOR OF THE NEWSLETTER—Dr. Kurt Schreiber

During the past year we again published five issues of the NEWSLETTER with a total of 68 pages. It is planned that we will continue this rate of publication of the NEWSLETTER for the coming year.

At the executive council meeting in the Fall it was mentioned that the October issue often appears too late to properly publicize the Fall Symposium of the Academy. It was suggested that instead of publishing an October issue, a September issue be published. On careful consideration of this suggestion and the logistics involved, I find that this is not a good solution.

I am, therefore, suggesting an alternative. Currently, the publication schedule is Jan., Feb., April, July, Oct. I would like to suggest that in the future we use the following publication schedule: Jan., Feb., May, August, & Oct. What are the advantages of this alternative? With the annual meeting in April, the April issue becomes a problem. It does not appear early enough to help publicize the annual meeting and at the same time the lead-time necessary for publication makes it difficult to report the actions taken at the Annual Meeting. Changing to a May publication date means that a timely report could be given to the membership about the activities and actions of the annual meeting.

The August issue would be mailed late in the month to reach most academics as they return to their campuses for the new academic year. This issue would contain the full details of the Fall Symposium

The October issue would, as in the past, contain the call for papers and would also be a last minute reminder of the Fall Symposium.

I believe that the above publication schedule would serve the Academy well and eliminate the current problem with publicity for the Fall Symposium.

7. REPORT OF THE STATE DIRECTOR, PENNSYLVANIA SCIENCE TALENT SEARCH—Dr. Kurt C. Schreiber

The 43rd annual Science Talent Search was conducted by the Science Service in Washington, D.C. this January. Participation in the STS by students from Pennsylvania was disappointing. Only 44 entries were submitted which is a decline from last year. However, on the positive side there was a slight increase in the number of honors winners, but, again, no trip winner.

	1982	1983	1984
Honors winners	6	10	11
Trip winners	1	—	—

The 1984 Penna. Science Talent Search is just in the process of being completed. The preliminary data together with the data from past years are shown below.

	1982	1983	1984
Honors awards	6	10	11
First awards	10	14	13
Judges awards	27	20	20
Junior awards	36	41	37
Total	*78*	*85*	*81*

There has been little overall change in the participation in the PSTS. Twelve of the thirteen first award winners were junior award winners last year.

8. REPORT FROM STATE DIRECTOR—PENNSYLVANIA JUNIOR ACADEMY OF SCIENCE—Clarence Myers

As the Fifth Year of my term of office comes to a close, I can see that there is still much to be accomplished. I am aware that we have done a lot in following our goals for the year, but in the time remaining, let us all work together toward our primary objective "TO PROMOTE A GREATER PARTICIPATION IN SCIENCE-ORIENTED ACTIVITES AMONG THE YOUTH OF THE STATE." In looking at the participation for this year, 1984, there are close to 1,200 student papers being presented, the hotel facility is at its maximum, and it looks as though we are expanding at a rate which is very commendable to all. This presents some problems but let us work on these in the year ahead.

Staff changes—No changes since last report.

State meeting Reports:

1983 state meeting at Host Farms and Corral with the Pennsylvania Academy of Science. All went well and the 1985 state meeting plans are underway to return on April 21, 22, 23, 1985.

1984 state meeting at Seven Springs, Fiftieth Anniversary of Pennsylvania Junior Academy of Science. Special activities have been planned. Special emblems for the students and sponsors have been made and will be distributed at this meeting. A program booklet will be given to each Academy member at the Academy meeting. A special Fiftieth Anniversary booklet will be put together following the state meeting. Each senior Academy member as well as each Junior Academy participant will be given a booklet when it is complete.

1986 state meeting will be at Seven Springs. Details to be worked out during the 1984 meeting. Region VII will host this meeting.

Activities of the Regions:

Each region has conducted various workshops, seminars, etc. as money and energies permitted. Video tapes have been made and distributed. The majority of the regions have purchased computers to operate the details of their regional meetings.

General Report of the Director:

Reprinted another 5,000 brochures.

Printed special Fiftieth Anniversary certificates for all meetings this year.

Distributed guides for conducting a state meeting to Region II.

Attended all planning meetings for the 1984 and 1985 state meetings.

Attended as many Regional Meetings as my schedule, time and (weather) permitted.

Attended other planning committee meetings in other regions as my time permitted.

Constitution is still under revision. A workshop is to be planned over the summer to finalize this work.

Plans have been initiated for the following regions to host the coming State Meetings.

1985—Region 2—Host Farms
1986—Region 7—Seven Springs
1987—Region 4
1988—Region 6
1989—Region 5
1990—Region 9

Obtained additional scholarships, awards, etc. for students at Regional and State Meetings.

A special effort will be initiated for an up-date of each Regional History. This will be combined into one report and included in the Anniversary Booklet.

9. REPORT OF MEMBERSHIP CHAIRMAN—Dr. George C. Boone

Spring Report
Membership Committee

The Membership Committee was composed of Miss Jennie Ranii, Dr. Henry Fremount, Dr. Paul Greisacker and Dr. George Boone, Chairman.

In September we undertook a drive to increase our members of Life Members. I am happy to report that we have at least 15 Life Members as of this date.

Approximately 700 Call for Papers posters were mailed in October and 150 more posters were delivered by committee members.

Approximately 700 Membership Posters were mailed in January and 150 posters were hand distributed.

I have received several inquiries of college science students seeking information on membership. I corresponded with these students and encouraged them to become members.

The Membership Committee is always open to suggestions as to how to attract new members. Please make your suggestions known to us.

10. REPORT OF THE PAST PRESIDENT AND FUND RAISER—Sister M. Gabrielle Maze, Ph.D.

During the past year, I was involved in the following activities of PAS:

1. The House Bill 2537 was changed to 57 and then to 56, finally it landed again in the Appropriation Committee.
2. Letters and telephone calls were made periodically to the Secretary of LeRoy Irvis. To get the latest on the progress of the Bill, I was told that it may take another month or longer before we get some action.
3. Dr. G. Shoffstall visited Harrisburg offices last week, same results—WAIT... he was told.
4. Last May, we took 4 students to the Amer. Jr. Academy of Science in Detroit. Here they presented papers and had poster sessions.
5. This year, during the Memorial weekend, the American Academy of Science will meet in New York City. PJAS is sending 6 students to represent the State.
6. Dr. G. Shoffstall, Dr. S. K. Majumdar and myself will attend the X Session of the AAAS Meeting in New York City.
7. During the past year, I was able to sell 100 Coal Books at $30 a book.
8. Two organizations donated by $500 to PAS for our Jubilee Celebration and gifts. The organizations are: Spectroscopy Society of Pittsburgh and Analytical Society of Pittsburgh. We thanked them for their generosity.

11. REPORT OF PROGRAM COMMITTEE CHAIRPERSONS—Robert F. Denoncourt, Carolyn F. Mathur

A total of 78 papers were scheduled for presentation at the 60th annual meeting of the Pennsylvania Academy of Science, March 30—April 1, 1984 at Seven Springs Resort, Champion, Pennsylvania. These were divided into a poster session and the following topic related sessions:

Aquatic I and Aquatic II, Behavioral Science, Biochemistry/Cell Biology, Botany, Engineering, Geology, Geography, Instructional Applications, Mammalogy, Medical/Physiology, Ornithology and Terrestrial Ecology.

The 78 papers represent a 20% decrease over 1983. The membership is asked to encourage the presentation of good research and submission of manuscripts.

The program was completed with the exception of "List of Exhibitors" by mid-December and copies forwarded to Dr. Kurt Schreiber. Letters with day, time and subject session and an application form for the P.A.S. were sent to each presentor.

The Friday evening "Symposium on Endangered Species" chaired by Dr. Fred Brenner, will be of special interest to Academy members and all persons interested in our environment and the preservation of habitats. The speakers will be: Mr. Paul Wiegman, Dr. Christine Schonewald-Cox, and Mr. Jack Edmundston. Saturday afternoon, the presentation by Dr. Nicholas M. Short entitled "Remote Sensing from Space—The New Approach to Managing our Earth's Resources," should also be informative to all those present.

Carol L. Denoncourt assisted with the organization and mailings, and Dr. Kurt Schreiber once again kept everything organized and on schedule.

12. REPORT OF GENERAL CHAIRMAN—Dr. Kurt C. Schreiber

He stated that he had three announcements.

A change in sessions for today. Encouraged the members to go see the exhibitors. He also asked if anyone had any suggestions to improve or enhance our meetings please let us know. We are always open for suggestions.

13. REPORT OF THE TIME AND PLACE CHAIRMAN FOR ANNUAL MEETINGS—Dr. William A. Uricchio.

The 60th Annual Meeting was held on March 30 to April 1, 1984 at Seven Springs Mountain Resort in Champion, Pennsylvania. The Senior Academy met by themselves since there was not sufficient room to also house the Junior Academy.

The 61st Annual Meeting will take place at Host Farm in Lancaster, Pennsylvania on Sunday, April 21 to Tuesday, April 23, 1985. This meeting will be held in conjunction with the Pennsylvania Junior Academy of Science.

Your chairman continues to evaluate various resorts and convention centers for possible meeting places.

14. REPORT OF THE RESEARCH GRANTS CHAIRMAN—Dr. Sherman Hendrix

In the one year interval between annual meetings of the PAS, the Research Grants Committee has received six applications for funds to support secondary school student research. Three of these were funded: Ms. Betty Shin, $163.00, for a study of pace and pulse relationships in athletes; Mr. Darin Katz, $50.00, to study the effects of sewage sludge and heavy metals on plant growth; Mr. Prabodah Sharma, $99.50, for work on the effects of the antibiotic bleomycin on DNA. One proposal was returned by the committee for being too vague, one is pending, and one was withdrawn by the applicant.

Dr. Hendrix reported that we had approximately $1,000. We have expended so far $260.00, so we have about $700 in the fund for the future. We are hoping that monies will be available in the future.

The President encouraged the members to come to our Fall symposium meeting in the fall. The date has not as yet been set for the Fall. Please read the issue of the Newsletter, the date will be announced then.

15. REPORT OF NOMINATING COMMITTEE—Dr. Bruce Martin

Dr. Martin announced the slate of candidates to be elected this day. President-Elect, Dr. Shyamal K. Majumdar—For Treasurer, Ernest H. Braue, Jr.—For Assistant Treasurer, Sherman S. Hendrix—For Corresponding Secretary, Howard S. Pitkow—For Editor of the Proceedings—two candidates—Daniel Klem, Jr. and Leonard M. Rosenfeld.

President-Elect—Shyamal K. Majumdar was elected by acclamation, since there were no other candidates heard from the floor.

Call for nominations from the floor to oppose Howard S. Pitkow. Nominations were closed since no one came forward. Motion carried and Howard S. Pitkow was elected as Corresponding Secretary of the Academy.

Nomination calls from the floor were made for Treasurer to oppose Ernest Braue, Jr. the incumbent assistant treasurer. No nominations from the floor the nominations were closed and Ernest Braue was elected Treasurer of the Academy.

Nominations calls from the floor for Assistant Treasurer. No nominations came from the floor, nominations were closed and the Assistant Treasurer, Sherman S. Hendrix was elected for the Academy.

Two nominees were announced for the Editor of the Proceedings. Daniel Klem, Jr. and Leonard M. Rosenfeld. The two gentlemen were introduced to the membership. Nominations were asked from the floor. No more nominations, ballots were passed out to vote for one of these gentlemen. Ballots were counted. It appears that Daniel Klem, Jr. received 34 votes and Leonard Rosenfeld received 11 votes. Congratulations to Daniel Klem the new Editor of the Proceedings.

New slate and list of officers for Pennsylvania Academy of Science. President—Dr. George Shoffstall—President-Elect—Shyamal Majumdar, Immediate Past President, Stanley Zagorski—Corresponding Secretary, Howard Pitkow—Treasurer, Ernest Braue, Jr., Assistant Treasurer, Sherman S. Hendrix—Editor of Proceedings, Daniel Klem, Editor of Newsletter, Kurt C. Schreiber—State Director, PJAS—Clarance Myers—Historian, Bob Halma and Recording Secretary -Viola Yakstis.

REPORT-SYMPOSIUM CHAIRMAN—Fred J. Brenner

The 1984 Annual Meeting Symposium is on Endangered Species. The three speakers are:

Mr. Paul Wiegman, Western Pennsylvania Conservancy—"Endangered Plants of Pennsylvania."

Dr. Christine Schonewald-Cox, National Park Service, U.S. Department of Interior—"Small Populations and Designs for Conservation".

Mr. Jack Edmundson, U.S. Fish and Wildlife Service, Office of Endangered Species—"Interaction of Federal and State Agencies in the Endangered Species Program."

All speakers have been asked to bring complete manuscripts to the meeting. I would like to arrange additional symposia on this theme and to develop a book on "The Management of Endangered Species in Pennsylvania" with S.K. Majumdar and F.J. Brenner as co-editors.

16. REPORT OF THE EXHIBITS CHAIRMAN—Theodore T. Ziegenfus

Letters of invitation to exhibit at the 60th PAS meeting were sent to 41 scientific supply houses and/or textbook companies. Unfortunately only 7 replies were received. Five companies are exhibiting. They are:

1. Connecticut Valley Biological Supply Co. Inc.
2. Carolina Biological Supply Company
3. AO Reichert Scientific Instruments
4. Fisher Scientific Company
5. Sargent Welch Scientific Company

Exhibitors fees, paid in full, accompanied each registration form.

Private conversations with supply company representatives would suggest that at future meetings perhaps a change in the length of time that exhibitors exhibit is appropriate, especially when a weekend is involved. Since the 1984 exhibitors have been long standing supporters of PAS, it is my intention to survey these exhibitors for suggestions/revisions in the format of future exhibits. This survey hopefully will result in "data" to strengthen our exhibits. Perhaps this should become a priority discussion agenda item for the Fall Executive Committee Meeting, not just a committee report.

Given that the 61st PAS/PJAS Meeting, April 21-23 1985, will be held at Host Farm, Lancaster, Pennsylvania, Dr. Ralph Cavaliere of Gettysburg College will serve as co-chairperson of the Exhibits Committee.

17. REPORT OF THE HISTORIAN—J. Robert Halma

The Historian reviewed book jobbers and marketing firms in the *Literary Marketplace.* The purpose of the investigation was to find alternate ways of marketing the books of the PAS. Several firms, in turn, responded to Dr. Majumdar, but none were willing/interested in acting as an agent without "up front" money.

Contact was made with several firms about producing PAS desk calendars. Prices vary greatly (.42-3.00 each plus mailing), but a "reasonable price" for a moderate desk calendar would be about $1.00/each (including postage).

Stanley Zagorski, the outgoing President, introduced Dr. Shoffstall the incoming President, turning the gavel over to him he asked him to say a few words to the members present.

The President stated that when he was the President of the AAAS he noticed the other states like Iowa, Maryland and New York who are being subsidized by their states and have money available for their use and also have buildings.

He asked for continued support of all the members of the Academy and thanked Stanley for a job well-done.

President Zagorski adjourned the meeting at 9:45 a.m.

Respectfully submitted,
Viola Yakstis, Recording Secretary

MINUTES OF THE PENNSYLVANIA ACADEMY OF SCIENCE EXECUTIVE COUNCIL MEETING SUNDAY, APRIL 1, 1984 SEVEN SPRINGS, CHAMPION, PA.

A brief meeting was called by the President, George C. Shoffstall, at 10:30 a.m. to appoint Committees and Chairpersons for 1984-1985. The following will serve until 1985.

1984-1985
Standing Committees and Councils (Chairpersons)
Honorary Council
Honorable Richard Thornburgh, Governor
Advisory Council
Justice J.P. Flaherty
Past Presidents
Stanley J. Zagorski
Memberships
G. Boone, Chairperson, Henry N. Fremount, Paul B. Griesacker, Gordon L. Kirkland, Jr., Jennie R. Ranii
Editorial
Daniel Klem, Jr.

Annual Meeting (*Shyamal K. Majumdar, President-Elect, coordinator)*
Time and Place
William A. Uricchio
Local Arrangements
Carolyn F. Mathur (East)
Kurt C. Schreiber (West)
Program
Robert F. Denoncourt, Chairperson
Carolyn F. Mathur
General Chairperson
Host Institution—York College
Auditing—Co-Chairpersons
Bernard Fried
Viola Yakstis
Nominating
Stanley J. Zagorski, Chairperson
Justice J. P. Flaherty
Bruce D. Martin

Special Committees Chairpersons
Special Symposia & Books
Shyamal K. Majumdar
Fall Symposium
F. J. Brenner
Pennsylvania Science Talent Search
Kurt C. Schreiber
Special Student Awards
Warren A. Lentz
Reserach Grants
John B. Schumann, Chairperson, James Dively, John Dropp, Jack Harclerode
Fund Raising
Sr. M. Gabrielle Maze
Representatives to AAAS, NAAS
Shyamal K. Majumdar, George C. Shoffstall, Sr. M. Gabrielle Maze
Affiliate Liaison
Ken R. Mechling
Industrial Liaison
Donald E. Zappa (Vector Corporation) West
Robert B. Domermuth (Pennsylvania Power & Light Company) East
Darbaker Awards
George C. Shoffstall
Resolutions
John B. Schumann
Public Relations
Viola Yakstis
Finance Committee
William Gregory (U.S. Steel)
Publications Endowment
Karl Oberlein

Annual Meeting—Carolyn F. Mathur
Guest Speakers
E. Willard Miller and Bruce D. Martin
Exhibits
Theodore Ziegenfus
Symposium
William G. Kimmel

As announced earlier, York College will be our host college for the year 1985 meeting. Carolyn Mathur presiding.

BROCHURES were distributed to be given out to those people interested in belonging to the Pennsylvania Academy of Science.

TEXTBOOKS that are being printed at this time, will need to be sold or funded. DER of Harrisburg has promised to fund us and to help us sell these textbooks. Mr. Zagorski and other officers are scheduling a meeting to take place in Harrisburg, perhaps next week, to meet with Mr. Debenedictis and present him with a book such as we did with Governor Thornburgh last fall. We are sure that they will help us as they have promised to do. How, we will have to see when we get to Harrisburg. The officers will pursue this matter further.

ANNUAL MEETING of PAS will take place in Host Farms, from Sunday to Tuesday, April 21 to 23, 1985. This meeting will be in conjunction with PJAS. When the announcement appears in the Newsletter, please send in your requests for rooms as soon as possible because at Host Farms Junior Academy will need as many rooms as they can get and the PAS will not be able to hold these rooms past the deadline of registering.

FALL MEETING—Is tentatively set for November 1 in Grantsville, Pennsylvania near Harrisburg. We will be the guests of PSTA since we became affiliated with them. Fred Brenner will check into this and he will notify the President if the date is agreeable and the Executive Council will be notified by mail as to correct time, date and place of the Fall Meeting.

EXPENSES to these meetings is automatically picked up by the PAS. Room, meals and mileage. All bills should be sent to Dr. Braue. Checks will be sent out to anyone sending a bill within a week. Anything over $5.00, send the bill to Dr. Braue or Assistant treasurer. Motion was made by Mr. Zagorski to change the mileage expense to 22¢ a mile instead of 20¢. Dr. Uricchio seconded. Motion carried. This becomes effective immediately.

Motion was made by Dr. Uricchio that anything above $5.00 should request a receipt for the food or whatever was purchased. Dr. Majumdar seconded. Motion carried. Therefore a receipt is needed for anything purchased over $5.00 (e.g., gas, food, stamps, etc.)

CORRESPONDING SECRETARY—Dr. Pitkow will be given a book of rules for all officers of the Academy. It is very important to have labels ready for Dr. Schreiber, Dr. Majumdar, Dr. Boone and Dr. Braue. After money for dues is received from a member, it is important that the Secretary send out the card and see that this new member's name is sent to the proper people for mailing newsletter, etc. He will check with Dr. Ostrovsky to get the computer listing from him, current or older than this year. Sherman and Ernie Braue will help Dr. Pitkow with the adjustment he needs.

TREASURER—Dr. Braue has asked permission to buy a new file (metal) because the one that he inherited is on its last leg, so to speak. He also needs a typewriter but it was suggested that he buy computer or word processor which will be more practical for him to use. Dr. Pitkow can also use this computer for labels. Should be an Apple Computer because of compatibility. A computer with all necessary equipment will cost about $5,000. Recommendation for this equipment was put on "hold" until at least May. We have a motion and submotion. Motion to buy equipment and ask for time for payment of 60 to 90 days delay. If we do not get the money then we will pay from the treasury. Dr. Uricchio seconded the motion. Motion carried. Equipment will be bought regardless.

Recommendation not to exceed $5,000 to purchase this equipment.

Dr. Pitkow asked if the duties that are in the manual still apply to him. Dr. Shoffstall agreed. Stanley Zagorski mentioned the fact that he will be able to have our stationery printed at a considerable cost. They have their own printer at the College. Dues notice will be modified. Dr. Pitkow will get notices of mailing, etc. from Dr. Ostrovsky. The new officers will be given the manual which contains their duties. One obligation is to bring the pennant with you to the state meeting. These are some of the duties of the Corresponding Secretary.

Summarization of the Editor of Proceedings position at this time. During the transition, Dr. Majumdar stated that he will be editing Volumes 57 and 58 but from Volume 59, Dr. Klem will be taking over. When he comes to Dr. Majumdar's office during May and June his duties will be explained to him. From September on he will be answering the mail for Proceedings, books, etc. Space will be needed to store all the books that have not been sold or mailed out. A space will be rented to store all the books in one facility.

INDUSTRIAL LIAISON—Robert Domermuth—Dr. Shoffstall stated that he would like if Bob would help to increase membership in the technologies to get the industries in. Spread the name of Pennsylvania Academy of Science when you attend meetings in the industrial areas of the state. Ask the industries if they would like to join Pennsylvania Academy of Science. It is an interface between you and the Academy. President also mentioned the fact that we will need money to help us, dues will not be sufficient to take care of our many needs. We will definitely need help from the state and industry. Dr. Shoffstall welcomed Dr. Domermuth as a committee person of the Academy.

Motion made and seconded for adjournment. Adjournment came at 11:50 a.m.

Respectfully submitted,
Viola A. Yakstis,
Recording Secretary

PENNSYLVANIA ACADEMY OF SCIENCE
EXECUTIVE COUNCIL MEETING
MARRIOTT HOTEL, MONROEVILLE, PA
MINUTES

Thursday, October 27, 1983

I. Old Business:

A. Meeting was opened by President Stanley Zagorski at 9:15 a.m. The following were present:

Ernest Braue, Michael Bucholtz, Stanley Zagorski, T. Ziegenfus, Warren Hendrix, Bruce Martin, George Shoffstall, Shyamal Majumdar, Sister Gabrielle, Robert Halma, William Uricchio, Ken Mechling, Kurt Schreiber, George Boone and Viola Yakstis.

Since the meetings of the Executive Council and the Business Meeting were published in the Proceedings and the Executive Council has not had a chance to see them before this meeting, they were asked to quickly look over the minutes printed on Pages 9 and 11 and pass on the approval of the minutes. The Secretary will have the minutes of the spring meeting typed and distributed before our fall meeting in 1984, before they are printed in the Proceedings.

In Item 14 of the Executive Committee of Sunday, April 10, 1983, Dr. John Dropp's name was misspelled. The Secretary apologizes and hereby corrects the misspelling.

Dr. Schreiber made the motion and Dr. Majumdar seconded that the minutes of the April Meeting be accepted. Motion carried.

B. Symposium—Radioactive Materials and Waste: Management, Transportation, Storage and Disposal. The Symposium takes place this afternoon. Dr. Shoffstall stated that there will be no charge for admission to the symposium. Guest speakers will be our guests for dinner after the symposium. Copies of the Newsletter announcing the Symposium were mailed to 80 radio and TV stations and newspapers in the Tri-County Area. We expect Channel 11 to be present; the other people we have not heard from. George was thanked publicly for the work he did alone on the symposium.

C. Disposition of the proposed Tri Beta joint meeting with the PAS, as requested by Fred Brenner. Dr. Brenner withdrew the proposal for a joint meetng with Tri Beta at this time due to travel inconvenience, etc. He asked if he could repropose at some future date. Membership agreed to this request.

D. Disposition of House Bill 56—Sister Gabrielle spoke on this very important House Bill which is important to the Academy of Science. Sister and Stanley Zagorski and George Shoffstall are very encouraged about the outcome and asked for patience on our part to wait out the time when we will receive the money. Stanley also sent cards to some key people asking for their help to intercede with the legislators on our behalf.

E. Release of Text Book, *Pennsylvania Coal,* by the PAS—Stanley mentioned the fact that he and members of the Executive Council met with Governor Thornburg and presented the Governor with the book on Pennsylvania Coal. The Governor was very enthused with the presentation. The media was there and we received much PR from this event. We are also very happy with the outcome of our presentation. Dr. Majumdar spoke briefly on the presentation also. Dr. Majumdar was publicly congratulated for the hard work and effort he put into the publishing of this book. Congratulations Dr. Majumdar.

II. New Business

A. Reports of Officers and Committee Chairpersons.

1. President—Stanley Zagorski gave his report.
   a. Met with members of Hammermill Paper Company and Zurn Industries to discuss their involvement in the forthcoming publications on Solid and Hazardous waster.
   b. Met with members of Governor's Energy Council regarding release of the PAS publication *Pennsylvania Coal.*
   c. Traveled to Harrisburg for official release and promotion of the *Pennsylvania Coal* book by Gov. Richard Thornburg and Lt. Governor William Scranton. Lobbied for House Bill 56.
   d. Wrote to Senators, the Governor and Lt. Governor and members of the House requesting support for House Bill 56.
   e. Traveled to Harrisburg to meet with Mr. Lazarchik and Mr. Galida of the Pennsylvania Department of Environmental Resources to discuss a joint effort in publishing the three volumes on Hazardous, Solid and Radioactive Wastes and also to ask for their financial support.
   f. Traveled to Pittsburg to meet with the President-Elect to discuss agenda for fall meeting.
   g. Telephoned Program Chairperson of PSTA regarding reservations, meeting rooms, etc. for the fall meeting.
   h. On behalf of the Academy, mailed PAS brochures and a copy of coal book to the twelve industrial leaders provided by the DER.
   i. Follow-up telephone calls were made to all twelve of the industrial leaders to ascertain arrival of publication and materials, and to establish formal contact with individuals involved.

2. President-Elect—George C. Shoffstall gave his report;
   a. Worked directly and indirectly with President Zagorski, Dr. S. K. Majumdar and Sister M. Gabrielle in seeking funds for PAS' new textbook on Pennsylvania Coal.
   b. Spoke with and wrote to legislators regarding continued funding for PAS/PJAS by passing House Bill 56.

c. Served as Chairman of the PAS Symposium Planning Committee and Presider for the symposium on Hazardous Nuclear and Solid Wastes Management.
d. Represented PAS at the fall PJAS Advisory Board Meeting.
e. Attended the fall Organizational Meeting for PJAS Region 7 at St. Francis Academy.
f. Represented the Academy at the PAS/PJAS Directors' Meeting at Seven Springs.
g. Served as Presider and Organizer of the National Association of Academies of Science Symposium on "the Crises of Science, Mathematics and Engineering Education: Perspective from the National, State and Local Levels" at the 149th Meeting of the AAAS in Detroit, Michigan.

3. Immediate Past President—Dr. Bruce Martin's report follows:
   a. Attended meetings of concern to the Academy including:
      (1) Academy Annual meeting, Lancaster, Pa., April 10-12.
      (2) Official release of *Pennsylvania Coal,* Governor's Office, Harrisburg, June 28.
      (3) Advisory Board Meeting, Region VII, PJAS, Pittsburgh, May 4.
      (4) PJAS Annual Meeting, Region VII, Pittsburgh, May ll.
      (5) Advisory Board Meeting, Region VII, PJAS, Pittsburgh, Oct. 5.
      (6) Chaired Nominating Committee, with Justice J.P. Flaherty, and Sister Gabrielle for the 1984 election of officers.

4. Secretary—David S. Ostrovsky was not present. He sent a letter of regret to Stanley Zagorski giving reasons for not attending this meeting and copies of his report. Stanley Zagorski will ask David to resubmit another report to the Executive Board at the next meeting with his correct title and signature. Stanley will call him personally, have him explain his absence. He was also asked to get a speaker for our banquet, this he did.

5. Recording Secretary—Viola Yakstis—Report follows:
   a. Attended Planning Meeting of the Executive Counsil at the Grantville Inn.
   b. Taped minutes of the meeting and transcribed five tapes for a total of thirteen pages.
   c. Mailed minutes to all appointed members of the Executive Council—25 packages.
   d. Attended PAS meeting at Host Corral, Taped minutes of Executive Council meeting and membership meeting. Transcribed a total of seven tapes for a total typewritten package of 18 pages.
   e. Attended meetings of PJAS Region VII and State meeting of PJAS and taped minutes and transcribed them also.
   f. Attended meetings of PJAS Planning, Executive and Advisory Boards, etc.

6. Treasurer and Assistant Treasurer—Michael Bucholtz and Ernest Braue:
   a. The Academy must pay sales tax on the sale of books. Appropriate forms have been completed and a sales tax number has been obtained and sales tax remitted to the state.
   b. Two individuals were in arrears for page charges and were rebilled as of April 1. One we collected from, the other has moved to the West and probably will be uncollectable.
   c. Files of membership cards were converted to Apple II computer file system.
   d. An updated membership list was submitted to Dr. Ostrovsky.
   e. Libraries are invoiced for the journal.
   f. Annual spring meeting showed a loss of $2,153.99. This was due to the fact that only 80 to 90 people took the package deal.
   g. Clarification of the Oerlein Bond. The number that is placed in this balance sheet says $5,000. That is the face value of the bond which Mike purchased. Mike paid $4,755. This is a discounted bond and the face value of the bond is $5,000. We do not know today's market value on this bond. The normal intention of the Academy is to hold on to that particular bond for interest income. This happened to be the best buy at this time.
   h. We are in good shape and we have a net worth of $62,207.72. Suggestion was given by Mike to make the package a little more so that we can cover the expenses of the meetings. There are many inherent costs that must be paid and Mike suggested that perhaps we could increase the registration fee a couple of dollars to sort of break-even.
   i. We have not had an opportunity to diversify our investment portfolio, until we can establish a spending pattern for our upcoming books and other possible compensating revenue factors but we are still holding the money in relatively low interest money market funds.
   j. Revenue will be coming in from the dues and invoicing libraries.

President Zagorski commended Mike and everyone who was involved in procuring monies for the Academy. He stated that we have grown in the last twenty years, namely, money, and extra jobs to do for the President, Treasurer, etc. Mike was congratulated for the stellar job he has done for the Academy as he steps down in 1984 as Treasurer of the Academy.

7. Editor of Proceedings—Dr. Shyamal Majumdar stated that the issue 1 of Volume 57 Proceedings was published in October 1983. *The Pennsylvania Coal: Resources, Technology and Utilization* edited by Dr. Majumdar and Dr. Miller was published in June 1983 as a special publication of the Pennsylvania Academy of Science. Approximately 150 Books were sold to private organizations. And we have promises of orders from Mexico, India and Hong Kong, this is without solicitation. Consolidation Coal has promised us $5,400 to pay for the publication of this book.

Dr. E. Willard Miller and Dr. Majumdar are co-editing three volumes on Solid, Hazardous and Radioactive Wastes. The books will be published by the Pennsylvania Academy of Science in association with the Pennsylvania Department of Environmental Research. The Book 1, *Hazardous and Toxic Wastes* is in press and is scheduled to be published in March 1984.

The editor expresses his appreciation to Stanley J. Zagorski, PAS President and George C. Shoffstall, PAS President-Elect for their generous assistance in preparation of the above books.

Dr. Majumdar was elected Secretary of the National Academy of Science and has published the NAAS publication, The Proceedings, Directory and Handbook.The Proceedings contains symposium papers on The Crises in Science and Mathematics Education: Perspectives from the National, State and local levels. The NAAS, AAAS sponsored symposium was organized by our own PAS President-Elect George C. Shoffstall.

The two other books will be published sometime in 1984.

Mr. Zagorski thanked Dr. Majumdar for his hard work and stated that Dr. Majumdar was a visible means of expressing what the Academy does.

Dr. Shoffstall explained to the Executive Committee how Dr. Majumdar was chosen to be Secretary of NAS.

8. Editor of the Newsletter—Dr. Kurt Schreiber stated that he would like a suggestion from the Executive Council whether we want to continue having a symposium together with our Fall meeting.
   1. Committee agreed to hold a fall symposium, together with meeting.
   2. By a raise of hands 9 people voted yes to have the September issue of the Newsletter contain the Call for papers and the announcement of the Symposium. Dr. Schreiber would like to have the name of the speaker and topic sent to him by August 1.
9. Director of the Junior Academy—Clarence Myers was not present but his report was brought by him to the meeting earlier in the evening. He sent a letter to Mr. Zagorski telling him that he could not come because he could not get released time from his school.
   a. Two regional directors have been appointed. Region 2—Joseph Durkin and Region 7—Duane Keenan.
   b. 1983 meeting at Host Farm—1,086 participants, 287 sponsors, 273 judges, 120 commuting technicians, 20 housed technicians, 5 PAS representatives.
   c. 1984 State meeting—Seven Springs April 1-3, 1984, 50th Anniversary Region 8 hosting—Price will be $70.00/person. 1985 State meeting Host Farm—April 21-23, 1985—Region 2 hosting—Price about $72.00/person.
   d. Each region has many activities scheduled. There are workshops, seminars, planning meetings, student and teacher orientation meetings, and special video sessions. Most regions have developed computer analysis of their regional meetings.
   e. State Director visited as many regions as possible during the year. Had meetings with planning committees for the 1984-1985 state committees. Is working closely with Region 8 in planning the State Fiftieth Anniversary Meeting. New certificates have been printed. Special State Awards have been offered because of the Fiftieth Anniversary Meeting. The constitution is still under revision and at present plans are being made for a special meeting to complete the writing.
   f. The State meeting held last year realized a profit of $3,614.85. Half of this money went to the State treasury and half to the region hosting the meeting.

A letter will be sent to Clarence Myers to send in the names of the awardees to AAAS post haste.

10. Historian—Dr. Robert Halma had no formal report but made a few remarks on the Indexing which will cost about $6,000 for indexers and about $12,000 for typesetting, publishing and mailing, etc. Since we have new books coming out and the other books not yet sold, perhaps we could delay this matter until the other books have been published and sold. Consensus is to wait until our 60th Anniversary abstract publishing.

11. Membership Chairman—Dr. George Boone was not present because of other commitments—He sent in the report which summarizes as follows:
   a. Committee has again begun activities in an attempt to stimulate an increase in the membership rolls.
   b. Letter mailed to all current members pointing out the benefits of Life Membership. The Call for Papers poster and membership posters have been sent to the printer and should be completed soon.
   c. Materials will be sent to industries so as to attract new memberships. Paul Griesacker has obtained an extensive list of industries in North Western Pennsylvania that we will be contacting.
   d. Recommends for Executive Committee action that all Life Members' dues be placed into a separate fund and use the income from that money to create a new scholarship of some type, research grant funds or some other scholarly use advantageous to the PAS.
   e. Open for suggestions. Members of the Academy are encouraged to contact Dr. Boone with ideas.
   f. Concerning note d. above, monies from the Life Membership Fund will be placed in a high yielding bond after we get to the point where we get more money in this fund. It will be placed temporarily in a low interest account. This will be postponed until the spring meeting, after we get a response from more Life Membership.

12. Director of the Pennsylvania Science Talent Search—Dr. Kurt Schreiber has no report at this time until the spring meeting.

13. Fundraising Chairman—Sister M. Gabrielle—Reported that she as fundraiser was incapacitated for a few months by an operation and a bout with a horse.
   a. Made numerous calls to Hershey to check on our House Bill 56. She has hopes but when???

b. Consolidated Coal Company has promised $5,400 for the Coal Book.
c. Plans for Headquarters in the New Landmark building did not materialize. Rent was beyond our means.
d. Made a trip to Scaife Mellon Foundation about a grant of $100,000 to help us with printing costs. This was refused because their money is invested at this time.
e. Attended many meetings to represent PJAS.
f. Took 8 special students, chosen at the State Meeting, to the American Academy of Science at Detroit's AAAS Meeting. These students presented papers and had poster sessions.
g. Society of Analytic Chemists and the Spectroscopy Society of Pittsburgh has set aside money for us in their budget for our 60th anniversary meeting. Money will be forthcoming in early January.

14. Convention Committees:
a. Time and Place Chairman—Dr. William Uricchio reported that the 60th Annual Meeting will take place at Seven Springs on Friday, March 30th to Sunday, April 1, 1984. Meeting will be by ourselves since there is not enough rooms for both the PAS and PJAS. The PJAS meeting will begin on Sunday, April 1 and conclude on Tuesday, April 3, 1984.
(1) Total cost of the package will be $80.00 per person, double occupancy. If paid by March 1, 1984 the cost will be $75.00. Registration fee will be $10.00 for members and students and $15.00 for nonmembers. The price of the package includes two nights in a double room and four meals. A social will follow the symposium on Friday night, and a social hour will be held before dinner on Saturday night.
(2) The 61st Annual meeting will be held in conjunction with the PJAS on April 21 to 23, 1985 at Host Farm in Lancaster, PA.
(3) Kurt Schreiber made a motion to increase the registration fee and Student fees to $25.00 from $10.00 and for nonmembers to $20.00 from $15.00. Leave the package deal as is. Dr. Majumdar seconded the motion. Motion carried.
b. General Chairpersons from Duquesne will be Kurt Schreiber and Bruce Martin. Duquesne is host University at Seven Springs.
c. Symposium—Dr. Brenner stated that the speakers for the symposium will be Paul Wiegman, Director of natural areas for the Western Pennsylvania Conservancy; Dr. Christine Schonewald-Cox from the National Park Service in Washington, D.C. and Jack Edmundson from the U.S. Fish and Wildlife Service's Office of Endangered Species in Washington, D.C. Symposium will be chaired by Dr. Brenner.
d. Exhibits—Tex Ziegenfus spoke about writing to Exhibitors who will be participating at the meeting in Seven Springs. A fee will be charged all exhibitors, regardless if they just send in the material or appear in person.
e. Dr. Ostrovsky has contacted and arranged to have Dr. Nicholas W. Short from the Goddard Space Flight Center to be the after-dinner speaker on Saturday evening. Dr. Short is currently in research within the Geophysics Branch at the Goddard Flight Center.

15. Dr. Ken Mechling of PSTA was asked to address the Executive Committee. Dr. Mechling—Affiliate Liaison for PAS has contacted several organizations in the State of Pennsylvania, namely, Philadelphia Academy of Science, The Wildlife Society, Delaware County Science Teachers, etc. Philadelphia Academy of Science and Pennsylvania State Association of College and University Biologists in considering our offer for affiliation. Wildlife Society expressed interest in affiliating with PAS and wrote a letter to Dr. Mechling stating so. They have 80 members. Dr. Mechling made a motion and it was duly seconded and passed to accept the Wildlife Society as an affiliate of PAS. Dr. Mechling thanked the membership for their vote of confidence in accepting the Wildlife Society as an affiliate.

16. Research Grants—Dr. Sherman Hendrix reported that PAS was recently awarded a competitive grant of $1,000, to help stimulate and improve research by secondary school students, from the Office of Science and Technological Education of the American Association for the Advancement of Science. This grant will enable the Research Grants Committee to fund several student projects during the coming year. Both Clarence Myers of PJAS and Rosemary Kuhn of PSTA were notified of this grant and asked to disseminate the information to their respective organizations. Announcement of the grant was published in the latest issue of the PAS Newsletter.
Two grant applications were received and reviewed by the Committee since the last report. A grant of $163.00 was made to Ms. Betty Shin working on cardiac physiology and athletes, at the Southern Lehigh High School under the direction of Mrs. Marie Dugan. A second grant was submitted and later withdrawn due to a change in personal circumstances of the individual involved.

17. Industrial Relations—Dr. Don Zappa was not present and no report was sent in.

18. Darbaker Award—Stanley Zagorski stated that the Darbaker award this year was presented to Dr. Daniel Klem, Jr. and two students of the Muhlenberg College's Department of Biological Sciences. Stanley sent a congratulatory letter to Dr. Klem and also a letter to the President of Muhlenberg College. Dr. Klem received a cash balance after the $150.00 page charge was deducted from the award money.

B. Motions and New Proposals—The President stated that he received some correspondence from Dr. Martin—a four-page letter, in particular, from Arlen Specter concerning political issues and whether the academy wanted to make comments on some of these issues. After discussion with President-Elect and several members of the committee, a letter will be sent to Mr. Specter telling him that we would be willing to give any comments on Scientific Issues and not political.

The issue was brought up again, which was voted down in the Spring meeting of 1982, that we should have a directory of area of expertise showing anyone interested that our members are experts in certain fields only (Biology, Archeology, etc.) and only those fields, just in case these kinds of issues come up again.

Dr. Fred Brenner will bring to the spring meeting a format of how to prepare such a Directory of Area of Expertise and he will look over the cards (dues) and see how we can have them imprinted with such a category for each member.

This will become our permanent reference for people who ask the Academy to supply information to them from our people.

An important clarification was made—A reciprocal agreement was reached between PAS and PSTA that we would reciprocate, in turn, those registration fees to Executive Officers of the PSTA when they attend our meetings as we are attending their meetings. We do not have to pay their registration fees and if they are attending our meeting they do not have to pay our registration fees.

Another issue to clarify is can we continue to afford to give gratis books besides the Proceedings and Newsletter, the types of books that we are publishing? Should we continue to mail these large volumes to members? We should look for a marketing area for these books and how to sell them to make a profit.

1. A suggestion was given to those who are interested in the Coal Book. There will be a form printed in the Newsletter telling those who are interested in the Coal Book to send $3.00 and a small donation to defray the costs of the mailing, handling, etc. and the Pennsylvania Coal book will be sent to you, if you are a member.
2. It was also suggested that for future publications, there will be a half-price charge for a book for members and a full price for nonmembers, with new publications thereafter.
Motion was made by Dr. Uricchio and seconded by Dr. Bucholtz to do this. Motion carried.
3. Three new books will be published by the Academy—Hazardous, Solid and Liquid Wastes. Dr. Shoffstall suggested that we make it known that these books will not be gratis in the future.
Mike Bucholtz mentioned the following suggestion. With state funding hanging in the balance, that it might be politically astute to submit to the legislators at the state and national level, a free complimentary copy of the book, sometime in the near future, so that they will see that they can have something on their shelf from which the state monies have been used more or less in the past, indirectly, since we do have a large number of extra copies.
Motion was made by Michael Bucholtz that the Pennsylvania Academy of Science submit to the state legislators of both the House and Senate as well as all U.S. Representatives from the State and the two State Senators, as well as the Supreme Court and other appropriate elected or appointed officials, copies of the Pennsylvania Coal book in a form of a complimentary fashion. Seconded by Shyamal Majumdar. Motion carried.

C. NEW BUSINESS
The Recording Secretary will retype the Constitution with the new addendums.
The President suggested that we designate September, October and November as membership drive months. We have to think of new ways to get new members to join PAS.
Many interesting and varied suggestions were expressed by Dr. Shoffstall, Dr. Majumdar, Dr. Uricchio, Dr. Martin, Sister Gabrielle and Mr. Zagorski.
Motion was made by Shyamal Majumdar and seconded by George Shoffstall that all members, who have paid their 1984 PAS dues are entitled to receive one copy of the new Academy publication, "Pennsylvania Coal" free, however, there is a charge of $5.00 for incidental expenses. Prepayment is required.
This incidental expense charge will be waived if the book request is accompanied by an application and check in getting another person to join the PAS. Motion passed.
An amendment to the first motion was made because the original motion contained a payment to be made of $3.00 for expenses for requesting the new book. The new amendment to motion is that we will increase the charge per book to $5.00 to members to cover expenses of the book. Motion was seconded and carried. The cost to defray expenses is $5.00.
There will be an application form printed in the forthcoming Newsletter explaining the details of procuring this book from the Academy. Additional copies for members and nonmembers and companies is $30.00.
The President appointed Bob Halma as Chairman, the duty of seeking marketing firms to help market the Coal book and other forthcoming books. Dr. Halma will give his report at the Spring meeting.
Dr. Shoffstall addressed the Executive Committee on importance of getting an office space for our archives and Harrisburg meeting rooms. There is a space available across from the Capitol in Harrisburg. If anyone has any other suggestions, please present them to us at the Spring meeting.
No further significant business was discussed, therefore the meeting adjourned at 1:00 p.m.

Respectfully submitted,
Viola A. Yakstis, Recording Secretary.

Proceedings of the Pennsylvania Academy of Science 58: 29-36. 1984

LECTIN INTERACTIONS WITH BIOMEMBRANES: A SURVEY[1]

DARRYL L. LANDIS and WILLIAM J. YURKIEWICZ

Department of Biology
Millersville University
Millersville, PA 17551

ABSTRACT

Lectins are multivalent saccharide-binding proteins capable of agglutinating cells and precipitating carbohydrates. They also exhibit a wide range of biological properties including mitogenic stimulation of lymphocytes, inhibition of fungal growth, insulin-like activity on fat cells, cytotoxic activity toward mammalian cells, and degranulation of mast cells. Usually isolated from plants, lectins have also been detected in bacteria, fungi, fish, invertebrates, birds, mammals, and humans. No specific biological role is known. This paper reviews previous and some current research on lectins. 1) Concanavalin A—summarizes the significance of this versatile lectin and its characteristics. 2) Lectin distribution and biological properties—surveys some current research to illustrate biological properties. 3) A general mechanism of lectin activity—discusses current thought on the mechanism of lectin activity. 4) Research techniques—reviews the importance of lectins as a research tool and presents research applications.

INTRODUCTION

The discovery of a toxic red blood cell agglutinin in castor beans by Stillmark in 1888 marked the beginning of scientific awareness and use of lectins. For many years following Stillmark's important description of the phenomenon of agglutination, lectins were considered nonspecific and relatively unimportant in living systems despite the fact that many of the early principles of immunology were delineated by Ehrlich using blood agglutinins recognized by Stillmark (1). Sumner and Howell successfully crystallized concanavalin A and identified it with the hemagglutinin of the jack bean plant in 1936 (2) but the term lectin was not generally applied to agglutinins until Boyd coined the term from the Latin *legere* (to pick or choose) in 1954 (3).

Since their physiological role is not clearly understood, a strict definition of lectin function is difficult. One of the most distinctive features of lectins is their ability to bind more or less specifically with certain carbohydrate groups. It is generally accepted that a lectin is a multivalent saccharide-binding protein that has the unique ability to agglutinate cells. In order to narrow this category, monovalent carbohydrate-binding toxins, carbohydrate-binding immunoglobulins and carbohydrate-binding enzymes are excluded (4). Lectins are not enzymes, although some enzymes such as the ∝-galactosidase from mung beans exhibit lectin-like activity (5).

[1]Received for publication January 28, 1984; reviewed; accepted March 19, 1984.

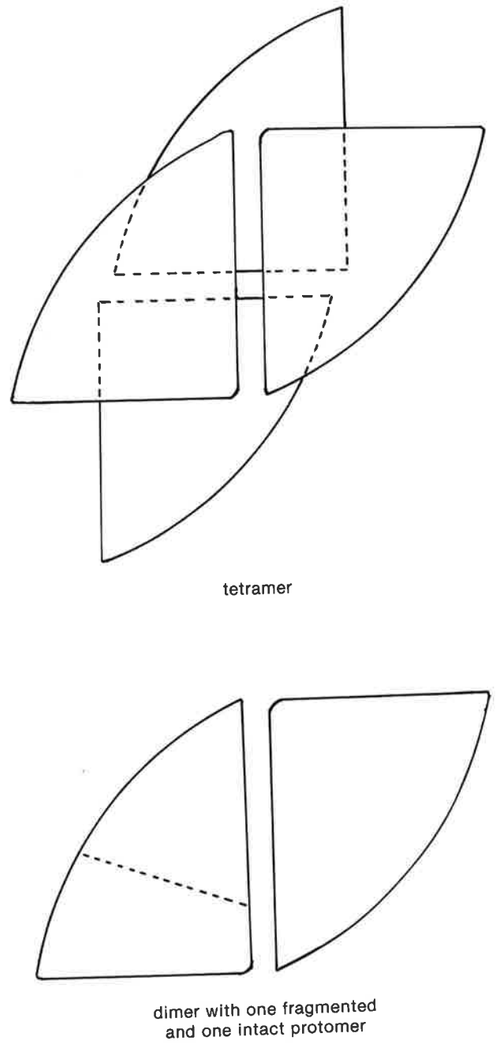


FIGURE 1. Schematic of concanavalin A assembly of protomers.

CONCANAVALIN A

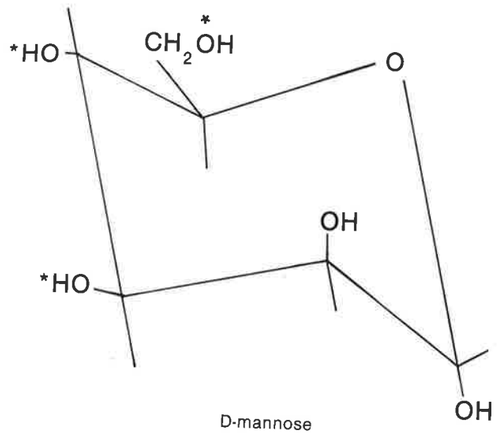
Because con A was purified and isolated first, this lectin has contributed a great deal to research on the physiological role of lectins in animals as well as plants. Constituting 2.5-3% of the total protein mass of jack bean meal, con A is a favorite choice for research because of its availability, ease of preparation and wide range of action (1). Con A can be separated into distinct molecular species in the presence of strong dissociating solvents. Each protomer formed in this manner has a MW of 27,000 and can be fragmented to smaller pieces of 12,500 and 14,000 (1). Con A is a species of two protomers below a pH of 6 and exists as a species of four protomers at pH 6.7 and higher. X-ray crystallography at 4 Å resolution reveals that each asymmetric subunit forms an elliptical dome with a base of 46 Å by 26 Å and a height of 42 Å (See Fig. 1). Although the amino acid sequence for con A is not known, a fairly good idea of the molecular packing can be obtained from X-ray crystallographic studies (1). Slight depressions on each protomer appear to be the binding sites of saccharides. It is known that Mg^{++} must bind to the con A molecule before Ca^{++} can bind and that con A activity is only present when both metals are in place (1).

Con A precipitates many polysaccharides that contain nonreducing ∝-D-glucopyranosyl, ∝-D-mannopyranosyl, β-D-fructofuranosyl and ∝-D-arabinofuranosyl residues (1, 3). The binding site of the sugars appears to be the C-3, C-4 and C-6 unmodified hydroxyl groups as any change at these groups prevents binding (1). It also appears that D-mannose and D-glucose bind in the chair conformation with the alpha position of the anomeric carbon preferred (see Fig. 2).

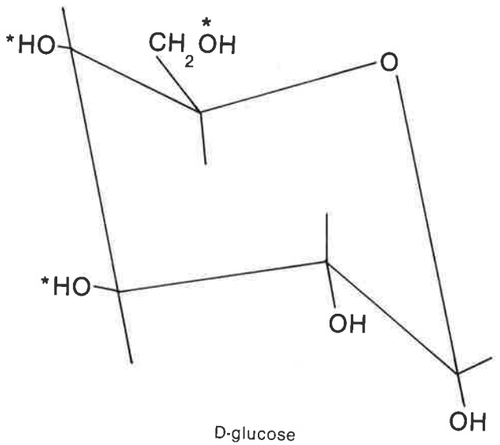
BIOLOGICAL PROPERTIES AND DISTRIBUTION

Although only about 50 lectins have been isolated, purified, and characterized (3), thousands have been examined. Lectins are usually extracted from plants where they have the widest distribution, but they have also been detected in bacteria, fungi, fish, invertebrates, birds, mammals, and humans (6). Lectins are found primarily intracellularly, but are also detectable on cell surfaces where they are involved in antibody-antigen reactions (4). For instance, Maynard and Baenziner (7) recently characterized a mannose/N-acetyl-glucosamine-specific lectin from rat liver. The lectin was solubilized from whole liver by NaCl without detergent. Upon subcellular fractionation, the lectin was detected on microsomes although it was not found on the hepatocyte surface. These results seem to indicate the lectin is a peripheral soluble protein on an intracellular membrane (7).

The specificity of saccharide-binding sites of lectins varies considerably depending on the valence of the lectin and the nature of the carbohydrate it binds (4). However, this interaction with carbohydrates at the surface of membranes has resulted in an extensive array of biological properties including: agglutination of erythrocytes, lymphocytes, viruses, spermatozoa, vesicles, tumor cells and microorganisms; insulin-like stimulation of fat cells; activation of suppressor T cells; mitogenic stimulation of lymphocytes; cytotoxic activity towards some mammalian cells; inhibition of fungal growth; and degranulation of mast cells (4, 6, 8). Attempts have been made to reduce this list of biological properties to a well-defined hypothesis for the role of lectins in living systems (4). Because of their valence, lectins possibly crosslink glycoproteins/glycolipids in membranes for organizational or



D-mannose



D-glucose

FIGURE 2. Chair conformers of D-mannose and D-glucose with con A binding positions indicated (*).

structural reasons. It has also been suggested that lectins play a role in receptor-mediated pinocytosis of glycoproteins for digestion and in intercellular interactions during tissue differentiation (4). Whatever their role, it is clear that it is mediated by protein-carbohydrate interactions.

The carbohydrate-binding characteristics of lectins enable their use in the study of other membrane binding particles. Huggins *et al.* (9) examined the binding of an attenuated strain of Venezuelan equine encephalomyelitis virus to a murine cell line using lectins. The lectins inhibit virus binding, thus suggesting the virus target site is glycoprotein in nature. Lectins (concanavalin A and wheat germ agglutinin) have also been utilized to explore glycoprotein differences in cystic fibrosis fibroblasts and normal fibroblasts (10).

Early research quickly revealed that lectins agglutinate erythrocytes and that the addition of sugar inhibits agglutination. It was concluded that lectins bind to saccharides on the cell

surface (1). Further experimentation showed that certain lectins have specific reactions with human blood groups providing a model for antibody-antigen reactions. The blood groups are thus determined by the presence of specific saccharide receptors; for instance, type A blood has an N-acetyl-glucosamine residue based on the inhibition of lectin binding to blood group A by the sugar N-acetyl-glucosamine. Lectins that demonstrate nonspecific binding patterns most likely bind to saccharide residues different than blood group determinants (1). An experiment by Allen *et al.* is indicative of the abundance of lectins that are blood group nonspecific (1). Extracts from 2663 varieties of plants were tested for blood group activity: 711 were found to be nonspecific, 90 extracts were specific, 227 hemolyzed all blood groups and 1635 were inactive (1).

Even though a lectin is carbohydrate specific, it still may bind many different types of glycoproteins as indicated by Maher and Molday (11). Using sodium dodecyl sulfate polyacrylamide gel electrophoresis (SDS-PAGE) and fluorescent lectins, the binding sites of wheat germ agglutinin (WGA) and concanavalin A (con A) to mouse neuroblastoma cells were identified. It was found that WGA binds almost exclusively to a glycoprotein receptor of 30,000d while con A tags over 20 glycoproteins with molecular weights in excess of 50,000 (11). These results suggest a possible explanation for the variety of biological properties lectins display; that is, it is probable that several different proteins with dissimilar functions have the same carbohydrate moiety. This hypothesis is supported by the experimental findings of Kolb *et al.* (12) who discovered that while Kupffer cells and rat hepatocytes both have a D-galactose-specific receptor similar in many respects, different processes occur when D-galactose binds.

The agglutination of cells by lectins occurs because lectins are multivalent and form crossbridges between two cells. It was soon discovered that lectins are capable of binding together two different cell types and that this is the mechanism by which lectins inhibit fungal growth (4). It has been postulated that lectins are involved in both the prevention of plant infection and the promotion of bacterial attachment to vertebrate cells as it is known that *E. coli* possesses a lectin that binds D-mannose (and its ∝-glycosides) and aids cellular attachment (4).

Lectins are being used quite extensively in research to distinguish between malignant cells and normal cells based on the increased agglutinability of tumor cells (1, 3). The probable explanation for this property of lectins lies in an alteration of tumor cell membranes as Mehta and Iyer suggested in a recent study involving Wistar rat erythrocytes (13). The erythrocytes of normal Wistar rats agglutinate maximally at 250 μg/ml of con A. An intraperitoneal injection of Yoshida ascites tumor causes the erythrocytes to agglutinate at 50 μg/ml con A. It was noted that the injected tumor alters the red blood cells within 24 hours although enhanced agglutinability is not manifested until 72 hours. The experimenters concluded that a sufficient concentration of con A-binding glycoprotein is needed before lectin agglutination is altered (13).

Researchers have been able to trace the changes in cellular membranes as the cell passes through stages of differentiation. Iodinated con A was applied to glycoprotein of rat epidermal cells separated by SDS-PAGE and the relative intensities of the 20 labeled bands were then measured (14). The relative intensities of con A-binding bands change depending on the stage of differentiation and labeling patterns for carcinogen-transformed cell lines are markedly different (14). Similarly, Katzin and Colli (15) used WGA, con A and *Lens culinaris* lectin to investigate the surface of *Trypanosoma cruzi* in three differentiation stages. In the infective stage of *T. cruzi,* a glycoprotein (TC-85) is isolable by a WGA-sepharose column. The protein TC-85 does not bind *Lens culinaris* lectin but does bind con A. Because the glycoprotein is absent in the other two stages of differentiation, it is thought to play a role in adhesion and interiorization of *T. cruzi* into mammalian cells via recognition of extensive N-acetyl-D-glucosamine receptor activity (15). Using the lectins *Ulex europaeus* agglutin I (UEA) and *Bandeiraea simplicifolia* I-B_4 (BS I-B_4), Zieske and Bernstein demonstrated that there is a change in saccharide residues as rat epidermal cells move out of the basal layer (16).

One of the first biological properties of lectins to be described by researchers was their cytotoxic effect on some eukaryotic cells. The lectin ricin, for example, is composed of two nonidentical disulfide-bonded subunits A and B. Subunit B binds specifically to the cell surface where ricin is endocytosed, whereupon subunit A interacts catalytically with the 60S ribosomal subunits to halt protein synthesis (17). Certain cell lines of a murine lymphoma are resistant to the effects of ricin. They probably express their resistance at the cell surface by changing membrane receptor mobility rather than at the level of the ribosome (18).

Some evidence has been obtained implicating lectin involvement in self-nonself recognition reactions. A lectin isolated from chick embryo muscle (dimer of 15,000d subunits) is thought to participate in myoblast fusion (19) although other research seems to contradict this conclusion as immunohistochemistry techniques reveal the lectin is mostly intracellular (4). Studying the hematocytes of the American oyster, *Crassostrea virginica,* Vasta *et al.* (2) located an integral glycoprotein thought to be a serum (soluble) lectin involved in nonself recognition.

Several phenomena directly related to lectin-binding of cells are being linked as a result of increased research on the mechanism of endocytosis. A radioactive asialoorosomucoid (ALM) was used by Hudgin *et al.* (21) to form a complex with circulating asialoglycoproteins which was then pinocytosed by rabbit liver cells. An integral protein thought to be involved in the pinocytic process was extracted with detergent and isolated by affinity chromatography using ALM (21). The purified carbohydrate-binding glycoprotein (10% sugar by weight) agglutinates human and rabbit erythrocytes (22) and induces mitosis in peripheral lymphocytes (23). The lectin has a high affinity for methyl-N-acetyl-α-D-galactosaminide but also binds galactose (24). Other researchers have indicated that only 5% ($7x10^4$ molecules/hepatocyte) of the lectin is at the plasma membrane surface while 95% is located intracellularly in association with the Golgi apparatus and lysosomes. The lectins associated with the lysosomes appear to be on the cytoplasmic surface while other organelles evidently have the lectin on their luminal side (25). The relationship between intracellular and extracellular lectins is not presently known. Glycoprotein clearance in liver is thought to be mediated by lectin involvement during pinocytosis. It is known that a protein is involved in the clearance of a glycoprotein with an exposed N-acetyl-glucosamine residue in avian liver (26), that rabbit liver has a protein crucial to mannose N-acetyl-glucosamine clearance (27) and that human fibroblasts clear mannose-6-phosphate-containing protein (4). Many studies have been done on the effects of lectins on endocytosis such as the work done by Storrie and Maurey (28). These researchers examined the effects of con A on pinocytic uptake and pinosome-lysosome fusion in Chinese hamster ovary cells and discovered that con A (> 50 μg/ml) promotes uptake while inhibiting degradation of horseradish peroxidase (glycoprotein). Con A has no effect on bovine serum albumin

which is nonglycosylated. Storrie and Maurey deduced that the effects of con A is a result of a complex formed and is not a modulating effect (28). By using the electron microscope and asialofetuin adsorbed onto colloidal gold, it is possible to visualize the N-acetyl-galactosamine-specific lectin on the surface of Kupffer cells. The colloidal gold complex is endocytosed via the coated pit-vesicle pathway since the lysosome membrane shows evidence of coated areas (29). An interesting experiment performed by Szoka *et al.* (30) demonstrated the possibility of using lectins and polyethylene glycol to increase the transfer of fluorescent lipid analog probes from the vesicle to the cell membrane and the transfer of fluoresceinated proteins from the vesicle interior to the cytosol. The lectin binds the cell surface to the lipid analog probes in the vesicle and the glycol induces fusion of the two membranes (30).

The ability of lectins to induce the formation of caps both on the cell surface and in the perinuclear region of the cytoplasm is being studied in conjunction with the phenomena of endocytosis and mitogenesis. While lectins are not the only agents that induce capping, there is much evidence supporting their role in cap formation and some researchers suggest the clustering of membrane receptors on the surface and of endocytic vacuoles in the perinuclear region occurs in connection with actin and myosin containing cytoskeletal structures (31). A simple experiment by Phelps *et al.* (32) is representative of the many observations of lectin-induced cap formation. Using the dye merocyanine 540, which is a fluorescent probe specific for disordered regions of lipid bilayers that displays the same binding patterns as con A and WGA, Phelps *et al.* discovered the dye and lectin localize in one region of the membrane forming a cap (See Fig. 3). While studying a lectin specific for D-galactose that mediates asialoglycoprotein endocytosis in rat hepatocytes, another researcher suggested three steps leading to endocytosis (33). First, the ligand binds at widely distributed sites, then local microaggregations of complexes form, and finally, larger clusters form and associate with coated pits.

It is known that native tetravalent con A inhibits cap formation at high concentrations (>5 μg/ml) and low temperatures (4°C) suggesting that con A inhibition is dependent to some extent on temperature and concentration conditions (34). Edelman thus concluded con A restricts receptor mobility and proposed three possible mechanisms: i) the binding of Con A decreases membrane fluidity and increases the phase transition temperature; ii) the binding of con A forms structures which trap other receptors; or iii) the binding of con A somehow alters cytoplasmic structures such as microfilaments and microtubules (34). Edelman stated it is most likely that binding alters cytoplasmic structures attached to glycoprotein receptors since colchicine and related drugs prevent mitogenesis and cap formation in some cases (34). Schwarz *et al.* (35) studied the internalization of surface-bound fluoresceinated con A in Chinese hamster ovary cells and noticed that microtubule inhibitors (colchicine) prevent aggregate formation in the perinuclear region of the cell for both con A and WGA. Because local anesthetics inhibit con A internalization, but not that of WGA, Schwarz et al. concluded con A and WGA enter the cell by different pathways but are collected in the same perinuclear region by similar pathways (35).

In order for internal cellular structures to control the movement of surface receptor sites, some connection across the membrane is necessary. In many cases it appears this connection is provided by a transmembrane protein such as the chicken hepatic lectin recently described by Drickamer and Mamon (36). The lectin is thought to be transmembrane because of the protein kinase target site near the NH_2 terminal, the presence of the string of 25 uncharged, hydrophobic residues, and glycosylation near the COOH end (36).

Much research has accumulated on the mitogenic effect of lectins (1, 4) and work is continuing to determine the precise mechanism of this unique lectin property. Mitogenic lectins act at the cell surface by interaction with certain receptors. Not all lectins trigger a mitogenic response indicating that binding to a particular type of receptor must occur (34). A glycoprotein was detected on T, B, null and myeloid cell lines of human lymphoid cells which was absent from normal B and T cells but could be produced by lectin (phytohemagglutin) stimulation (37). The glycoprotein is present on dividing lymphoid cells, but not on nondividing cells. Some researchers (38) have reported results indicating lectins can also suppress DNA synthesis. *Agaricus bisporus* lectin (ABL) suppresses DNA synthesis in human T lymphocytes and Ig production in human B lymphocytes even in the presence of known mitogenic lectins like con A and phytohemagglutinin (38).

MECHANISM OF LECTIN ACTIVITY

While the endocytic ability of lectins is thought to depend on the ability to form aggregates of surface receptors, no correlation has been established between capping and mitogenesis (34). A model for the formation of caps has been suggested based on interactions between cytoplasmic structures and membrane receptors. The cytoplasmic structures are probably related to actin-like proteins or microtubules which exist in an equilibrium between anchored and free states with the membrane receptors (See Fig. 4). The distribution of glycoprotein receptors on the cell surface is affected by this equilibrium (34). Alterations of the microtubular assembly change the mobility of the receptors; in this way, colchicine has its effect by disassembly of the complex. Surface receptors can be linked to the intracellular network either directly or indirectly by the use of integral proteins that span the membrane.

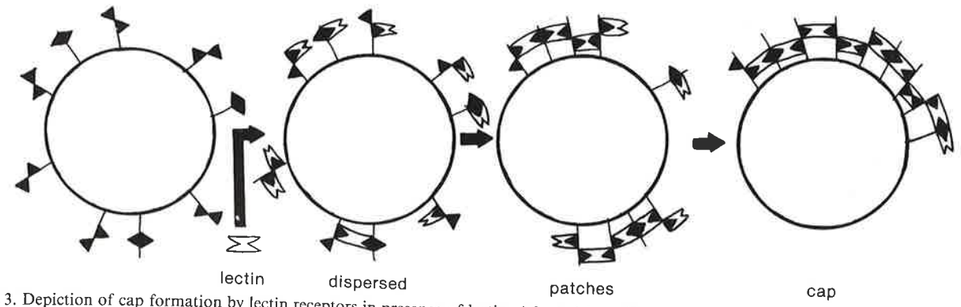


FIGURE 3. Depiction of cap formation by lectin receptors in presence of lectin. Adapted from (3).

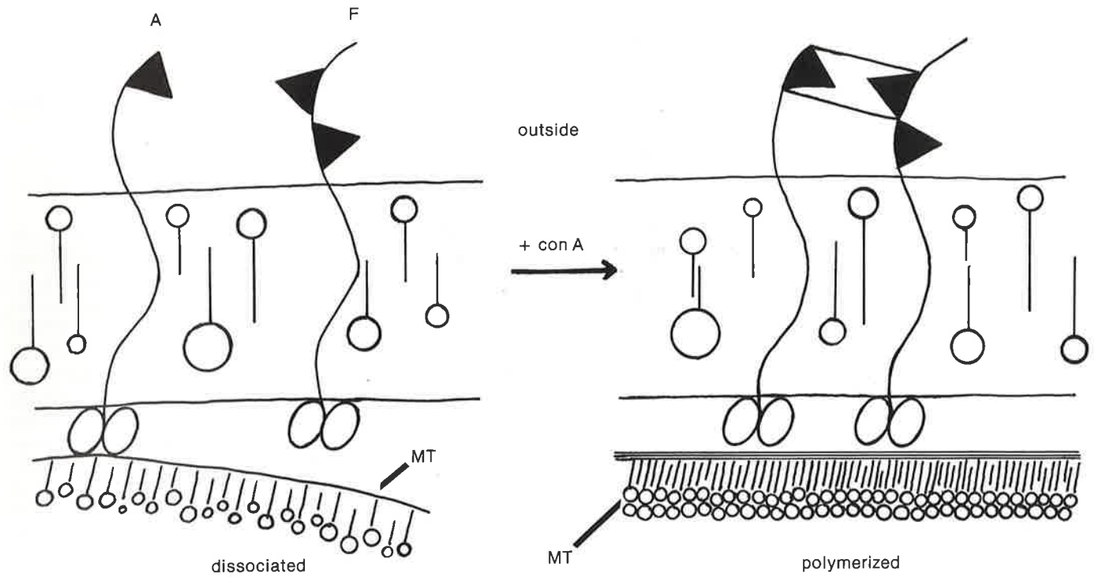


FIGURE 4. Representation of anchored (A) and free (F) states of glycoprotein receptor with intracellular microtubular structures (MT). Adapted from (39).

Studies done by Parker (40) suggest that microtubules and microfilaments exist in conjunction with the membrane and normally oppose one another in their action. Colchicine and cytochalasins increase and decrease, respectively, the capping response indicating cytoskeletal structures are directly involved with control of membrane fluidity. Colchicine affects tubulin structure and diminishes membrane perturbations while cytochalasins interfere with cross-linking of actin polymers eliminating the stabilizing effect of microfilamentous structures and thus exaggerating the response (40). These data imply that microfilaments normally aggregate in response to lectin binding thus helping to restore the configuration of the plasma membrane to its original state. Conversely, microtubules act by binding different elements of the membrane and by transmitting stimuli to cell regions not directly attached to lectin receptors (40).

While there does seem to be a negative correlation between immobilization of receptors and mitogenic stimulation, cap formation is not necessary for mitogenesis. Edelman found that only 6% of the available lectin receptors need to bind in order to induce mitogenesis and that inhibition of the mobility of these receptors by high con A doses leads to inhibition of mitogenesis, supposedly by altering the cytoplasmic microtubule system. Evidently the concentration of lectin is primary in determining receptor mobility and ultimately its mitogenic effects (34).

The cytoplasmic microtubular system plays an important role in mitogenic activity as indicated by the research of Pfeifer and Irons (41). They reported that preincubation of rat spleen lymphocytes with hydroquinone prevents blast transformation in the presence of phytohemagglutinin. The inhibition occured in the absence of depressed energy production suggesting impairment of cytoskeletal function. This can be explained by the interaction of polyhydroxy metabolites of benzene with sulfhydryl groups on microtubule proteins (41). Other researchers have raised antibodies against a cytoskeleton-associated nonphosphorylated 230,000d bovine lens polypeptide that is localized as a distinct subplasmalemmal layer in the peripheral cytoplasm of cells (42). The polypeptide constitutes less than 0.3% of total cellular protein in many human cell types including fibroblasts, endothelial and epithelial cells and is thought to be part of a cell surface and cytoskeleton-associated structure participating in cell surface-cytoskeleton interactions (42).

Lectin-induced endocytosis is also related intimately with the microtubular system of cells. By using electron microscopy and fluorescence, Herman and Albertini (43) found that con A-containing endocytic vesicles formed within 20 minutes (37°C) of binding to rat ovarian granulosa cells and migrated to the cell center by 60 minutes. During vesicle translocation, microtubules and 10 nm filaments were altered in composition. Electron microscopy confirmed that large receptosomelike structures form in conjunction with cytoplasmic microtubules and 10 nm filaments (43).

A host of membrane and intracellular changes have been catalogued upon introduction of mitogenic lectins to the medium of lymphocytes grown *in vitro* (44). These changes include: rapid intake of K^+, amino acids, nucleotides, sugars, and Ca^{++}; stimulation of endocytosis; and alterations in intracellular levels of cyclic nucleotides such as cAMP and cGMP. There is some evidence for changes in membrane fluidity and increased synthesis of ribosomal RNA (44, 45). From these data a simple scheme can be applied:

binding of mitogenic agent → modification of membrane function and structures → cytoplasmic changes and messengers → various nuclear and cytoplasmic events of activation (44)

It has been argued that Ca^{++} is critical in controlling not only intracellular levels of cGMP and cAMP, but also the binding equilibria of the microtubular system both of which have been implicated in relaying the mitogenic message to the nucleus (44) (See Fig. 5). Upon binding of the mitogen to the membrane receptor, Ca^{++} crosses the membrane and activates cyclase systems responsible for cGMP and cAMP resulting in the assembly/disassembly of microtubular cytoplasmic structures. The surface to nuclear signal is not known (44). The progress made recently in studying the mechanisms of lectin action implies that the varied biological properties exhibited by lectins are all related to a general mechanism which has not been fully delineated.

As no single mechanism has been determined for lectin activity, it is thought that the biological effect of lectins is determined not only by specific binding sites, but also by cellular localization and concentration (4). Opportunistic factors (being in the right place at the right time) probably play a role just as important as carbohydrate specificity (4). For instance, a study by Ishikawa *et al.* (47) indicated the presence of an extracellular protease enhances agglutination of human erythrocytes by *C. lamprauges* agglutinin, WGA, soybean agglutinin and con A. The protease (MW ~ 20,000) produced by *C. lamprauges* along with chitin-binding agglutinin, hydrolyzes band 3 of an SDS-PAGE separation of a red blood cell preparation (47). In another study, the amount of con A binding was shown to be related to the population doubling time of the cell culture at the time of analysis (10). Interactions with macromolecules associated with the active site of lectins apparently play some role. WGA binding to erythrocytic glycophorin is affected by nonspecific interactions of the receptor with other proteins and oligosaccharides present at the membrane surface (48). Ketis and Grant (49) reported that the lectin binding curves of con A indicate positive cooperativity when plotted for binding to model membranes and intact erythrocytes. Binding to model membranes is influenced by the presence of apparently unrelated macromolecules which suggests receptor modulation by local interactions (49). Amino acids spatially adjacent to the reactive site on lectins have also been shown to have some involvement in binding. The specific binding patterns of *Vicia graminea* lectin, which reacts with glycoproteins that have unsubstituted or sialylated galactose ($\beta 1 \rightarrow 3$) N-acetyl-galactosamine residues, is enhanced by the presence of hydrophobic amino groups (50).

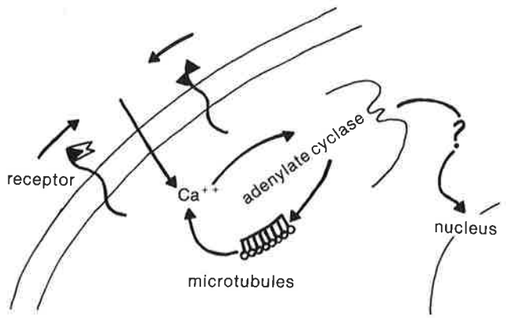


FIGURE 5. A mechanism for the role of Ca^{++} in cellular changes during lectin binding. Adapted from (46).

RESEARCH TECHNIQUES

The saccharide specificity of lectins and their varied modes of action make them ideal research tools in many cases as summarized in Table 1 (1). In an experiment performed by Snider and Robbins (51), con A was used to study the location of oligosaccharide-lipid in microsomal vesicles made from hamster fibroblasts. Lectin treatment indicated the oligosaccharide-lipid is on the luminal side of the vesicle as treatment with detergent is a prerequisite for lectin binding (51). Roth (52) reported a relatively new technique using the light microscope to demonstrate the presence of specific sugar sequences in glycoconjugates. The colloidal gold-lectin complex remains stable for months and is highly specific. Other researchers (53) have used antiserum prepared against con A binding glycoproteins separated by DEAE cellulose chromatography to investigate alterations in glycoprotein expression as a result of malignant transformation. Techniques have also been designed to separate lymphocyte subpopulations of differential agglutination and to induce mitogenic responses in cell cultures (54). However, the most frequently used research tool is lectin affinity chromatography. This technique can be employed to lower background radioactivity in radioactive glycoprotein studies (54) and to examine molecular heterogeneity of membrane glycoproteins (55). A *lens culinaris*-sepharose column is utilized to separate glycoproteins from plasma membrane extracts of HSV-1 transformed hamster embryo fibroblasts (56). A more novel application of lectin chromatography by Baumann *et al.* (55) involved the use of a con A column to follow the fate of a labeled glycoprotein. As the glycoprotein was destroyed in the course of the reaction, less labeled glycoprotein was able to bind to the stationary lectin (57).

Lectins are protein in nature, sometimes glycosylated, and interact to some degree of specificity with saccharide components. They exhibit an array of action on the biomembrane including agglutination, inhibition of fungal growth, cytotoxicity, endocytosis, cap formation and mitogenic stimulation. Although a general mechanism and specific role has not yet been assigned to lectins, it has been determined that the mechanism is modulated by protein-saccharide interactions. Further research will undoubtedly elucidate the function of lectins in animal physiology and better define their interactions with animal biomembranes.

TABLE 1

Biological properties of lectins identified with possible research application (1).

Property	Application
Specificity for human blood groups	Blood typing; identification of new blood types
Toxicity in animals	Studies of nutritional value of foodstuffs
Induction of mitosis	Detection of chromosomal abnormalities
Agglutinatin of malignant cells	Studies on cell surface architecture and alterations
Precipitation of polysaccharides and glycoproteins	Isolation and purification of carbohydrate compounds
Binding of sugars	Studies of specific combining sites on proteins

REFERENCES CITED

1. Sharon, N. and H. Lis. 1972. Lectins: cell-agglutinating and sugar-specific proteins. *Science*. 177:949-958.
2. Sumner, J.B. and S.F. Howell. 1936. The identification of the hemagglutinin of the jack bean with concanavalin A. *J. Bacteriol.* 32:227.
3. Sharon, N. 1977. Lectins. *Sci. Am.* 236:18, 108-16.
4. Barondes, S.H. 1981. "Lectins: their multiple endogenous cellular functions," in (Snell, E.E., Gen. Ed.). *Annual Review of Biochemistry.* Annual Reviews, Inc. Palo Alto. pp. 207-232.
5. Hankins, C.N. and L.M. Shannon. 1978. The physical and enzymatic properties of phytohemagglutinin from mung beans. *J. Biol. Chem.* 253:7791-7797.
6. Lis, H. and N. Sharon. 1977. *The Antigens.* Academic Press, New York.
7. Maynard, Y. and J.U. Baenziner. Characterization of a mannose and N-acetylglucosamine-specific lectin present in rat hepatocytes. *J. Biol. Chem.* 257:3788-3794.
8. Pereira, M.E.A., A.F.B. Andrade, and J.M.C. Ribeiro. 1981. Lectins of distinct specificity in *Rhodnius prolixus* interact selectively with *Trypanosoma cruzi. Science.* 211:597-599.
9. Huggins, J.W., W.R. Jahrling, and C.D. Linden. 1983. Characterization of the binding of the TC-83 strain of Venezuelan equine encephalomyelitis virus to BW-J-M, a mouse macrophage-like cell line. *J. Gen. Virol.* 64:149-158.
10. Harris, A. and M.E. Bramwell. 1983. Cystic fibrosis: a detailed analysis of fibroblast membrane glycoproteins. *Clin. Chem. Acta.* 128:41-52.
11. Maher, P. and R.S. Molday. 1981. Analysis of lectin-specific cell surface glycoprotein on neuroblastoma cells. *Biochim. Biophys. Acta.* 647:259-269.
12. Kolb, H., D. Vogh, L. Herbetz, A. Corfield, R. Schaufer and J. Schleper-Schaefer. 1980. The galactose-specific lectins on rat hepatocytes and Kupffer cells have identical binding characteristics. *Hoppe-Seyler's Z Physiol. Chem.* 361: 1747-1750.
13. Mehta, N.G. and S.S. Iyer. 1982. Enhanced concanavalin A agglutinability of erythrocytes in rats bearing Yoshida ascites sarcoma: a study of the mechanism. *Eur. J. Cancer Clin. Oncol.* 18:693-704.
14. Brysk, M.M. and J.M. Snider. 1982. Concanavalin A binding glycoproteins of epidermal cells. *J. Invest. Dermatol.* 79:193-197.
15. Katzin, A.M. and W. Colli. 1983. Lectin receptors in-*Trypanosoma cruzi* an N-acetyl-D-glucosamine-containing surface glycoprotein specific for the trypomastigote stage. *Biochim. Biophys. Acta.* 727:403-411.
16. Zieske, J.D. and I.A. Bernstein. 1982. Modification of cell surface glycoprotein: addition of fucosyl residues during epidermal differentiation. *J. Cell Biol.* 95:626-631.
17. Olsnes, S., K. Refsnes and A. Pihl. 1974. Mechanisms of action of the toxic lectins abrin and ricin. *Nature.* 249:627.
18. Robbins, J.C., R. Hyman, V. Stallings and G.L. Nicholson. 1977. Cell-surface changes in *Ricin communis* toxin (ricin)-resistant variant of a murine lymphoma. *J. Natl. Cancer Inst.* 58:1027.
19. MacBride, R.G. and R.J. Przybylski. 1980. Purified lectin from skeletal muscle inhibits myotube formation *in vitro. J. Cell Biol.* 85:617-25.
20. Vasta, G.R., J.T. Sullivan, T.C. Cheng, J.J. Marchalonis and G.W. Warr. 1982. A cell membrane-associated lectin of the oyster *(Crassostrea virginica)* hematocyte. *J. Invertebr. Pathol.* 40:367-377.
21. Hudgin, R.L., W.E. Pricer, Jr., G. Ashwell, R.J. Stockert and A.G. Morell. 1974. The isolation and property of a rabbit liver binding protein specific for asialoglycoproteins. *J. Biol. Chem.* 249:5536-43.
22. Stockert, R.J., A.G. Morell and I.H. Scheinberg. 1974. Mammalian hepatic lectin. *Science.* 186:365-366.
23. Novogrodsky, A. and G. Ashwell. 1977. Lymphocyte mitogenesis induced by a mammalian liver protein that specifically binds desialylated glycoproteins. *Proc. Natl. Acad. Sci. USA.* 74:676-78.
24. Sarkar, M., J. Liao, E.A. Kabat, T. Tanabe and G. Ashwell. 1979. The binding site of rabbit hepatic lectin. *J. Biol. Chem.* 254:3170-74.
25. Steer, C.J. and G. Ashwell. 1980. Studies on a mammalian hepatic binding protein specific for asialoglycoproteins: evidence for receptor recycling in isolated rat hepatocytes. *J. Biol. Chem.* 255:3008-13.
26. Lunney, J. and G. Ashwell. 1976. A hepatic receptor of avian origin capable of binding specifically modified glycoprotein. *Proc. Natl. Acad. Sci. USA.* 73:341-343.
27. Kawasaki, T., R. Etoh and I. Yamashina. 1978. Isolation and characterization of a mannan-binding protein from rabbit liver. *Biochem. Biophys. Res. Commun.* 81:1018-24.
28. Storrie, B. and K.M. Maurey. 1981. Role of concanavalin A as an endocytic modulator in Chinese hamster ovary cells. *J. Cell Sci.* 50:135-147.
29. Kolb-Bachofen, V., J. Schlepper-Schaeffer, W. Vogell and H. Kolb. 1982. Electron microscopic evidence for asialoglycoprotein receptor on Kupffer cells: localization of lectin-mediated endocytosis. *Cell.* 29:859-866.
30. Szoka, F., K. Magnusson, Y.H. Wojcieszyn, Z. Derzko and K. Jacobsen. 1981. Use of lectins and polyethylene glycol for fusion of glycolipid-containing liposomes with eukaryotic cells. *Proc. Natl. Acad. Sci. USA.* 78:1685-1689.
31. Singer, S.J., J.F. Ash, Y.W. Bourguignon, M.H. Heggeness, and D. Louvard. 1978. Trans-membrane interactions and the mechanisms of transport proteins across membranes. *J. Supramol. Struct.* 9:373-389.
32. Phelps, B.M., P. Williamson and R.A. Schlegel. 1982. Lectin-induced rearrangement of am immature hematopoietic cell surface marker. *J. Cell Physiol.* 110:245-248.
33. Kolb-Bachofen, V. 1981. Hepatic receptor for asialoglycoproteins: ultrastructural demonstration of ligand-induced microaggregaton of receptors. *Biochim. Biophys. Acta.* 645:293-299.
34. Edelman, G.M., I. Yahara and J.L. Wang. 1973. Receptor mobility and receptor-cytoplasmic interactions in lymphocytes. *Proc. Natl. Acad. Sci. USA.* 70:1442-1446.
35. Schwarz, M.A., P.A. Harper and R.L. Juliane. 1982. Interaction of lectins with CHO cell surface membranes: differential effects of local anesthetics on endocytosis of concanavalin A and wheat germ agglutinin binding sites. *J. Cell Physiol.* 111:264-274.
36. Drickamer, K. and J.F. Mamon. 1982. Phosphorylation of a membrane receptor for glycoproteins: possible transmem-

brane orientation of the chicken hepatic lectin. *J. Biol. Chem.* 257:15156-15161.
37. Judd, W., C.A. Poodry and J.L. Strominger. 1980. Novel surface antigen expressed in dividing cells but absent from nondividing cells. *J. Exp. Med.* 152:1430-1435.
38. Greene, W.C., T.A. Fleisher and T. A. Walsmann. 1981. Suppression of human T lymphocyte and B lymphocyte activation by *Agaricus bisporus* lectin: 1. Suggestive evidence for a surface suppressor receptor in human lymphocytes. *J. Immunol.* 126:580-586.
39. Cunningham, B.A., Ben-Ami Sela, I. Yahara and G. M. Edelman. 1976. "Structures and activities of lymphocyte mitogens," in (Rosenstreich, D.L. and J.J. Oppenheim, Eds.),*Mitogens in Immunobiology.* Academic Press, Inc., New York. p. 23.
40. Parker, C.W. 1982. Pharmacologic modulation of release of arachidonic acid from human mononuclear cells and lymphocytes by mitogenic lectins. *J. Immunol.* 128(1):393-397.
41. Pfeifer, R.W. and R.D. Irons. 1981. Inhibition of lectin-stimulated lymphocyte agglutination and mitogenesis by hydroquinone: reactivity with intracellular sulfhydryl groups. *Exp. Mol. Pathol.* 35(2):189-198.
42. Lehto, V.-P. and I. Virtanen. 1983. Immunolocalization of a novel, cytoskeleton-associated polypeptide of a molecular weight of 230,000 daltons (p. 230). *J. Cell Biol.* 96(3):703-716.
43. Herman, B. and D.F. Albertini. 1982. The intracellular movement of endocytic vesicles in cultured granulosa cells.*Cell Motil.* 2(6):583-598.
44. Quastel, M.R. 1975. "Summary of symposium lymphocyte activation: the coupling of membrane signals to nuclear and cytoplasmic events," in (Rosenthal, A.S. Ed.), *Immune Recognition.* Academic Press, Inc., New York. pp. 517-521.
45. Verghese, M.W. and R. Snyderman. 1983. Hormonal activation of adenylate cyclase in macrophage membranes is regulated by guanine nucleotides. *J. Immunol.* 130(2):869-873.
46. Wang, J.L., G.R. Gunther, D.A. McClain and G.M. Edelman. 1976. "Biochemical signals," in (Rosenstreich, D.L. and J.J. Oppenheim, Eds.), *Mitogens in Immunobiology*. Academic Press, Inc., New York. p. 114.
47. Ishikawa, F., T. Kameyama, A. Takenaka, K. Oishi and K. Aida. 1981. Action of proteases on human erythrocyte glycoproteins in relation to hemagglutination by *Conidiobolus lamprauges* chitin-binding agglutinin. *Agric. Biol. Chem.* 45:2105-2110.
48. Ketis, N.V. and C.W.M. Grant. 1982. Control of high affinity lectin binding to an integral membrane glycoprotein in lipid bilayers. *Biochim. Biophys. Acta.* 685:347-354.
49. Ketis, N.V. and C.W.M. Grant. 1982. Cooperative binding of concanavalin A to a glycoprotein in lipid bilayers.*Biochim. Biophys. Acta.* 689:194-202.
50. Duk, M., E. Lisowska, M. Kordowicz and K. Wasniowska. 1982. Specificity of the binding site of *Vicia graminea* anti-N lectin. *Eur. J. Biochem.* 123:105-112.
51. Snider, M.D. and P.W. Robbins. 1982. Transmembrane organization of protein glycosylation: mature oligosaccharide-lipid is located on the luminal side of microsomes from Chinese hamster ovary cells. *J. Biol Chem..* 257:6796-6801.
52. Roth, J. 1983. Applications of immuno colloids in light microscopy. 2. Demonstration of lectin binding sites in paraffin sections by the use of lectin-gold or glycoprotein gold complexes. *J. Histochem. Cytochem.* 31:547-552.
53. Shinohara, T., M.W. Thomas, E.G. Gilliam, V.P. Wray and E.F. Walborg, Jr. 1982. Selective solubilization and purification of cell-surface concanavalin A-binding glycoproteins from Novikoff hepatocellular carcinoma cells.*Arch. Biochem. Biophys.* 219:411-421.
54. Mishell, B.B. and S.M. Shiigi, eds. 1980. *Selected Methods in Cellular Immunology.* W.H. Freeman and Co., San Francisco.
55. Boldt, D.H. 1982. Chronic lymphocytic leukemia: demonstration of cell surface structural heterogeneity by lectin affinity chromatography of cell extracts. *Leuk Res.* 6:499-510.
56. Shneider, D., D. Brauer and D. Falke. 1982. Alkaline phosphodiesterase I and alkaline phosphatase in plasma membranes of herpes simplex virus type I transformed hamster cells. *Biochim. Biophys. Acta.* 685:94-104.
57. Baumann, H., E. Hou and G.P. Jahreis. 1983. Preferential degradation of the terminal carbohydrate moiety of membrane glycoproteins in rat hepatoma cells and after transfer to the membranes of mouse fibroblasts. *J. Cell Biol.* 96:139-150.

Proceedings of the Pennsylvania Academy of Science 58: 37-41. 1984

AN AGING SCHEME FOR THE PINE VOLE, *PITYMYS PINETORUM SCALOPSOIDES*[1]

TYRONE R. CORNBOWER and GORDON L. KIRKLAND, JR.
Vertebrate Museum
Shippensburg University
Shippensburg, Pennsylvania 17257

ABSTRACT

An aging scheme for the pine vole, *Pitymys pinetorum scalopsoides,* based on total length and weight is described. Five relative age classes ranging from juvenile to adult are recognized. The distinctiveness of the five relative age classes is assessed by comparing morphological data for four external measurements, weight, 12 cranial, and two postcranial measurements among the five age classes in a sample of 222 specimens and by examining reproductive characteristics of members of the five age classes using data from 150 males and 155 females. All specimens were collected in a three-county area in southcentral Pennsylvania. The five age classes tend to be morphologically distinctive for most characters analyzed, and the aging technique is particularly reliable in distinguishing breeding or potentially breeding adult females from those in younger age classes. Our proposed aging technique is easy to apply in contrast to aging techniques utilizing eye lens weight and is valid for the larger subspecies *P. p. scalopsoides* in contrast to two previously proposed techniques which were developed using samples of pine voles from the nominate subspecies.

INTRODUCTION

Demographic studies of free-ranging mammalian populations are predicated on the ability of the investigator to assign chronological or at least relative ages (e.g. juvenile, subadult, adult) to all or a majority of the individuals in a given population. Such research is fostered by the availability of an effective and easily-applied aging scheme for the species being studied. Although the pine vole, *Pitymys pinetorum,* has been extensively studied in recent years because of it role as a serious pest in orchards, relatively little effort has been expended on the development of an aging scheme for wild-caught pine voles which is both reliable and easy to employ. Gourley and Jannett ((1975) developed a relatively accurate aging technique based on eye lens weight; however, this technique requires special handling of specimens and considerable laboratory work. Gentry (1968) and Paul (1970) proposed aging techniques for pine voles based primarily on single traits, weight and total length, respectively. These two techniques were devised using specimens from the nominate subspecies found in the southeastern United States (Hall 1981).

[1] Received for publication June 30, 1983; revised; accepted October 21, 1983.

In the process of studying the ecology of pine voles in southcentral Pennsylvania (Cornbower 1982, Cornbower and Kirkland, 1983), we attempted to employ both the Gentry (1968) and Paul (1970) aging schemes to assign relative ages to a sample of 406 field-caught specimens. Owing to the fact that the subspecies represented in our study area and throughout much of the northeastern United States *(P. p. scalopsoides)* is substantially larger than *P. p. pinetorum* (Hamilton 1943), our results were unsatisfactory. Too many obviously subadult individuals (based on our assessments of pelage and reproduction) were classed as adults using the two above-mentioned aging techniques. In order for us to examine seasonal age distributions and to compare age distributions between populations, we needed to devise an easily-applied aging technique for pine voles that would be applicable to *P. p. scalopsoides.* In this paper, we present the details of such an aging technique which employs total length and weight and permits assignment of specimens to one of five relative ages ranging from juvenile to adult.

METHODS AND MATERIALS

Four hundred and six pine voles were collected over an 18-month period between November 1979 and April 1982 in three southcentral Pennsylvania counties: Adams, Cumberland, and Franklin (Cornbower 1982). During routine necropsies, specimens were weighed and standard external measurements (total, tail, and hind foot lengths) were taken. Reproductive data were recorded for members of both sexes (see Cornbower and Kirkland, 1983, for details). All intact specimens were prepared as study skins and partial skeletons, and 222 of these with undamaged crania were used in analysis of morphology and growth. Fifteen skeletal measurements, 12 cranial and 3 postcranial, were taken using dial micrometers (0.05 mm calibration). Eight cranial measurements are described by Snyder (1954): condylobasal length, condylozygomatic length, nasal length, zygomatic breadth, interorbital breadth, cranial height, diastema length, and incisive foramen. Three of the cranial measurements, tooth row length, palatal length, and postpalatal length, are defined by DeBlase and Martin (1981). Lambdoidal breadth is the greatest distance between the outer margins of the lambdoidal crest. Postcranial measurements are as follows: Femur length—greatest length of the femur; pelvic length—greatest length from the ilium to pubic bone; scapular height—greatest length of the scapula from the point of articulation with the humerus to the edge of the scapula.

We selected at random 25 specimens for each sex for use in initially defining our age classes. This respresented 22.5% of our

TABLE 1

Comparisons of males and females within age classes for four external measurements, weight, 12 cranial and three postcranial measurements ($\bar{X} \pm 1$ SD). Comparisons within juvenile and young subadult age classes were with Mann-Whitney U test. Comparisons within three oldest age classes were with Student's t test.

	Juvenile		Young Subadult		Subadult		Young Adult		Adult	
	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀
Sample size	(3)	(5)	(1)	(3)	(27)	(25)	(27)	(19)	(51)	(61)
Total length	99.33 ±3.22	97.00 ±4.12	102.00	103.33 ±1.53	114.33 ±4.18	114.16 ±4.45	120.37 ±2.94	119.47 ±2.04	127.57** ±3.90	129.72 ±4.91
Tail length	16.00 —	17.20 ±1.30	17.00	19.33 ±2.08	19.44 ±1.99	19.88 ±1.92	20.41 ±2.41	20.95 ±2.04	21.76 ±2.20	22.26 ±2.01
Body length	83.33 ±3.22	79.80 ±3.56	85.00	84.00 ±0.58	94.89 ±3.96	94.28 ±4.21	99.96 ±2.07	98.53* ±2.48	105.80* ±3.89	107.46 ±4.50
Hind foot length	15.33 ±1.16	15.40 ±0.89	15.00	15.67 ±0.33	15.81 ±0.99	16.04 ±0.68	16.41 ±0.57	16.16 ±0.69	16.65 ±0.56	16.61 ±0.64
Weight	12.00 ±1.32	11.80 ±2.64	15.00	15.83 ±1.17	20.17 ±1.53	19.92 ±1.59	23.67 ±1.40	24.04 ±1.29	26.65*** ±2.16	28.71 ±3.85
Condylobasal length	19.72 ±0.45	19.82 ±0.65	20.40	21.17 ±0.51	22.26 ±0.77	22.33 ±0.75	23.62 ±0.64	23.34 ±0.70	24.19 ±0.64	24.28 ±0.67
Condylozygomatic length	15.25 ±0.57	15.40 ±0.58	15.70	16.68 ±0.34	17.29 ±0.53	17.33 ±0.59	18.25 ±0.51	18.02 ±0.50	18.62 ±0.47	18.72 ±0.54
Nasal length	5.92 ±0.14	5.88 ±0.41	5.80	6.42 ±0.11	6.48 ±0.66	6.61 ±0.33	6.91 ±0.28	6.99 ±0.24	7.21 ±0.29	7.22 ±0.37
Zygomatic breadth	12.27 ±0.73	12.29 ±0.67	12.90	13.37 ±0.37	13.86 ±0.47	14.03 ±0.54	14.78 ±0.57	14.61 ±0.49	15.41 ±0.49	15.27 ±0.48
Lambdoidal breadth	10.62 ±0.56	10.30 ±0.40	11.00	11.27 ±0.40	11.77 ±0.34	11.71 ±0.51	12.47 ±0.31	12.23** ±0.32	12.76 ±0.30	12.68 ±0.33
Interorbital breadth	4.22 ±0.10	4.13 ±0.14	4.35	4.43 ±0.02	4.38 ±0.17	4.32 ±0.17	4.35 ±0.15	4.32 ±0.16	4.38 ±0.20	4.31 ±0.17
Toothrow length	5.13 ±0.08	5.17 ±0.14	5.10	5.60 ±0.08	5.63 ±0.25	5.65 ±0.30	5.90 ±0.23	5.83 ±0.20	6.08 ±0.23	6.12 ±0.22
Cranial height	8.58 ±0.08	8.63 ±0.21	8.95	8.85 ±0.21	9.20 ±0.20	9.22 ±0.24	9.43 ±0.28	9.30 ±0.27	9.54 ±0.25	9.60 ±0.28
Palatal length	10.42 ±0.40	10.24 ±0.37	10.15	11.18 ±0.44	11.37 ±0.08	11.47 ±0.10	12.06 ±0.50	11.85 ±0.40	12.52 ±0.38	12.50 ±0.45
Postpalatal length	7.10 ±0.26	7.34 ±0.31	7.90	7.67 ±0.13	8.45 ±0.33	8.43 ±0.40	8.92 ±0.31	8.92 ±0.39	9.17 ±0.36	9.24 ±0.34
Diastema	6.10 ±0.13	5.98 ±0.27	6.30	6.48 ±0.30	6.80 ±0.28	6.88 ±0.30	7.27 ±0.38	7.12 ±0.30	7.55 ±0.27	7.51 ±0.33
Incisor foramen	3.03 ±0.18	3.15 ±0.40	3.05	3.38 ±0.09	3.62 ±0.26	3.72 ±0.27	3.80 ±0.24	3.73 ±0.20	3.92 ±0.31	3.91 ±0.29
Sample size	(1)	(4)			(27)	(23)			(48)	(57)
Femur length	11.00 —	10.13 ±0.62	10.40	11.03 ±0.49	12.22 ±0.45	12.21 ±0.75	13.00 ±0.47	13.02 ±0.50	13.63 ±0.49	13.70 ±0.51
Sample size	(1)	(1)			(22)	(21)	(27)	(17)	(47)	(58)
Pelvic length	12.90 —	12.60 —	12.70	13.10 ±0.81	14.72 ±0.59	14.83 ±0.75	15.55 ±0.75	15.92 ±0.57	16.30*** ±0.56	16.70 ±0.66
Sample size	(2)	(4)		(2)	(18)	(20)	(23)	(13)	(39)	(42)
Scapular height	7.50 ±0.42	7.60 ±0.46	8.10	8.85 ±0.75	9.58 ±0.54	9.59 ±0.44	10.12 ±0.43	10.02 ±0.50	10.56 ±0.42	10.66 ±0.45

* $p < .05$ ** $p < .02$ ***$p = .001$

total usable sample of 222 specimens. We designated total length and weight as two key age-related variables and used these to define five relative age classes, ranging from juvenile to adult. The validity of these age classes was then assessed by examining the pelage and reproductive characteristics of each specimen. Based on this evaluation of our age classes, we modified the total length and weight ranges slightly for some of the age classes until the age class designations were consistent with pelage and reproductive characteristics of specimens placed in them. After it appeared that our aging scheme was reliable in assigning relative ages, we aged the remainder of the 222 specimens and once again assessed the validity of the age classes in terms of the pelage and reproductive characteristics of these specimens.

RESULTS AND DISCUSSION

The five age classes and their distinguishing characteristics as defined by our aging scheme are as follows:

Age Class		Total Length (mm)		Weight (g)
Juvenile		<105	and	<15.0
Young Subadult	Either	<105	and	≥15.0
	or	≥105	and	<15.0
Subadult		≥105 and <123	and	≥15.0 and <22.5
Young Adult	Either	<123	and	>22.4
	or	>123	and	<22.5
Adult		>123	and	>22.4

TABLE 2

Comparisons of age classes for four external measurements, weight, 12 cranial and three postcranial measurements ($\bar{X} \pm 1$ SD). Horizontal bars connect values that do not differ significantly at $p = 0.05$. (See text for description of statistical tests employed.)

Sample size ( )	Juvenile	Young Subadult	Subadult	Young Adult	Adult
Total length *	97.88 (8) ±3.76	103.00 (4) ±1.41	114.25 (52) ±4.27	120.00 (46) ±2.62	128.74 (112) ±4.59
Tail length *	16.75 ±1.17	18.75 ±2.06	19.65 ±1.95	20.63 ±2.25	22.04 ±2.10
Body length *	81.13 ±3.68	84.15 ±0.95	94.59 ±4.05	99.37 ±2.33	106.71 ±4.29
Hind foot length *	15.38 ±0.92	15.50 ±0.58	15.92 ±0.74	16.30 ±0.63	16.63 ±0.60
Weight *	11.88 ±2.12	15.63 ±1.70	20.05 ±1.55	23.82 ±1.36	27.77 ±3.35
Condylobasal length *	19.78 ±0.55	20.98 ±0.81	22.29 ±0.75	23.51 ±0.67	24.24 ±0.65
Condylozygomatic length *	15.34 ±0.54	16.44 ±0.68	17.31 ±0.55	18.16 ±0.51	18.67 ±0.51
Nasal length *	5.89 ±0.32	6.26 ±0.34	6.54 ±0.52	6.94 ±0.27	7.21 ±0.33
Zygomatic breadth *	12.28 ±0.64	13.25 ±0.57	13.94 ±0.51	14.71 ±0.54	15.33 ±0.49
Lambdoidal breadth*	10.42 ±0.45	11.20 ±0.58	11.74 ±0.43	12.37 ±0.33	12.72 ±0.32
Interorbital breadth	4.16 ±0.13	4.41 ±0.05	4.35 ±0.17	4.34 ±0.15	4.34 ±0.19
Toothrow length *	5.16 ±0.12	5.48 ±0.27	5.64 ±0.27	5.87 ±0.22	6.09 ±0.22
Cranial height *	8.61 ±0.16	8.88 ±0.29	9.21 ±0.22	9.38 ±0.28	9.57 ±0.27
Palatal length *	10.31 ±0.36	10.93 ±0.81	11.42 ±0.45	11.97 ±0.47	12.51 ±0.42
Postpalatal length *	7.25 ±0.29	7.73 ±0.22	8.44 ±0.36	8.92 ±0.34	9.21 ±0.35
Diastema *	6.03 ±0.23	6.44 ±0.44	6.84 ±0.29	7.23 ±0.29	7.53 ±0.30
Incisor foramen *	3.11 ±0.32	3.30 ±0.21	3.66 ±0.27	3.77 ±0.23	3.91 ±0.29
Femur length *	10.30 (5) ±0.67	10.8 (4) ±0.76	12.21 (50) ±0.51	13.01 (46) ±0.48	13.67 (105) ±0.50
Pelvic length *	12.72 (2) ±0.21	13.00 (4) ±0.16	14.78 (43) ±0.67	15.69 (44) ±0.70	16.52 (105) ±0.65
Scapular height*	7.57 (6) ±0.40	8.60 (3) ±0.87	9.58 (38) ±0.48	10.08 (36) ±0.45	10.62 (81) ±0.44

* ANOVA $p < .05$ — Comparisons of Subadult/Young Adult/Adult age classes

An important consideration in any aging scheme is the impact that sexual dimorphism might have on the reliability of assigning relative ages to specimens. Accordingly, we statistically compared the sexes within each age class for the four external measurements, weight, 12 cranial and three postcranial measurements (Table 1). The only significant differences observed were for body length and lambdoidal breadth in young adults and for total length, body length, weight, and pelvic length within the adult age class. In young adults, males were significantly larger for both characteristics; however, the differences did not involve characters used in the aging scheme. In adults, females averaged larger than males in all four characters. Owing to the fact that the adult age class is open-ended, the significant differences between the sexes for total length and weight do not affect the validity of the aging scheme.

The differences observed within the young adult age class are inexplicable. The sexual dimorphism within the adult age class is attributed to the influence of 33 pregnant females in the sample. Comparison of 51 adult males with 28 non-pregnant adult females revealed no statistically significant differences between the sexes for total length, body length, weight and pelvic length. The 33 pregnant adult females averaged larger than the 28 non-pregnant adult females in all four characters as follows: total length—130.70 vs. 128.57 mm; body length—108.67 vs. 106.04 mm; weight—30.58 vs. 26.52 g; pelvic length—16.82 vs. 16.55 mm. Student's t comparisons revealed significant differences between preg-

TABLE 3

Reproduction as a function of age in a sample of 305 pine voles taken throughout year in southcentral Pennsylvania.

	AGE CLASS				
	Juvenile	Young Subadult	Subadult	Young Adult	Adult
MALES (N)	3	2	39	36	70
Testis Length $\bar{X}$ (range) mm	2.3 (2.0-3.0)	2.5 (2.0-3.0)	3.5 (2.0-5.0)	4.2 (3.0-6.0)	4.4 (2.0-6.0)
Testis Width $\bar{X}$ (range) mm	1.3 (1.0-2.0)	2.0 (2.0)	2.8 (1.0-4.0)	3.3 (2.0-4.0)	3.5 (2.0-4.0)
Testis Weight $\bar{X}$ (range) g	0.010 (0.01)	0.010 (0.01)	0.026 (0.01-0.05)	0.036 (0.01-0.07)	0.041 (0.01-0.07)
% Reproductively Active	0.0	0.0	51.3	86.0	94.3
FEMALES (N)	11	6	34	20	84
% Pregnant	0.0	0.0	0.0	20.0	44.1
% with Placental Scars	0.0	0.0	3.0	30.0	54.8
% Pubic Symphasis Open/Partly Open	0.0	0.0	5.9	35.0	78.6
% Reproductively Active	0.0	0.0	5.9	55.0	86.9

nant and non-pregnant adult females only for body length ($p < .05$) and weight ($p < .001$).

Differences approaching statistical significant ($p = 0.09$) were also observed between the sexes in young adults for weight and pelvic length. Four of the 19 young adult females were pregnant. Pelvic lengths and weights were virtually identical between the sexes in the three younger age classes (Table 1), and none of the females in these age classes was pregnant (although one subadult evinced placental scars). These results confirm 1) that the initiation of sexual dimorphism in weight (attributed to presence of pregnant females in samples) and pelvic length coincides with the initiation of sexual maturity in females, 2) that our aging technique is reliable in distinguishing adults from non-adults, and 3) that the scheme is applicable to both sexes.

With the sexes combined, we compared the age classes for the 20 variables examined. Owing to the small sample sizes in the juvenile and young subadult age classes, nonparametric statistics (Mann-Whitney U test) were employed to compare these two age classes and young subadults with subadults. Single factor analysis of variance and subsequent multiple range tests (SNK) were used in comparisons of the three oldest age classes. The results of these analyses are presented in Table 2. The juvenile and young subadult age classes were the least differentiated with no significant differences between them for 11 characters: tail length, body length, hind foot length, nasal length, tooth row length, cranial height, palatal length, diastema, incisor foramen, femur length, and pelvic length. Young subadults and subadults were somewhat more differentiated but still evidenced no significant differences in eight characters: tail length, nasal length, lambdoidal breadth, interorbital breadth, tooth row length, cranial height, palatal length, and diastema. The three oldest age classes were highly differentiated with significant F values (minimum $p < .001$) for all characters, except interorbital breadth. In addition, there was no significant difference between subadults and young adults in the length of the incisive foramen. Otherwise, the three age classes differed significantly among and between themselves in all characters examined. These results confirm the morphological distinctiveness of the adult age class within our aging scheme.

Reproductive data provided confirmation of the ability of our aging technique to separate non-reproducing juveniles and subadults from sexually active adults. Among males, juveniles and young subadults had small testes, non-coiled epididymi, and minute to small seminal vescicles. Accordingly, none were judged to be reproductively active. Development of sexual maturity commenced in subadults as evidenced by the enlargement of the testes, epididymi, and seminal vescicles. Based on testis size, about half of the subadult males were considered to be sexually active (Table 3). The vast majority of young adult and adult males were reproductively active; however, maximum testis size was not attained until the adult age class. A similar pattern of development of sexual maturity was observed in females, the exception being that a very small pecentage of subadults were judged reproductively active (Table 3). Our technique is therefore better at distinguishing between non-reproducing (juveniles to subadults) and actually or potentially reproductive (young adults/adults) females. We do not consider the lesser sensitivity of our technique in distinguishing between sexually active and inactive males to be a critical shortcoming, inasmuch as the reproductive status of females is more important than that of males in determining the natality of pine vole populations.

Gentry (1968) and Paul (1970) have devised easily applied aging techniques for pine voles both of which were based on the smaller subspecies, *Pitymys pinetorum pinetorum,* and recognize three age classes: juvenile, subadult, and adult. Gentry utilized weight classes similar to ours. In his scheme juveniles ranged in weight from 8.0 to 16.5 g, subadults 17.0 to 19.0 g, and adults 20.0 to 25.5 g. He excluded pregnant females. Data on the weights of specimens in our study (Tables 1, 2) reveal the degree to which the weights of *P. p. scalopsoides* from southcentral Pennsylvania exceed the upper limits of Gentry's scheme and the degree to which subadults in our sample would be misclassified as adults under Gentry's scheme. Paul's (1970) age classes were defined by total length measurements modified by pelage, reproductive condition, and the condition of the epiphyses. His age classes were defined as follows: juvenile less than 105 mm total length, subadults 105 to 115 mm, and adults greater than 115 mm. The data in Tables 1 and 2 reveal that Paul's aging technique is likewise not applicable to *P. p. scalopsoides* because it also tends to misclassify many subadults as adults.

The apple growing regions of New York, Pennsylvania, and Virginia lie within the geographic range of *P. p. scalopsoides.* Within these regions, the pine vole is a serious agricultural pest and has been the subject of considerable basic and applied ecological research. Designed specifically for use with *P. p. scalopsoides,* our aging scheme should facilitate future demographic studies of pine voles by providing researchers with an easily-applied and reliable relative aging technique.

ACKNOWLEDGEMENTS

Specimens utilized in the development of this aging scheme were collected as part of research supported by contract No. 14-16-0009-79-089 of the U.S. Fish and Wildlife Service. We thank J. E. Hench, N. W. Koch, E. A. Malinowski, D. Payne, and K. A. Shank for their assistance in the collection of the specimens. We acknowledge with special thanks the orchardists and managers who permitted us to work on their properties or orchards under their supervision.

LITERATURE CITED

Cornbower, T. R. 1982. The biology of the pine vole *(Pitymys pinetorum scalopsoides)* in southcentral Pennsylvania. Unpubl. Master's thesis. Shippensburg State College, Shippensburg, PA. 62 pp.

Cornbower, T. R. and G. L. Kirkland, Jr. 1983. Comparisons of pine vole *(Pitymys pinetorum)* populations from orchards and natural habitats in southcentral Pennsylvania. Proc. Penna. Acad. Sci., 57:147-154.

DeBlase, A. F. and R. E. Martin. 1981. A manual of mammalogy, with keys to families of the world. W. C. Brown Publ., Inc., Dubuque, IA. 436 pp.

Gentry, J. B. 1968. Dynamics of enclosed populations of pine mice, *Microtus pinetorum.* Res. Popul. Ecol., 10: 21-30.

Gourley, R. S. and F. J. Jannett, Jr. 1975. Pine and montane vole age estimates from eye lens weights. J. Wildl. Mgmt., 39: 550-556.

Hall, E. R. 1981. Mammals of North America, Vol. II, 2nd Ed., John Wiley & Sons, New York, NY. 601-1181 + 1-90 pp.

Hamilton, W. J., Jr. 1943. Mammals of the Eastern United States. Comstock Publishing Co., Ithaca, NY. 432 pp.

Paul, J. R. 1970. Observations on the ecology, populations, and reproductive biology of the pine vole, *Microtus pinetorum,* in North Carolina. Reports of Investigations, No. 20. Illinois State Museum, Springfield. 28 pp.

Snyder, D. P. 1954. Skull variation in the meadow vole *(Microtus pennsylvanicus)* in Pennsylvania. Ann. Carnegie Museum, 33: 201-234.

Proceedings of the Pennsylvania Academy of Science 58: 42-46. 1984

A SURVEY OF THE FURBEARERS OF THE CODORUS DRAINAGE, YORK COUNTY, PENNSYLVANIA[1]

GORDON L. KIRKLAND, JR. and EDWIN C. GILLMAN[2]

The Vertebrate Museum
Shippensburg University
Shippensburg, PA 17257

ABSTRACT

Furbearers of the Codorus Creek Drainage, York County, Pennsylvania were sampled by the second author during the open trapping seasons of 1979 through 1981. Three hundred and one furbearers representing seven species were trapped; the pelted carcasses or skulls of 256 of these were deposited in the Vertebrate Museum, Shippensburg University, as follows: 48 opossums (*Didelphis virginiana*), 21 red foxes (*Vulpes vulpes*), 1 gray fox (*Urocyon cinereoargenteus*), 60 raccoons (*Procyon lotor*), 3 long-tailed weasels (*Mustela frenata*), and 124 muskrats (*Ondatra zibethicus*). The two other species trapped were the striped skunk (*Mephitis mephitis*) and the mink (*Mustela vison*). Beaver (*Castor canadensis*) were also present in the study area during one year (1979). Based on our analysis of data from specimens and recorded in the field, we report on the sex ratios, relative age structures, reproduction, morphology, and habitat preferences of four species: opossum, red fox, raccoon, and muskrat. In all species, the sex ratio approximated 1:1. Non-adults predominated in the samples of opossums and muskrats, but 17 of 21 red foxes were judged to be adults. Half of the raccoons were young of the year. Only the opossum exhibited significant year to year variation in relative abundance. Sexual dimorphism with males larger than females was observed in the red fox and raccoon. Preferred habitats for the terrestrial species were for the opossum—woods and stream edges in woods; the raccoon—large streams and streams in woods; and the red fox—cultivated fields and a fallow orchard.

INTRODUCTION

Each year hundreds of thousands of furbearers are harvested in Pennsylvania. Between the winters of 1970-71 and 1975-76, the total annual harvest of furbearers in Pennsylvania ranged from 372, 000 to 757,000 (Deems and Pursley 1978). The deaths of these animals contribute virtually nothing to our knowledge of the biology of furbearers in the Commonwealth owing to the fact that they usually are not collected by trained biologists, and relatively few of the carcasses are deposited in museum collections or are otherwise made available to mammalogists for study. To partially fill this void in our knowledge of the biology of furbearers in Pennsylvania, the second author deposited in the Vertebrate Museum at Shippensburg University the skulls or pelted carcasses of 256 of the 301 furbearers he trapped during the 1979 through 1981 trapping seasons. Included in this sample were 48 opossums (*Didelphis virginiana*), 21 red foxes (*Vulpes vulpes*), 1 gray fox(*Urocyon cinereoargenteus*), 60 raccoons (*Procyon lotor*), 3 long-tailed weasels (*Mustela frenata*), and 124 muskrats (*Ondatra zibethicus*). All specimens were collected within the drainage of Codorus Creek, York County, Pennsylvania (Fig. 1). In this paper, we present the results of analyses of data on the sex ratios, relative abundance, relative age structure, reproduction, morphology, and habitat selection of four species: opossum, red fox, raccoon, and muskrat.

METHODS

All specimens were taken during the Pennsylvania trapping seasons of 1979-80 through 1981-82. The terrestrial species were taken in leg-hold traps set on land, whereas the semi-aquatic muskrats were taken in body-hold (Conibear) traps set in water. Land sets were made in semi-open areas, along streams and natural runs, next to natural attractants and near den entrances. Bait and various prepared lures were used at terrestrial sets. All sets intended to catch *Vulpes* were sprinkled with red fox urine, and these traps were covered so as to blend into the surroundings.

Trapping effort for terrestrial furbearers totaled 1821 trapnights (TN) distributed over the three years 1979-81 as follows: 681, 507, and 633. Trapping for muskrats differed from that for terrestrial species because trapping effort each year was predicated on the amount of sign present, principally the number of dens in the sampling area. As a consequence of the declining amounts of sign annually, the 752 trapnights of sampling effort was distributed

[1]Received for publication July 29, 1983; reviewed; accepted November 4, 1983.

[2]Present address: Department of Biological Chemistry, Milton Hersey Medical Center, Pennsylvania State University, Hershey, PA 17033

TABLE 1

Sex and age ratios of four species of furbearers from the Codorus Creek drainage, York Co., Pennsylvania.

SPECIES	MALES	FEMALES	RATIO	χ^2	NON-ADULTS		ADULTS	RATIO
Opossum	24	24	1:1	0.02	11		6	1.8:1.0
Red Fox	13	8	1.6:1	0.76	4		17	0.24:1.0
Muskrat	65	59	1.1:1	0.20	63		28	2.3:1.0
						Young of Year	1 Year Old	2 Years +
Raccoon	30	30	1:1	0.02	N	30	23	7
					%	50.0	38.3	11.7

over the three years as follows: 347, 297, and 108. Because the terrestrial and semi-aquatic species were collected by separate methods and in different trapping seasons, the relative abundances expressed as catch/100 trapnights (TN) of the terrestrial species and the muskrat were calculated separately based on their respective sampling efforts.

Specimens were weighed and measured prior to pelting. Reproductive organs were examined prior to the specimens being eviscerated or decapitated. Notes on habitat were recorded in the field at the time the specimens were removed from the traps.

The aging schemes used to assign relative ages varied among the species but were all based on cranial characteristics. Opossums were judged to be 12 months old or older if they had a full set of adult dentition (Blumenthal 1974). Adult muskrats were separated from young of the year on the basis of their having a zygomatic breadth $\geq$40 mm (Alexander 1951). In raccoons, adults of at least two years are characterized by having the postorbital breadth less than the interorbital breadth, while young of the year lack adult dentition. One year old individuals possess complete adult dentition but have partially open cranial sutures and an interorbital breadth greater than the postorbital constriction (Stains 1956).

Red foxes were aged on the basis of data published by Nelson and Chapman (1982). In our analysis, males were considered to be adults if they had a zygomatic breadth $\geq$ 74.5 mm; females were classed as adults if they had a zygomatic breadth $>$70.4 mm.

Inasmuch as published data on the external and cranial measurements of furbearers from southcentral Pennsylvania are largely lacking, we measured selected cranial dimensions of adults of all species. The cranial measurements used in this study are defined by DeBlase and Martin (1974). All measurements were taken with Helios dial micrometers (0.5 mm calibration). Sufficient sample sizes of males and females in the raccoon, muskrat, and red fox permitted statistical comparisons of the sexes in these species.

RESULTS AND DISCUSSION

Sex Ratios

The sex ratios of all species approximated 1:1 (Table 1). The red fox showed the greatest deviation from parity with 13 of 21 specimens males. This non-significant deviation may be explained by the fact that urine of females was used as a lure at fox traps, and this may have acted to attract more males. The 1:1 sex ratio in this sample of 48 opossums contrasts sharply with the male:female ratio of 1.00:1.95 found in aa sample of 62 free-ranging opossums taken throughout the year in the Cumberland Valley of southcentral Pennsylvania; however, the male:female ratio in 124 pouch young carried by females in that sample was 1.00:0.98 (Blumenthal and Kirkland 1976). The slightly higher percentage of males (52.4%) in this York County sample of muskrats appears to be typical of the species. Beer and Truax (1950) reported an overall sex ratio of 55.6% males in a sample of 89,540 muskrats, and Errington (1939) found the percentage of males in fall/early winter-caught young of the year in Iowa to be 54.9%. The 1:1 sex ratio observed in our sample of 60 raccoons from York County is typical of the species (Lotze and Anderson 1979).

Age Structure

The proportions of non-adults to adults were determined for the opossum, muskrat, and red fox, while in the sample of raccoons, individuals were divided into three relative age classes: young of the year, one year olds, and two + year olds (Table 1). In the opossum and muskrat, non-adults substantially outnumbered adults. The non-adult to adult ratio of 1.8:1.0 in 17 opossums closely approximates the 1.7:1.0 ratio in a sample of 19 specimens taken by Blumenthal (1974) in the Cumberland Valley of Pennsylvania from November 1973 through January 1974. In muskrats, the non-adult:adult ratio of 2.3:1.0 is substantially less than the 3.6:1.0 ratio reported for 24,082 muskrats taken in Wisconsin but falls within the range of values of 1.91-6.73:1.00 observed at individual localities in that state (Beer and Truax 1950). The age ratio in our York County sample approximates the 2.6:1.0 ratio of subadults to adults reported for 541 muskrats from upstate New York (Alexander 1951).

In our sample of 60 raccoons, young of the year comprised 50% of the sample, and adults judged to be at least two years old only 11.7% (Table 1). Lotze and Anderson (1979) report that most raccoons in the wild live less than five years and cite mean ages of 3.1 and 1.8 years, respectively, for raccoons from Alabama and Missouri. The apparent low mean age of raccoons in this sample may reflect a heavily exploited population.

The sample of red foxes showed a higher proportion of adults than non-adults, with 81% judged to be adults (Table 1). This is somewhat surprising because in many canid populations, samples

TABLE 2

Relative abundance (catch/100 trapnights) of four principal species of furbearers in the Codorus Creek drainage, York Co., Pennsylvania (1979-1981).

TERRESTRIAL SPECIES	1979	1980	1981	χ^2
OPOSSUM	2.2	7.7	4.3	19.68*
RED FOX	1.3	1.0	1.1	0.30
RACCOON	4.1	4.1	2.1	5.20
COMBINED SPECIES	7.6	12.8	7.4	11.31*
SAMPLING EFFORT (TN)	681	507	633	1821
SEMI-AQUATIC SPECIES				
MUSKRAT	20.2	14.6	11.1	5.45
SAMPLING EFFORT (TN)	347	297	108	752

*Significant at $p < 0.001$

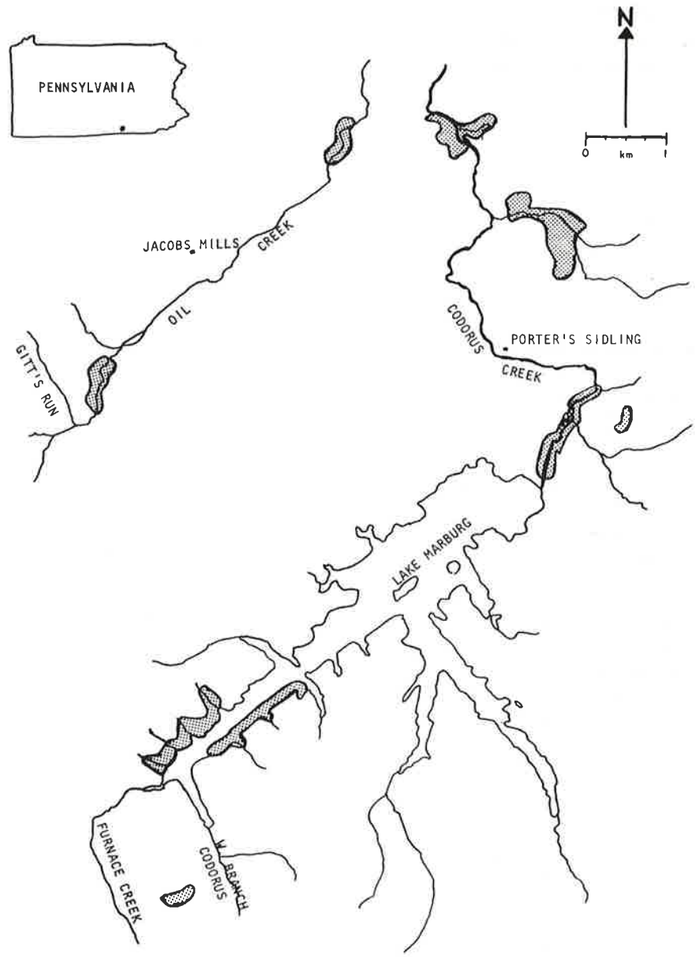


FIGURE 1. Map of a portion of Codorus Creek drainage in York County, Pennsylvania. The areas sampled in this study are stippled.

taken in early winter show a higher percentage of young animals than samples taken in late winter, the difference being attributed to a marked sampling bias towards inexperienced juveniles (Harris 1977).

Abundance

The relative abundance of the four principal terrestrial furbearers varied significantly among the three years (Table 2). This was due primarily to the large number of opossums taken in 1980. As a consequence, the opossum was the only species to exhibit significant year to year variation in relative abundance (Table 2).

In contrast with the terrestrial species for which sampling effort was relatively constant over the three year study period, the sampling effort for muskrats was proportional to the amount of sign present, principally the number of dens. As the amount of muskrat sign declined annually from 1979, the sampling effort declined proportionately (Table 2). The catch per year fell from 70 to 43 to 12 during the three years of the study, but because our analysis of relative abundance was a function of sampling effort, it tended to underestimate the actual decline. Consequently, the results indicated that the relative abundance of muskrats did not vary significantly among the years ($X^2 = 5.45$, $0.05 \leq p \leq 0.10$).

Reproduction

Because the specimens in this study were taken in November and December, little information on reproduction was gleaned from our examination of the carcasses. Data on litter size were obtained from raccoons and muskrats. Five female raccoons had visible placental scars averaging 4.8 (range 3-6). Stains (1956) found an average litter size of 4.6 for raccoons in Kansas. The number of placental scars in six muskrats ranged from 4-11 and averaged 7.6. Mean litter size in muskrats ranges from 4 to 8, but most investigators report an average litter size of six or seven young (Willner et al. 1980).

TABLE 3

Distribution of captures of three species of terrestrial furbearers in nine habitats sampled in the Codorus Creek drainage, York Co., Pennsylvania. For each species, preferred habitats (≥ 5% more than expected from sampling effort) are indicated with a + sign; habitats substantially less than expected are indicated with a − sign.

HABITAT	Sampling Effort	PERCENTAGE Opossum	Raccoon	Red Fox
Woodland Stream	36.3	43.2+	40.3	4.8−
Large Stream	13.9	10.0	21.0+	4.8−
Cultivated Field	19.3	7.4−	14.5	38.1+
Woodland	8.5	13.6+	6.5	9.5
Old Field Edge	6.4	3.7	3.2	9.5
Old Field Stream	4.3	8.7	4.8	—
Fallow Orchard	2.9	4.9	—	14.3+
Pasture	3.5	3.7	4.8	9.5+
Cultivated Field Stream	5.1	4.9	4.8	9.5
TOTALS (N)	1821	81	62	21

Habitat Associations

Owing to the underlying economic motives that prompted the collection of the specimens described in this paper, no effort was made to sample habitats systematically or in proportion to their occurrence or extent in the study area. The second author was further constrained by the habitats available on properties to which he had access, as well as the activities of other trappers. As a consequence, trapping was carried out on a small proportion of the Codorus Creek Drainage, with emphasis placed on habitats adjacent to Lake Marburg and along streams (Fig. 1). Nevertheless, the distribution of the captures of the three most abundant terrestrial species (opossum, raccoon, and red fox) provide some insights into their degree of habitat utilization and preferences (Table 3). Analysis of the percentages of captures of the three species in the nine habitats sampled using the Kendall Coefficient of Concordance (Siegel 1956) produced a $W = .322$ ($0.25 \leq p \leq 0.50$). Since this revealed no significant association among the rankings of the proportions of captures of the three species in the nine habitats, we conclude that the three species of terrestrial furbearers have independent patterns of occurrence in the habitats sampled.

We were unable to utilize chi-square analysis to statistically examine habitat preferences in these three terrestrial furbearers because of the large number of habitat categories, many with small sampling efforts, which yielded too high a percentage of expected values less than 5.0 (Zar 1974). Nevertheless, comparisons between the observed percentages of captures and expected values based on sampling efforts in each habitat provided some insights into the habitat preferences of the three most abundant terrestrial furbearers (Table 3). We arbitrarily selected a 5% deviation from the expected as the minimal level of deviation indicative of either preference or avoidance. Opossums were caught more frequently than expected in woodland stream and woodland habitats; they were taken less frequently than expected in cultivated fields. Raccoons evinced a pronounced preference for sites along the large streams (Codorus Creek). In contrast to these two species which tended to be captured in proportion to the sampling effort in most habitats, red foxes exhibited substantial deviation from the expected in five of nine habitats. They preferred open agricultural land and were taken in greater numbers than expected in cultivated fields, pastures, and a fallow orchard. They were trapped much less than expected along the edge of wooded streams. The preference of red foxes for farmland and edge habitats is well documented, as is its tendency to avoid unbroken forests.

The relative abundance of muskrats differed significantly ($X^2 = 15.58$, $p < .001$) in the three habitats in which they were collected, as follows: large lake (29.7/100 TN), large streams (13.2/100 TN), and small streams (15.5/100 TN). A preference for the large lake (Lake Marburg) habitat was evident from the fact that 34.4% of the total of 125 specimens were trapped in this habitat in only 19.3% of the total sampling effort of 752 TN. In comparison, 56.8% of the specimens were taken in 71.3% of the sampling effort on large streams and 8.8% of the specimens were trapped in small streams in 9.4% of the sampling effort. Part of this difference may be attributed to the fact that muskrat dens are more easily found in the lake, and therefore the population can be more easily exploited in this habitat.

Morphology

Table 4 presents the results of our analyses of the external and cranial measurements of adults of four species. Because of insufficient sample sizes, no statistical comparisons were made between the sexes of oppossums. Male raccoons were significantly larger than females in four of eight cranial measurements and two of four external measurements. Based on data presented by Lotze and Anderson (1979), male raccoons tend to be larger than females. Willner et al. (1980) report that there is no sexual dimorphism in muskrats, and our data agree with this assessment of the species as a whole. Because of an error in measuring the hind foot of red foxes, this measurement was not included in our analysis. Red foxes in our sample exhibited pronounced sexual dimorphism with males significantly larger in six of eight cranial characters, three external measurements and weight (Table 4). It is of interest to note that despite the geographic proximity of York County to Maryland, the means for zygomatic breadth, the three external measurements and weight in our sample exceeded most of those reported by Nelson and Chapman (1982) for a sample of red foxes taken from throughout Maryland.

Other Species

Four other species of furbearers of the Codorus Creek drainage were caught in low numbers or observed during the study period, all in the Lake Marburg region (Fig. 1). The totals for the specimens trapped included gray fox (1—1979), striped skunk (*Mephitis mephitis*) (1—1979; 4—1980; 1—1981), long-tailed weasel (2—1979; 1—1980), and mink (*Mustela vison*) (2—1979; 1—1980). During the 1979 trapping season, an unknown number of beaver (*Castor canadensis*) inhabited the region of Codorus Creek adjacent to the dam on Lake Marburg; however, no beaver activity was observed in subsequent years. Weasels were taken in baited sets for raccoons or opossums. Mink were trapped along Codorus Creek in sets intended for muskrats. Four skunks were taken in cultivated fields, the other two in a woodland and along a woodland stream. Although only one gray fox was collected during the three trapping seasons encompassed in this study, three were taken by the second author during 1978 in fields and woodland bordering Lake Marburg.

SUMMARY

The results of our analyses of the data obtained from a sample

TABLE 4

Cranial and external measurements (mean, standard deviation, sample size) for males and females of four species of furbearers of York Co., Pennsylvania. Linear measurements in mm; weight in kg. Student's t-test used for statistical comparisons of sexes.

MEASURMENT	Raccoon		Opossum		Muskrat		Red Fox	
	Males	Females	Males	Females	Males	Females	Males	Females
Condylobasal Length	109.53 2.31(16)	104.87*** 2.90(15)	118.73 5.06(2)	117.03 2.30(2)	65.68 1.74(12)	65.52 1.19(12)	144.39 3.57(11)	134.99*** 3.90(6)
Least Interorbital Breadth	22.11 1.05(16)	21.85 1.46(16)	25.77 2.21(3)	22.92 1.60(7)	6.47 0.32(12)	6.13 0.55(12)	27.60 1.27(11)	26.63 2.45(6)
Zygomatic Breadth	66.94 5.03(17)	64.26 3.86(15)	68.32 6.66(3)	62.50 2.60(4)	41.29 1.52(12)	40.23 3.03(12)	76.69 4.18(11)	71.72*** 0.81(6)
Cranial Breadth	49.14 0.93(15)	46.33*** 1.45(15)	—	—	—	—	47.96 0.72(9)	45.71*** 0.89(5)
Maxillary Tooth Row	42.36 1.08(17)	40.89 1.22(15)	49.1 0.77(3)	45.37 1.36(7)	16.28 0.51(12)	16.39 0.45(12)	64.59 2.75(12)	61.36* 1.64(6)
Mastoid Breadth	56.95 3.62(15)	53.44** 2.95(15)	—	—	29.71 0.67(12)	29.47 0.97(12)	47.54 1.02(10)	44.89*** 1.22(6)
Postorbital Constriction	23.53 0.89(16)	23.66 1.58(16)	—	—	—	—	22.78 1.57(10)	23.89 1.76(6)
Basilar Length	100.08 3.81(14)	96.28** 2.74(15)	111.55 3.65(2)	111.70 (1)	59.94 1.86(12)	60.28 1.51(12)	136.31 3.98(10)	128.97** 3.75(6)
Total Length	764.4 34.5(17)	734.0* 11.2(18)	862.5 27.6(2)	766.8 26.2(6)	612.9 14.7(12)	605.8 13.7(12)	1071.2 27.9(11)	973.8*** 26.7(6)
Tail Length	230.3 17.0(17)	223.1 21.3(18)	339.5 19.9(2)	295.7 23.2(6)	269.6 11.4(12)	261.9 12.5(12)	400.1 24.4(11)	359.7** 18.9(6)
Hind Foot Length	112.0 4.7(17)	107.4** 4.1(18)	75.0 0.00(3)	69.0 3.5(7)	85.5 2.5(12)	81.0 2.4(12)	—	—
Ear Length	64.4 4.1(17)	62.9 3.1(18)	52.7 8.3(3)	54.9 3.4(7)	27.2 1.5(12)	26.4 1.6(12)	98.2 2.1(12)	92.7* 4.2(6)
Weight	4.8 1.2(17)	4.5 0.9(18)	4.0 0.7(3)	3.1 0.6(7)	1.4 0.1(12)	1.5 0.3(12)	5.8 0.6(11)	4.4*** 0.3(6)

*Sexes differed significantly at $p < 0.05$
**Sexes differed significantly at $p < 0.01$
***Sexes differed significantly at $p < 0.001$

of the furbearers of York County, Pennsylvania contain no striking revelations. By and large, the furbearers examined in this study tended to be typical of their species in terms of sex ratios, age distributions, litter size, habitat preferences, and morphology. The significance of our results lies in the good set of baseline data we have reported on selected aspects of the biology of furbearers inhabiting York County, and by extension, other portions of south-central Pennsylvania.

ACKNOWLEDGEMENTS

We thank Pat Bria for his help as the second author's trapping partner. We acknowledge the following landowners for providing access to their properties: R. Bortner, R.C. Dennis, M. Martin, and A. Winebrenner.

LITERATURE CITED

Alexander, M. M. 1951. The aging of muskrats on the Montezuma National Wildlife Refuge. J. Wildl. Managem. 15: 175-186.

Beer, J.R. and W. Truax. 1950. Sex and age ratios in Wisconsin muskrats. J. Wildl. Managem. 14: 323-331.

Blumenthal, E.M. 1974. Some aspects of the biology of the opossum, *Didelphis marsupialis virginiana,* in the Cumberland Valley of Pennsylvania. Master's Thesis, Shippensburg State College, Pennsylvania. 80 pp.

Blumenthal, E.M. and G.L. Kirkland, Jr. 1976. The biology of the opossum, *Didelphis virginiana,* in southcentral Pennsylvania. Proc. Penn. Acad. Sci. 50: 81-85.

DeBlase, A.F. and R.E. Martin. 1974. A manual of mammalogy. Wm. C. Brown Company, Dubuque, Iowa. 329 pp.

Deems, E.F., Jr. and D. Pursley. 1978. North American furbearers, their management, research, and harvest status in 1976. Univ. Maryland, Univ. Press, College Park. 171 pp.

Errington, P.L. 1939. Observations on young muskrats in Iowa. J. Mammal. 20: 465-478.

Harris, S. 1977. Distribution, habitat utilization, and age structure of a suburban fox *(Vulpes vulpes)* population. Mammal Rev. 7: 25-39.

Lotze, J.H. and S. Anderson. 1979. *Procyon lotor.* Mammal. Species 119: 1-8.

Nelson, B.B. and J.A. Chapman. 1982. Age determination and population characteristics of red foxes from Maryland. Z. Saugetierkunde 47: 296-311.

Siegel, S. 1956. Nonparametric statistics for the behavioral sciences. McGraw-Hill Book Company, New York. 312 pp.

Stains, H.J. 1956. The raccoon in Kansas: natural history, management, and economic importance. Misc. Publ. Mus. Nat. Hist., Univ. Kansas 10: 1-76.

Willner, G.R., G.A. Feldhamer, E.A. Zucker, and J.A. Chapman. 1980. *Ondatra zibethicus.* Mammal. Species 141: 1-8.

Zar, J.H. 1974. Biostatistical analysis. Prentice-Hall, Inc., Englewood Cliffs, New Jersey. 620 pp.

Proceedings of the Pennsylvania Academy of Science 58: 47-52. 1984

CORRELATION OF BLOOD GLUCOSE AND CHOLESTEROL WITH SOCIAL RANK AND TESTOSTERONE REPLACEMENT IN MALE HAMSTERS *(MESOCRICETUS AURATUS)*[1]

FRED J. BRENNER and SHARON K. BRADLEY WIRTZ

Biology Department
Grove City College
Grove City, PA 16127

ABSTRACT

The role of aggressive behavior in the establishment of a social hierarchy and its effect on blood glucose and cholesterol levels was studied in male hamsters (*Mesocricetus auratus*) subjected to round-robin pairings or housed in population cages. In addition, the effects of castration and subsequent testosterone replacement on social rank, blood glucose and cholesterol levels was determined. Significantly lower blood glucose and cholesterol levels occurred in castrated and intact animals subjected to social interaction than in isolated individuals receiving the same treatment. In all populations, regardless of treatment, blood glucose decreased in a linear relationship with decreasing social rank while the reverse occurred with cholesterol.

INTRODUCTION

Changes in blood glucose and cholesterol may be related to a variety of external and internal factors. Hyperglycemia in animals has been shown to be related to the emotional state of an individual (1) while increased aggressive activity and resultant changes in the endocrine system may ultimately increase mortality through hypoglycemic shock (2,3,4,5,6,7,8). While diet has been shown to be a major contributing factor in elevating blood cholesterol in a variety of mammals (9,10,11,12,13,14), several studies have shown that changes in endocrine function also affect serum cholesterol and blood lipids (15,16). Christian (3,4), in summarizing the available data, suggested high population density affects serum cholesterol and shifts in blood lipids which may be partially responsible for the deposition of lipids in blood vessels while Ross and Harker (16) postulated that hyperlipidemia initiates and maintains lesions in the endothelial cells resulting in arteriosclerosis.

Previous studies have demonstrated that testosterone enhanced aggressive behavior in female hamsters (18) and restored aggressive behavior in castrated hamsters (19). While hamsters have been used extensively in physiological studies, the relationship between social interactions and physiological changes within the individual has not been studied in any detail. Previous investigators have reported serum cholesterol levels in hamsters varying from 112-216 mg % (20,21) and glucose levels ranging from 20-155 mg % (22,23,24,25,26). The variation in glucose levels reported among these different studies was probably due to a variety of external and internal factors including time of sampling, techniques (27), housing and possibly social interactions.

This study was designed: (1) to measure the effect of social interactions on blood glucose and cholesterol in mate hamsters; and (2) to study the effect of gonadectomy and hormone replacement on the relationships between social rank and blood glucose and cholesterol.

METHODS

The subjects used in this study were 232 male hamsters (5 weeks of age—same breeding stock) obtained from a local supplier (Bell Pet Supply). On the day of arrival, all animals were weighed, color-coded with ear-tags for identification, and placed in individual opague polypropylene cages with Sta-Dri bedding and then randomly assigned to either an experimental population of four individuals or as an isolated control. Four types of experimental populations were established: (1) intact animals housed individually; (2) intact animals housed collectively in 10 liter terraria; (3) animals to be castrated and subjected to round-robin encounters (every animal paired with every other animal); and (4) animals to be castrated and housed in groups continually in 10 liter terraria. All animals were provided water and fed a mixture of Purina hamster chow and sunflower seeds (Cardinal Brand) *ad lib.* Social rank was determined by scoring the observed aggressive encounters between four hamsters within wach population (19,28). The encounters consisted of a variety of behaviors and were recorded as defined below by the observer: nosing—contact by the nose of one hamster with the body of another; dislodge—a sudden move away from a stationary position by one hamster as the other approached; attack—a physical assault by one hamster upon the other to which the assaulted hamster responded by running or by remaining stationary in a defensive posture; chase—a fast pur-

[1]Received October 21, 1983; revised; accepted December 16, 1983.

suit of one animal by another; fight—one hamster grasping the opponent and wrestling, rolling or biting; marking—forceful thrusting of the animal flank against a ventral body surface, usually accompanied by a movement along the surface. The scores for the various behavioral acts were summed to provide an overall measure of overt aggression for each hamster (19,28).

Animals were maintained at 16 h of light: 8 h of darkness at all times. Prior to the determination of rank, each population was assigned a number and then the rank of all population members subjected to round-robin encounters was determined. These numbers were randomly drawn from a spinning wheel by an unbiased observer who then assigned the population as either an intact or treatment populations. All tests were conducted during the dark phase with observations staggered randomly to eliminate a possibility of a time effect. Before each observation period animals were weighed and both hamsters were placed simultaneously in an unfamiliar container with a removal partition for a 60-second acclimation period. The container was washed and disinfected with 90% alcohol between pairing. The arena was dimly illuminated from above by a 10-watt incandescent bulb. A continuous record was kept by the observer throughout the observation period. Each animal in the population of four individuals was placed with all other individuals for three 20 minute encounters in round-robin fashion.

Once social rank was determined, three males for each of the treatment populations were castrated and a fourth received a sham-operation. All animals in the remaining six populations remained as intact individuals. Treatments were rotated among the different ranks in each population so that the same treatment was administered to animals at each social level. For example, in one population, hamsters ranked, 1, 2 and 3 were castrated and 4 received a sham-operation while in another population, rank 1 was sham-operated while ranks 2, 3 and 4 were castrated, etc. After a 7-day recovery period, two castrated hamsters received 0.5 mg of testosterone proprionate in 0.1 ml of ethyl-oleate (T.P.) subcutaneously daily for 14 days, whereas the third castrated animal and sham-operated individual received 0.1 ml of ethyl-oleate (E.O.). Animals in both the intact population and the treatment populations were re-paired in round-robin fashion on the seventh and fourteenth day of the treatment period. After the final hormone injection and the re-establishment of social rank of the fourteenth day, a blood sample was removed under mild ether anesthesia (animal rendered immobile) by heart puncture and all animals were handled inexactly the same manner. Since diurnal changes in metabolism influenced the glucose content of the blood (24), all blood samples were removed between 0800 and 1000 hrs. All samples were numbered in sequence and analyzed by the same technician who did not know the group treatment of the animal. The blood glucose and cholesterol content were determined immediately using a Clay-Adams Accro-Stat blood analyzer. Blood glucose and cholesterol concentrations in animals subjected to various treatments and social interactions were compared with those in isolated animals. Isolated hamsters received the same treatment and were handled exactly the same way except that they were not exposed to social encounters.

Social rank was also determined on 7 intact and 15 treatment populations of four animals, each housed continuously in a 10 liter terraria equipped with one-way viewing glass. The same procedures were followed for these hamsters except that social rank was determined by twelve 20 minute observation sessions for a total of 240 minutes for each population.

Comparisons between the different groups and the correlation between treatments, social rank and blood parameters were analyzed either by a regression analysis or analysis of variance according to statistical procedures described by Snedecor (29) and Simpson *et al.* (30). In addition, a two-tailed t-distribution analysis was utilized to determine if a difference existed in the slopes of the regression lines and wherever appropriate between treatment groups. The relationship between body weight and social rank as well as the changes in the position of the animal within the hierarchy were determined by a Spearman rank correlation analysis (29).

RESULTS

In all populations, there was a significant correlation between body weight and dominance (Table 1) ($P < 0.001$). Moreover, once the social hierarchy became established, it remained relatively constant and did not vary significantly regardless of treatment (Table 2) ($P < 0.001$). Hence, castration and subsequent hormone replacement did not significantly alter the rank of an animal once the hierarchy was established.

Social interactions, regardless of whether hamsters were subjected to round-robin pairing or housed in population cages, significantly affected blood glucose and cholesterol concentrations in both intact and treatment populations. Significantly higher blood glucose and cholesterol levels occurred in isolated hamsters than they were in animals subjected to round-robin encounters ($P < 0.001$) and housed in population cages ($P < 0.001$), regardless of treatment (Table 3). In both populations of intact hamsters, blood glucose was inversely correlated with the position of animals in the social hierarchy (Fig. 1) ($P < 0.005$). A comparison of the slope of these regressions by a t-distribution analysis indicated that the change in glucose levels between animals of different ranks was greater in those subjected to round-robin pair-

TABLE 1

Comparison of body weight of male hamsters subjected to social encounters and isolated animals with identical treatments.

	SOCIAL ENCOUNTERS								ISOLATED							
	Round-Robin				*Population Cage*											
Rank	*Intact* (*N* = 24)		*Treatment* (N = 60)		*Intact* (N = 28)		*Treatment* (N = 60)		*Intact* (N = 24)		*Sham* (N = 12)		*Castrate* T.P.(n = 12)		*Castrate* E.O.(N = 12)	
	Mean	S.E.	Mean	S.E.	Mean	S.E.	Mean	S.E.	Mean	S.E.	Mean	S.E.	Mean	S.E.	Mean	S.E.
1	98.0	4.5	92.1	5.2	80.2	3.5	84.1	4.3	86.1	2.3	88.0	1.8	96.3	1.3	98.6	3.5
2	91.5	2.5	87.8	4.6	78.9	2.1	78.3	2.1								
3	92.0	4.8	88.7	2.2	76.3	5.8	78.6	4.8								
4	78.8	4.2	86.5	5.4	60.8	4.8	72.7	5.1								

Treatment: hamsters were either castrate receiving testosterone propionate (T.P.), castrate receiving only ethyl-oleate (E.O.) or sham-operated.

Table 2

Comparison of changes in social rank of intact male hamsters with those that were castrated and injected with either testosterone propionate (T.P.), ethyl-oleate alone (E.O.) or sham-operated.

	ROUND-ROBIN								
	4	3	2	1	0	1	2	3	4
Treatment	Decrease in Rank				No Change	Increase in Rank			
Intact	0	0	1	1	20	1	1	0	0
Sham	0	0	0	0	13	1	4	1	0
Castrate T.P.	0	3	0	2	15	0	0	0	0
Castrate E.O.	0	0	1	1	18	0	0	0	0
Sub-Total	0	3	1	3	46	1	4	1	0
Total	0	3	2	4	66	2	5	2	0
	POPULATION CAGE								
	4	3	2	1	0	1	2	3	4
Treatment	Decrease in Rank				No Change	Increase in Rank			
Intact	0	1	0	2	22	2	0	1	0
Sham	0	0	0	0	18	1	1	1	0
Castrate T.P.	0	2	0	4	13	0	1	0	0
Castrate E.O.	0	0	0	0	17	2	1	0	0
Sub-Total	0	2	0	4	48	3	3	0	0
Total	0	3	0	6	70	5	3	1	0

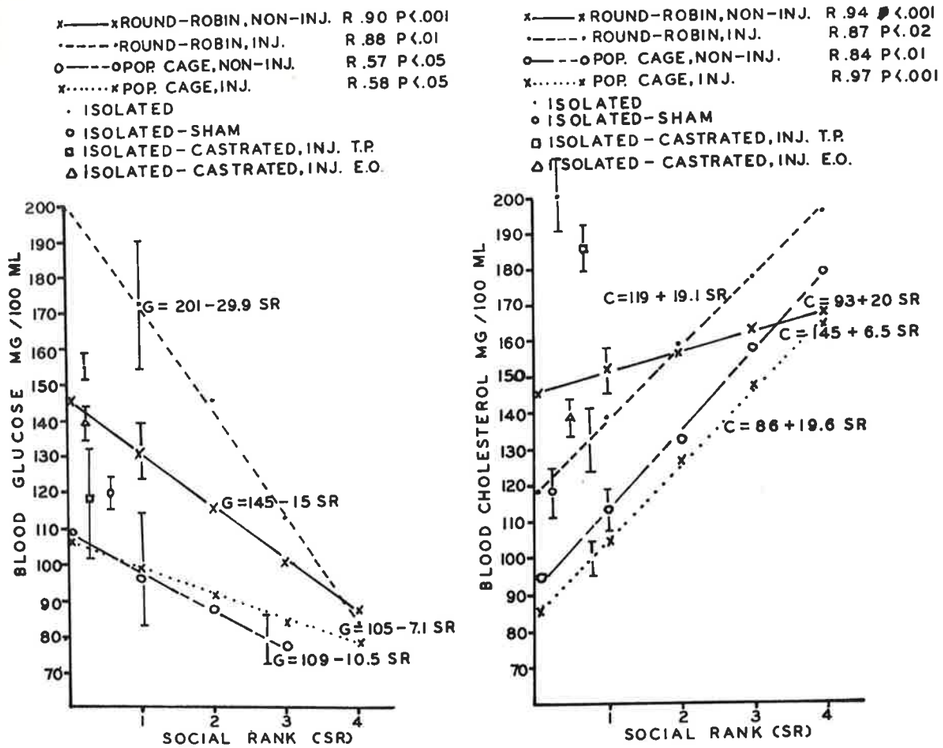


FIGURE 1. Correlation ±2 between social rank and blood glucose and cholesterol concentrations in male hamsters subjected to different treatments. The number of fights won by a hamster is directly related to its rank (Rank 1 = 10-12 fights won; Rank 2 = 7-9 fights won; Rank 3 = 4-6 fights won; Rank 4 = less than 4 fights won).

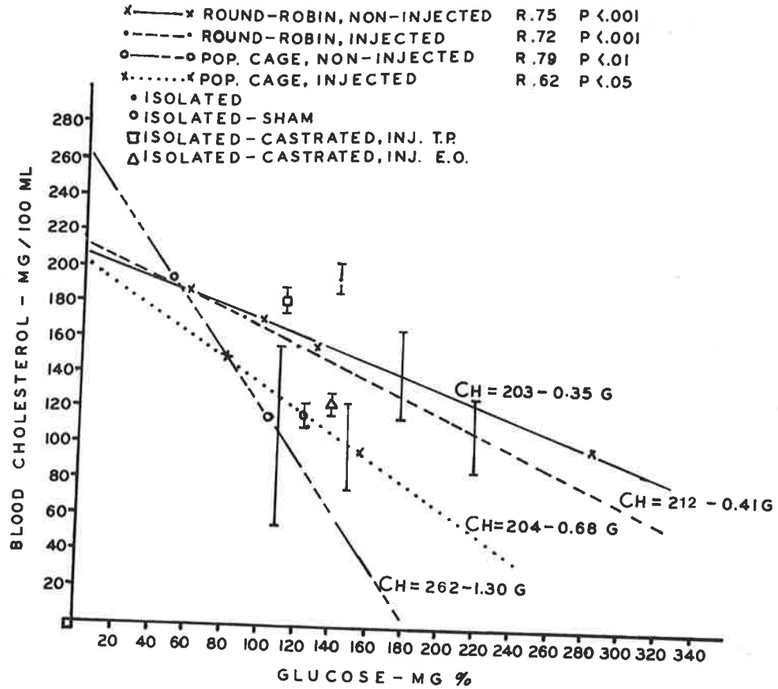


FIGURE 2. The correlation between blood glucose and cholesterol concentrations in male hamsters subjected to different treatments and social encounters. = 95 percent confidence limits of regression line. (Non-injected or injected animals in treatment populations injected with testosterone proprionate in ethyl-oleate or ethyl-oleate alone.)

ings than in animals housed in population cages ($P < 0.05$). On the other hand, cholesterol levels were higher in lower ranking animals subjected to both types of social interactions ($P < 0.001$). In contrast to glucose, the change in cholesterol levels between animals of different ranks was greater in animals maintained in population cages than it was in those subjected to round-robin encounters ($P < 0.05$).

Castration and subsequent hormone treatment significantly affected blood cholesterol but not glucose levels in isolated animals (Fig. 1). The type of social interaction, however, did significantly affect blood glucose since it was greater in isolated animals and those subject to round-robin pairings than it was in those housed in population cages regardless of treatment ($P < 0.001$). There was not, however, a significant variation within the different treatments between isolated and round-robin animals. Blood cholesterol was also affected by the type of social interactions as well as the type of treatment. Cholesterol levels were greater in isolated castrated hamsters receiving testosterone proprionate replacement than they were in animals subjected to round-robin pairings. Cholesterol levels were lower in castrated animals receiving ethyl-oleate and sham-operated individuals and subjected to round-robin pairings than in isolated animals receiving the same treatment ($P < 0.01$). On the other hand, isolated animals in all treatment groups had higher levels of cholesterol than hamsters housed in population cages receiving the same treatment.

Both glucose and cholesterol levels were significantly correlated with the position of the animal in the hierarchy, the treatment and with the interaction between treatment and social rank ($P < 0.05$) as determined by an analysis of variance. Blood glucose was inversely related to social rank in animals subjected to both types of social interactions, but the change was greater in animals subjected to round-robin pairings ($P < 0.05$). Cholesterol levels increased linearly with decreasing social rank but did not differ significantly between animals subjected to both types of social interactions (Fig. 1).

Blood cholesterol decreased linearly with increasing glucose levels and this inverse linear relationship occurred regardless of treatment or type of social interaction (Fig. 2). A comparison of the change in the amount of blood cholesterol with increasing glucose levels by a t-distribution analysis indicated that this change was greater in animals subjected to round-robin encounters than it was in those housed in population cages (Fig. 2) ($P < 0.05$).

DISCUSSION

Body weight has been found to be an accurate prediction of the aggressiveness and the ultimate position of male hamsters within a social hierarchy (18,31), but the maintenance of a social hierarchy is dependent on several factors operating within a population. This stability is probably due to recognition of individuals since castration and hormone replacement did not significantly alter the position of animals with the hierarchy. Testosterone has been shown to be a primary factor in restoring

TABLE 3
Blood glucose and cholesterol levels in male hamsters subjected to social encounters compared with isolated animals with identical treatments.

Condition	Treatment	N	mg Glucose/100 ml Blood mean	S.E.	mg Cholesterol/100 ml Blood mean	S.E.
Round-Robin	Intact	24	106.3	12.0	168.0	9.9
	Sham	20	100.7	3.7	160.3	6.9
	Castrate T.P*	20	120.8	15.7	153.5	6.0
	Castrate E.O.**	20	125.7	13.2	181.4	6.4
Population Cage	Intact	28	84.3	7.6	118.6	7.5
	Sham	20	68.5	17.9	85.5	17.9
	Castrate T.P*	20	65.8	12.8	129.4	10.2
	Castrate E.O.**	20	80.1	24.4	128.3	3.5
Isolated	Intact	24	155.0	23.0	204.0	3.3
	Sham	12	120.0	21.4	119.0	15.6
	Castrate T.P*	12	119.0	31.0	186.0	15.0
	Castrate E.O.*	12	140.0	13.5	136.0	13.9

*Testosterone Propionate in ethyl-oleate
**Ethyl-oleate

aggressive activity in hamsters (14), but once a hierarchy is established, it remains relatively stable (28) and provides a mechanism for the establishment and maintenance of a social hierarchy in captive populations (19).

Blood glucose and cholesterol concentrations observed in hamsters during this study were within the range of those reported by previous investigators (20,21,22,23,24,26). Blood glucose and cholesterol levels, however, may be affected by social interactions or other types of emotional stress. Blood glucose has been demonstrated to be related to the degree of excitement and emotional stress of the individual (1,32). The changes in blood glucose and cholesterol concentrations may be proportional to the duration of the stressful encounter. This may account, at least in part, for the difference in blood glucose and cholesterol levels between animals subjected to round-robin pairings and those housed in population cages because of the continual stress of animals housed collectively.

Available evidence indicates that blood glucose levels are mediated by a variety of endocrine secretions including cortisol, epinephrine and norepinephrine. Frank (37) found that hypoglycemic shock in *Microtus auratis* was corrected by glucose injections but not epinephrine. The release of epinephrine, on the other hand, has been demonstrated to be responsible for short term hypoglycemia in mammals (38,39).

The relationship between behavioral interactions, endocrine function and metabolism may not be firmly established but the androgenic hormones involved in glucose metabolism are also an integral part of the endocrine—neural complex operating during behavioral stress. Several authors have suggested that blood sugar levels may be mediated via the hypothalmic-adrenal axis (38,40,41) and as early as 1937, (42) demonstrated that epinephrine may be liberated by hypothalmic stimulation. Available evidence suggests that social stress affects adrenocortical activity resulting in changes in glucose and cholesterol metabolism. Cortisol is generally considered to be an antagonist to the action of insulin, which, in conjunction with glucogen, would result in hyperglycemia. Both cholesterol and glucose metabolism would, therefore, be affected by behavioral stress that would modify adrenalcortical secretions. Brenner *et al.* (28) found that social interactions affect the size, morphology and ascorbic acid content of the adrenal cortex of male hamsters, affecting lipid and glucose metabolism. The question remains, however, as to whether social interactions operating via the hypothalmic—adrenal axis are affecting glucose and cholesterol metabolism within the animal.

ACKNOWLEDGEMENTS

The authors thank Dr. Norman J. Dubiel and has staff for the use of their diagnostic laboratory and their help in the blood glucose and cholesterol determinations.

REFERENCES

1. Daly, M.M. 1976. Effects of age and hypertension on utilization of glucose by rat aorta. Am. J. Physiol. 230: 30-33.
2. Christian, J.J. 1950. The adreno-pituitary system and population cycles in mammals. J. Mamm. 31: 247-259.
3. Christian, J.J. 1963. Endocrines and populations. Vol. I pp. 189-353. *In* W.V. Mayer and R.G. VanGelder (ed.) Physiological Mammalogy. Academic Press. New York. 381 pp.
4. Christian, J.J. 1978. Neurobehavioral endocrine regulation of small mammal populations. pp. 143-158. *In* Populations of small mammals under natural conditions. Ed. Dana P. Snyder. Univ. of Pitt. Pymatuning laboratory series of Ecology Special Publication Series. 238 pp.
5. Christian, J.J. and H.L. Ratcliffe. 1952. Shock disease in captive wild mammals. Am. J. Pathol. 28: 725-737.
6. Green, R.G. and C.L. Larson. 1938. A description of shock disease in the snowshoe hare. Am. J. Hyg. 28: 190-212.
7. Green, R.G., C.L. Larson and J.F. Bell. 1939. Shock disease as the cause of the periodic decimination of the snowshoe hare. Am. J. Hyg. 308: 82-102.
8. Hamilton, W.J. 1937. The biology of microtone cycles. J. Agr. Research 54: 778-790.
9. Barter, P.J. 1974. Production of plasma esterified cholesterol in lean, normotirglyceridemic humans. J. Lipid. Research. 15: 234-242.
10. Egger, D.A. 1974. Cholesterol metabolism in rhesus monkey, squirrel monkey and baboon. J. Lipid Research. 15: 130-145.
11. Hagsted, D.M. and A. Gallagher. 1967. Dietary fat and cholesterol and serum cholesterol in the gerbil. J. Lipid Research 8: 211-214.

12. Kovanen, E., A. Nikkita and F.A. Miettime. 1975. Regulation of cholesterol synthesis and storage in fat cells. J. Lipid Research. 16: 211-223.
13. Lofland, H.B., T.B. Clarkson, R.W. St.Clair and N.D.M. Lehner. 1972. Studies o n the regulation of plasma cholesterol levels in squirrel monkeys of two genotypes. J. Lipid Research 13: 39-47.
14. Quintao, E., S.M. Grundy and E.H. Ahrens, Jr. 1971. Effects of dietary cholesterol on the regulation of total body cholesterol in man. J. Lipid Research. 12: 233-247.
15. O'Connell, M., E. Danforth, Jr., E.S. Horton, L. Salens and E.A.H. Sims. 1973. Experimental obesity in man III, Adrenocortical function. J. Clin. Endocr. Metab. 36: 323-329.
16. Watson, W.C. and E. Murray. 1966. Fat digestion and absorption in the adrenalectomized rat. J. Lipid Research. 7: 236-241.
17. Ross, R. and L. Harker. 1976. Hyperlipidemia and arteriorsclerosis Science. 193: 1094-1100.
18. Payne, A.P. 1976. A comparison of the effects of neonatally administered testosterone, testosterone propikonate and dihydrotestosterone on aggressive and sexual behavior in the female golden hamster. J. Endocrinol. 69: 23-31.
19. Vandenbergh, J.G. 1971. The affects of gonadal hormones on the aggressive behavior of adult golden hamsters (*Mesocricetus auratus*). Animal Behav. 19: 589-594.
20. Lee, C.L., T. Davidson, Y.B. Lee and E. Belanger. 1959. Experimental hemolytic anemia in the hamster. Fed. Proc. 18: 488.
21. House, E.L., B. Pansky, R. Raphaely, J. Palmes and M.S. Jacobs. 1962. Blood volume, total protein and total cholesterol in normal and diabetic hamsters. Anat. Rec. 114: 25-30.
22. Beaton, J.R. 1961. Notes on blood metabolite and electrolyte levels in the hypothermic hamster. Canad. J. Biochem. Physiol. 39: 1207-1208.
23. Burns, K.F. and C.W. de Lanny. 1962. Compendium of normal blood values for laboratory animals with indications of variations CRDL. Special Publications 4-36. Army Chemical Center, MD.
24. Chen, K.K., C.E. Powell and N. Maze. 1945. The response of the hamster to drugs. J. Pharmacol. Exp. Ther. 85: 348-355.
25. Nace, P.F., E.L. House and J.P. Tassoni. 1956. Alloxan diabetes in the hamster. Dosage and blood sugar surveys. Endocrinol. 58: 305-308.
26. Sullivan, R.E. and F.G. Everett. 1952. Studies in the Syrian hamster. II Blood sugar: method and results. J. Dent. Res. 31: 151-153.
27. Robinson, P.F. 1968. General aspects of physiology. pp. 111-118. *In.* The golden hamster its biology and use in medical research. Eds. Roger A. Hoffman, P.F. Robinson and H. Magukles. The Iowa State University Press. Ames. 545 pp.
28. Brenner, F.F., S.W. Wirtz, P.S. Campbell and C. Church. 1978. Effect of social rank on adrenal morphology in the male hamster (*Mesocricetus auratus*). J. Mammal. 59: 366-373.
29. Snedecor, G.W. 1956. *Statistical Methods.* The Iowa State College Press. Ames, Iowa. 531 pp.
30. Simpson, G.C., A. Roe and R.C. Lewontin. 1960. *Quantitative Zoology.* Harcourt Brace. New York. 440 pp.
31. Drickamer, L.C., J.G. Vandenbergh and D.R. Colby. 1973. Predictors of dominance in the male golden hamster (*Mesocricetus auratus*). Animal Behavior 21: 557-583.
32. Natelson, B.J., G.P. Smith, P.E. Stokes and A.W. Root. 1973. Changes of plasma glucose and insulin during defense reactions in monkeys. Am. J. Physiol. 224: 1454-1462.
33. Clarke, W.L., J.V. Santiago, L. Thomas, E. Ben-Galin, N.W. Haywood and P.E. Cryer. 1979. Adrenergic mechanisms in recovery from hypoglycemia in man: Adrenergic blockage. Amer. J. Physiology. 236: E-147-#-152.
34. Glick, J.J., Davis, M. Lorenzi, R. Rizza, M. Bohannon, J. Karam, S. Lewis, R. Kaplan, T. Schroltz and P. Cryer. 1979. Hormonal mechanisms of recovery from insulin-induced hypoglycemia in Mammals. Amer. J. Physiol. 236: E380-E385.
35. Rizza, R., M. Haymond, P. Cryer and J. Glich. 1974. Differential effects of epinephrine on glucose production and disposal in man. Am. J. Physiol. 237: E356-E362.
36. Ganthier, C.M. Vranic and G. Hetenyl, Jr. 1980. Importance of glycogen in regulatory rather than emergency responses to hypoglycemia. Amer. J. Physiol. 238: E131-E140.
37. Frank, F. 1953. Untersuchunden under den Zusammenbrunch con Feld, ausplagen (*Microtus arvalis* Pallas). Zool. Jahrb. Jena. 82: 95-136.
38. Skikoma, H. and M. Ui. 1975. Adrenergic receptor and epinephrine-induced hyperglycemia and glucose tolerance. Am. J. Physiol. 229: 962-966.
39. Winkler, B., I. Rathgeb, C. Bjerknes, R. Steele and N. Altzuler. 1973. Effects of norepinephrine on glycerol and glucose metabolism in the normal dog. Am. J. Physiol. 225: 81-84.
40. Booth, D.A., E.E. Coons and N.E. Miller. 1969. Blood glucose responses to electrical stimulation of the hypothalamic feeding area. Physiol. Behav. 4: 991-1001.
41. Kokka, H., R.M. Eisenberg, J. Garcia and R. George. 1972. Blood glucose, growth hormone and cortisol levels after hypothalamic stimulation. Am. J. Physiol. 222: 296-301.
42. Magoun, H.W., S.W. Ranson and A. Hetherington. 1937. The liberation of adrenalin and sympathin induced by stimulation of the hypothalamus. Am. J. Physiol. 119: 615-622.

Proceedings of the Pennsylvania Academy of Science 58: 53-54. 1984

A SURVEY OF THE MAMMALS OF THE WATTSBURG FEN NATURAL AREA[1]

STEVEN J. ROPSKI
[2]*Department of Life Sciences*
Indiana State University
Terre Haute, Indiana 47809
and
KENNETH W. ANDERSEN
Department of Biology
Gannon University
University Square
Erie, Pennsylvania 16541

ABSTRACT

A study of the mammals of the Wattsburg Fen Natural Area, Erie County, Pennsylvania was conducted through 14 site visits during March 1978 to March 1979. Twelve species represented by 53 specimens were captured. Species taken in greatest numbers were *Blarina brevicauda* (16 individuals), *Peromyscus leucopus* (14), and *Microtus pennsylvanicus* (11). Also obtained were *Sorex fumeus* (1), *Sorex cinereus* (1), *Condylura cristata* (1), *Tamias striatus* (2), *Glaucomys volans* (1), *Clethrionomys gapperi* (1), *Zapus hudsonius* (1), *Napaeozapus insignis* (3), and *Mus musculus* (1). Another 12 were recorded on the basis of sign or direct observation. They were *Dipelphis virginiana, Myotis* sp., *Lasiurus cinereus, Sylvilagus floridanus, Marmota monax,* squirrel, *Castor canadensis, Ondatra zibethicus,* fox, *Procyon lotor, Mustela sp.,* and *Odocoileus virginianus.*

INTRODUCTION

This study was part of a survey of the vertebrates of the Wattsburg Fen Natural Area (1). Herein we report on the species of mammals present. The fen, property of the Western Pennsylvania Conservancy, is in eastern Erie County Pennsylvania at the confluence of several small creeks in the headwaters of Hubbel Run. It consists of 12.9 hectares which are mostly peatlands centered around several beaver ponds. The ponds range from a few square meters to 1.4 hectares in area and are of different ages. The older ponds have semi-floating mats around the edges dominated by sphagnum and contain several typical acid-bog plant species. Some of the more distinctive species include sundew (*Drosera rotundifolis),* cotton grass (*Eriophorum virginicum*), grass pink orchid (*Calopogon pulchellus*), rose pogonia (*Pogonia ophioglossoides*), purple fringed orchis (*Habenaria psycodes*), and showy lady's slipper (*Cypripedium reginae*). The density and diversity (seven species) of the orchid flora has been described as the finest in Pennsylvania (2). Other less common species include bunchberry (*Cornus canadensis*), white adder's mouth (*Malaxis brachypoda*) and hooded ladies tresses (*Spiranthes romanzoffiana*).

Throughout the area are hummocks of sphagnum often surmounted by poplar (*Populus*) and various species of shrubs, especially red osier (*Cornus stolonifera*). The hummocks are more numerous toward the edges of the peat blankets where they give way to woodland species including larch (*Larix decidua*), white pine (*Pinus strobus*), hemlock (*Tsuga canadensis*), and a few broadleaf species including oaks (*Quercus* spp.) and maple (*Acer* spp.). Evidence of significant cultural disturbance is limited to the woodland surrounding the wetlands and a glacial knoll near the center. These areas have been logged, cultivated, and used as orchards.

Several distinct habitats were surveyed within Wattsburg Fen. In order of decreasing aerial extent, they were shrub-sphagnum, shrub-poplar, woodland, marshy-grass, grass-forbs, and shrub-grass edge. The latter two were restricted to small areas immediately adjacent to some of the ponds.

MATERIALS AND METHODS

The small mammal community at the Wattsburg Fen was surveyed by using aluminum Sherman livetraps (45-50 each of sizes 2 x 2.5 x 5 in. and 3 x 3.5 x 9 in.) which were set for one to three night intervals during 11 of 14 visits between March 1978 and March 1979. Bait was either peanut butter or powdered lab chow. Traps were set in the early evening of the first day of each visit, and on the following mornings checked and rebaited if necessary. They were removed from the area each final day of trapping. Trap lines generally consisted of ten traps placed approximately eight paces apart. Additional species were noted by recording signs of tracks, scats, dwellings, and direct observations.

[1]Received for publication April 12, 1983; reviewed; accepted October 24, 1983.
[2]Present address: Department of Biology, Gannon University, University Square, Erie, Pennsylvania 16541.

TABLE 1

Mammals captured in six major habitats at the Wattsburg Fen Natural Area, Erie County, Pennsylvania and their trap success based upon 1510 trapnights (TN)

	Grass-Forbes TN - 170	Marshy-Grass TN - 150	Poplar-Shrub TN - 360	Shrub-Sphagnum Tn - 360	Woodland TN - 315	Shrub-Grass Edge TN - 155	Total Specimens	Trap Success x 100
Sorex cinereus masked shrew		1					1	0.06
Sorex fumeus smoky shrew					1		1	0.06
Blarina brevicauda short-tailed shrew		1	8	4	3		16	1.05
Condylura cristata star-nosed mole			1				1	0.06
Tamias striatus eastern chipmunk			2				2	0.12
Glaucomys volans southern flying squirrel					1		1	0.06
Peromyscus leucopus white-footed mouse			4	6	3	1	14	0.92
Clethrionomys gapperi Gapper's red-backed mouse			1				1	0.06
Microtus pennsylvanicus meadow vole		2	1	6	1	1	11	0.72
Zapus hudsonius meadow jumping mouse		1					1	0.06
Napaeozapus insignis woodland jumping mouse				1	2		3	0.19
Mus musculus house mouse		1					1	0.06
TOTAL	0	6	17	17	11	2	53	3.51

Live specimens were released after they were toe clipped to prevent multiple tabulation. Other specimens were prepared as standard skins and skulls or preserved in fluid and deposited in the Carnegie Museum of Natural History Mammal Collection (CM numbers 70877-70899). Species represented include *Sorex cinereus* (one specimen), *S. fumeus* (1), *Blarina brevicauda* (10), *Peromyscus leucopus* (7), *Clethrionomys gapperi* (1), *Microtus pennsylvanicus* (2), and *Zapus hudsonius* (1). A specimen of *Condulura cristata* is in the vertebrate study collection of Gannon University.

RESULTS AND DISCUSSION

The presence of 24 species of mammals were recorded at the Wattsburg Fen. Among the mammals trapped, most abundant were *Blarina brevicauda* (16 specimens). *Peromyscus leucopus* (14), and *Microtus pennsylvanicus* (10). The areas which yielded the most specimens (17 each) were the secondary growth of shrubs and poplars and shrub-sphagnum (Table 1). These two areas were trapped with equal intensity to yield 4.73 animals/100 trapnights. Trapnights for the six habitats trapped in the fen totaled 1510 with an average of 3.51 animals/100 trapnights (Table 1). At no time was the trap success very high and no seasonal differences in population numbers could be discerned.

Tracks of mammals on the site included opossum (*Didelphis virginiana*), cottontail rabbit (*Sylvilagus floridanus*), squirrel (probably *Tamiasciurus hudsonicus*), muskrat (*Ondatra zibethicus*), fox (sp.), raccoon (*Procyon lotor*), weasel (*Mustela* sp.), and white-tailed deer (*Odocoileus virginianus*). Species observed included four to six beaver (*Castor canadensis*), and on one evening in late August, several hoary bats (*Lasiurus cinereus*) and *Myotis* sp., were seen feeding in flight. An active den of woodchuck (*Marmota monax*) was also found.

Perhaps the most interesting species recorded for the site was *Clethrionomys gapperi*. This part of Pennsylvania is on the periphery of its range (3) and records indicate that it is rare in Erie County, Pennsylvania. For example, trapping records of northwestern Pennsylvania in 1946-1948 show that out of 189 specimens only three were taken from Erie County by Richmond et al. (4). Occasional trapping by one of us (Andersen) in other parts of Erie County during the past six years has yielded but two additional specimens.

Unquestionably the beaver is the most influential vertebrate affecting the physical and biotic conformation of the fen. Without their ponds the sphagnum mats would be less extensive and the associated bog species would be less numerous. The fen appears to be progressing toward woodland and in time the boglike characteristics should be expected to disappear. However, as long as beaver continue to inhabit the area this succession should be slowed considerably.

ACKNOWLEDGEMENTS

This study was funded by the Western Pennsylvania Conservancy. The efforts of Gannon University students Mike Adams, Mark Haibach, and Steve Volgstadt in small mammal trapping are appreciated.

REFERENCES

1. Andersen, K.W. 1979. "Vertebrates of Wattsburg Fen Natural Area." Unpublished manuscript, Western Pennsylvania Conservancy, Pittsburgh, 9 pp.
2. Anonymous. "Wattsburg Fen Natural Area." Unpublished manuscript, Western Pennsylvania Conservancy, Pittsburgh, 4 pp.
3. Hamilton, W.J., Jr., and J.O. Whitaker, Jr. 1979. *Mammals of the Eastern United States,* 2nd ed. Cornell University Press, Ithaca and London, 346 pp.
4. Richmond, M.D., and H.R. Rosland. 1949. *Mammal Survey of Northwestern Pennsylvania.* Pennsylvania Game Commission and U.S. Fish and Wildlife Service, Harrisburg, 67 pp.

Proceedings of the Pennsylvania Academy of Science 58: 55-60. 1984

VASCULAR RIFFLE FLORA OF APPALACHIAN STREAMS: THE ECOLOGY AND EFFECTS OF ACID MINE DRAINAGE ON *JUSTICIA AMERICANA* (L.) VAHL[1]

MICHAEL KORYAK and ROSEMARY J. REILLY

U.S. Army Corps of Engineers
Pittsburgh District
Pittsburgh, Pennsylvania 15222

ABSTRACT

Luxuriant growths of the emergent aquatic plant *Justicia americana* (L.) Vahl have been observed on gravel bars and riffles of larger, unpolluted streams throughout the upper Ohio River drainage basin. This plant, however, is conspicuously absent or severely suppressed in stream reaches influenced by acid mine drainage (pH consistently or intermittently depressed to 5.5 or less). The gravel shoals and riffles of the acid streams are either barren or dominated by other emergent species, especially *Eleocharis acicularis*. The elimination of *J. americana* from suitable habitat has been observed to adversely affect channel morphology, substrate composition, general aesthetic quality and aquatic stream life in the region.

INTRODUCTION

This paper reports some observations on the distribution of *Justicia americana* (L.) Vahl in relation to acid drainage from bituminous coal mining operations in the upper Ohio River drainage basin and discusses possible fluvial and biological consequences of the colonization or absence of *Justicia.*

Justicia americana is a stout-based colonial plant, abundant in most of the larger, low to moderate gradient streams of the upper Ohio River basin (Koryak, 1978; and Strausbaugh and Core, 1952). In those streams where it occurs, this emergent herbaceous aquatic perennial is usually the dominant plant of gravel and cobble riffles and bars (Clovis, undated; and Koryak, 1978). The dense colonial stands are fairly uniform in height, ranging from 0.2 to 1 meter (Fernald, 1950).

The root system of *Justicia* is very extensive with abundant thick cord-like stolons and rhizomes (Fernald, 1950). These subterranean stems form a web that binds the substrate, collects sediment, and tenaciously resists scouring and other mechanical disruption. This root-stem network and entrained materials create a low but durable bench, typically elevated roughly 5 to 25 centimeters above the adjacent channel area.

The range of *Justicia americana* extends from Quebec and Ontario west to Michigan and south to Georgia and Texas (Fassett, 1975). This range overlaps the Appalachian coal fields where sulfuric acid from coal mine drainage degrades numerous streams. The source of the H_2SO_4 is primarily from the oxidation of pyrite and marcasite (both having the composition FeS_2). These pyritic sulfur forms occur in coal, and in rock and clay found above and below coal seams. The sulfides are uncovered in the process of coal mining, and exposed to the oxidizing action of air, water, and sulfur-oxidizing bacteria. The end products are water soluble and the basic reaction is:

$$2FeS_2 + 7O_2 + 2H_2O \rightarrow 2FeSO_4 + 2H_2SO_4$$

Justicia americana has been recognized as an important biological component of Appalachian streams. Hill (1981) investigated *J. americana* distribution and productivity in the Virginia portion of the New River. He determined that the productivity of *J. americana* was 4 to 5 times greater than any other aquatic species in this Ohio River basin Appalachian stream, and that in spite of its limited distribution, contributed to 12 percent of the total aquatic macrophyte organic matter. *J. americana* productivity and standing crop in the New River averaged 23.3g ash free dry weight (AFDW) $m^{-2}d^{-1}$ and 2524g AFDW m^{-2} respectively.

Kondratieff and Voshell (1979) point out that aquatic vegetation can significantly influence invertebrate distribution and abundance. Specifically, they noted that mayfly productivity and diversity in the North Anna and South Anna Rivers of Virginia was high where *Justicia* was abundant. The ephemeropteran *Heterocloeon curiosum* was associated especially with upright stems of *Justicia americana* in the North Anna River.

Ortmann (1919), in his classic monograph of the freshwater pearly mussels or naiades (Mollusca: Unionidae), reported forty mussel taxa for the Ohio River drainage of Pennsylvania. Of these forty mussels, he described a frequent or distinct association with *Justicia americana* for eight.

Six of these mussel taxa are generally considered as small river, riffle organisms: *Lampsilis fasciola* (Rafinesque 1820), *Quadrula cylindrica* (Say 1817), *Quadrula verrucoa* (Rafinesque, 1820), *Ellipsaria fasciolare* (Rafinesque 1820), *Eurynia fabalis* (Lea 1831) and *Eurynia iris* (Lea 1830). According to Ortmann, whose work is still considered the most in-depth study of the naiades (Burch, 1975), the six animals listed above are associated with the lively currents and gravelly substrates of riffles interrupted by *Justicia* patches. They were usually most abundant near the edge of the plant growths.

The two remaining mussels Ortmann associated with *Justicia, Lampsilis ovata ventricosa* (Barnes 1823) and *Strophitus edentulus* (Say 1829), are quiescent water organisms that he found to be abundant within the shelter of the *Justicia* growths.

While he discussed a number of plant-mussel relationships in lakes, in his entire massive monograph, *Justicia americana* is the only plant mentioned in relation to mussel habitat in streams.

[1] Received for publication January 17, 1984; reviewed; accepted March 12, 1984.

The richest unionacean mussel fauna in the world is found in North America. There are a total of 227 species north of Mexico (Burch 1975). Most of these occur within or are limited to the distribution range of *Justicia,* and a very substantial percentage of these mussel species prefer gravel riffles. Therefore it is not unlikely that there exists mussel-*Justicia* associations in addition to those described by Ortmann.

The availability of food and shelter for aquatic organisms in *Justicia* stands is readily apparent. A less obvious but probably even more important aspect of *Justicia* colonization of riffles occurs outside the stands, in the adjacent gravel riffles of low to moderate gradient streams. Because the dense root and stem benches formed in patches of *Justicia* constrict riffles and provide well defined low flow channels, adjacent riffle areas are generally silt free and of sufficient depth and velocity to support abundant and diverse riffle faunas.

Conversely, where *Justicia* has been eliminated by acid mine drainage, gravel riffles generally lack low-flow channel definition. These riffles show a tendency to be broad, shallow and silted with depressed faunal communities.

This paper presents observations that show that *Justicia americana* is very sensitive to acid mine drainage pollution and the hypothesis that the elimination of *Justicia* from suitable habitat represents a very significant and previously unrecognized secondary adverse effect of mine drainage pollution on Appalachian region streams.

METHODS

Relationships between vascular riffle flora, acid mine drainage and riffle channel morphology and ecology became apparent over more than eight years of routine water quality and riffle zoobenthos monitoring of streams in the Pittsburgh Engineer District. In the 40,000 square kilometer area of the Pittsburgh District (Fig. 1), both chemical data and Surber invertebrate samples were collected at approximately 200 riffle stations. Observations of the riffles, including floral characteristics, were routinely made.

Since acid mine drainage is widespread and of special interest in the basin, a considerable percentage of the sampling stations were selected to be representative of stream reaches upstream and downstream of major acid polluted tributaries.

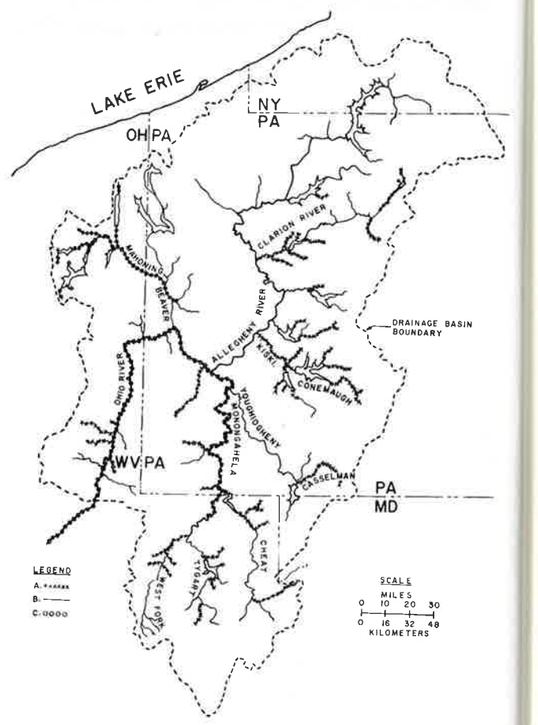


FIGURE 1. Distribution of *Justicia americana* and the extent of significant acid mine drainage pollution in inventoried streams of the upper Ohio River drainage basin. (A) Mine drainage pollued stream reaches where *Justicia* is sparse or absent. (B) pH circumneutral streams where *Justicia* is moderately to highly abundant. (C) pH circumneutral streams where *Justicia* is sparse or absent from apparently suitable habitat.

TABLE 1.

Chemical characteristics and occurrence of Justicia americana in selected major stream reaches of the upper Ohio River drainage basin.

Stream Reach	Sampling Station Location (River Kilometer*)	*Justicia americana* Present	pH # OBS	pH MEAN	pH MAX	pH MIN	ALKALINITY mg/1 as $caCO_3$ # OBS	ALKALINITY MEAN	ALKALINITY MAX	ALKALINITY MIN
Laurel Hill Creek	0.7	yes	8	7.0	7.5	6.3	8	12	15	9
Casselman River	15.2	no	41	6.5	7.7	4.5	41	9	44	0
Upper West Fork River	104.2	yes	48	6.9	7.8	6.1	49	32	54	8
Lower West Fork River	19.3	no	29	6.7	7.3	4.9	34	43	72	5
Tygart River, Upstream of Ford Run	72.8	yes	6	6.7	7.6	6.2	7	13	22	5
Tygart River, Downstream of Ford Run	34.6	no	8	6.3	7.5	5.4	121	11	26	3
Kiskiminetas River	17.9	no	17	5.1	6.4	3.8	17	3	15	0
Upper Cheat River	70.4	yes	187	6.7	7.7	6.0	187	11	63	3
Lower Cheat River	0.5	no	17	5.2	6.5	4.1	5	3	9	0
Conemaugh River	11.6	no	232	4.2	6.6	2.6	231	0.5	21	0
Upper Clarion River	79.7	yes	88	6.7	7.9	5.9	88	14	61	2
Lower Clarion River	26.6	no	77	5.7	7.8	4.0	75	3	12	0
Allegheny River	48.8	yes	8	7.2	7.7	6.7	9	34	44	25

*Distance from mouth of stream.

Water chemistry and Surber macroinvertebrate samples were collected and analyzed according to EPA recommended methods. The chemical parameters analyzed and the sampling frequencies were highly variable for each station but always included pH, alkalinity and acidity measurements.

DISTRIBUTION AND ACID MINE DRAINAGE

Distributional observations of *Justicia americana* in the upper Ohio River drainage basin (Fig. 1) indicate that this plant is very sensitive to acid mine drainage pollution. Within this basin there are 40,000 kilometers of perennial stream, and acid mine drainage is the most serious and widespread water quality problem. Both the degree of mine drainage pollution and the occurrence of *Justicia* in suitable habitat were determined along 2,800 kilometers of 105 different reaches of the larger streams in this area. A total of 2,200 kilometers of 66 different stream reaches were observed to be free of significant acid pollution (pH greater than 5.5) and approximately 600 kilometers of 39 different reaches were found to be frequently or chronically acid degraded. Without exception, *Justicia* was sparse or entirely absent from all 39 of the mine drainage polluted reaches. On the other hand, it was moderately to luxuriantly abundant on riffles and gravel shoals along 1,600 kilometers of 49 stream reaches that were not significantly acid degraded.

A single-factor analysis of variance (ANOVA) was used to examine the observed distribution in relation to the presence of mine drainage pollution. Acid mine drainage was chosen as the independent variable and was evaluated at two levels, present and absent. The presence of *Justicia* was the dependent variable and each stream reach was considered a replicate. Replicates were assigned a value of one if *Justicia* was present, and zero if the plant was absent. The results of the ANOVA show that acid mine drainage degradation is clearly significant (at a 99.9% confidence level) in determining if a given stream can support *Justicia americana*.

Figure 1 is a map showing the approximate extent of inventoried acid polluted and non-acid polluted stream reaches in the basin. Table 1 is a summary of pertinent water quality characteristics for stations representative of reaches of larger streams in the basin that were judged to be suitable *Justicia* habitat. The occurrence of *Justicia* as either moderately to highly abundant or as sparse to totally absent is indicated in both the figure and the table. From the data in Table 1, pH values in the range of 5.5 appear to be the lower limit of pH tolerance for the plant. Except for two reports from the acid degraded Kiskiminetas River, where we have never detected the plant, our observations of the distribution of *Justicia* in the Pennsylvania portion of the Ohio River basin is compatible with the distribution presented by Wherry et al (1979).

The 207 km length of the Monongahela River and a 210 km reach of the upper Ohio River are two large inventoried stream segments with apparently adequate water quality which, as of 1978, had not been colonized by *Justicia*. Both of these rivers are pooled by low head navigation dams. However, in a 116 km long reach of the Allegheny River that is similarly canalized to maintain commercial navigation, *Justicia* was abundant.

Differences in channel forms, substrates, and recent water quality histories may explain the variation in the emergent aquatic plant types of the Allegheny and Monongahela Rivers. In the Allegheny River, *Justicia* was usually abundant where the river channel was braided. It grew on lightly silted gravel shoals and around the numerous islands of the Allegheny River that are of glacial gravel origin. This type of habitat is not abundant on the Monongahela River, which has a generally undiversified ditch-like channel form and no islands (Koryak 1978). Also, the Monongahela River has a recent history of severe mine drainage pollution. This condition persisted into the early 1970's and *Justicia americana* was not among the 12 species of aquatic macrophytes collected by Clarkson and Moore (1971) in the mine acid waters of the upper Monongahela River and major polluted tributaries. Clovis (1971) found only four stems in one clump in the lower acid-polluted reach of one of these tributaries, the Cheat River. He noted, however, that the plant was common in the upper Cheat River, which is only mildly influence by mine drainage. It now appears that the previous water quality pollution of the Monongahela River has been the most significant factor limiting *Justicia* colonization because, since 1978, the plant has been observed in increasing abundance along the upper 50 km of the mainstem of the river.

In spite of apparently suitable stream order, gradient, channel form, substrate and water quality, only a few scattered strands of *Justicia* have been found along the mainstem of the upper Ohio River. Except to note that no species of emergent aquatic vegetation are particularly abundant along the upper Ohio River mainstem, we are unable to explain the disjunct scarcity of *Justicia* in this stream. Another major area of unexplained *Justicia* paucity was along streams on the Mahoning River Basin in a glaciated portion of north eastern Ohio.

It should be noted here that *Justicia americana* is not the only aquatic plant observed to be adversely affected by acid mine drainage. For example, a total of 23 taxa of vascular aquatic macrophytes were found along the acid free reaches of the upper West Fork River of north central West Virginia, but only 4 taxa

TABLE 2

Total and low-flow (7% of mean annual flow) channel widths at riffles along the West Fork River.

Riffle Location (West Fork River km)	Total Channel Width at Riffle (m)	Low-Flow Channel at Riffle Width (m)	Low-Flow Channel at Riffle % of Total Channel Width
Unpolluted Reach			
Upstream of km 36.2			
103.4	34	5.8	17
103.3	34	18	53
90.6	35	11	31
88.2	27	5.5	20
77.4	58	14	24
			MEAN 29%
Acid Mine Drainage Polluted Reach			
Downstream of km 36.2			
35.6	49	23	47
32.5	52	46	88
23.2	52	43	83
22.6	46	35	76
22.5	34	23	68
15.3	37	30	81
7.2	61	34	56
			MEAN 71%

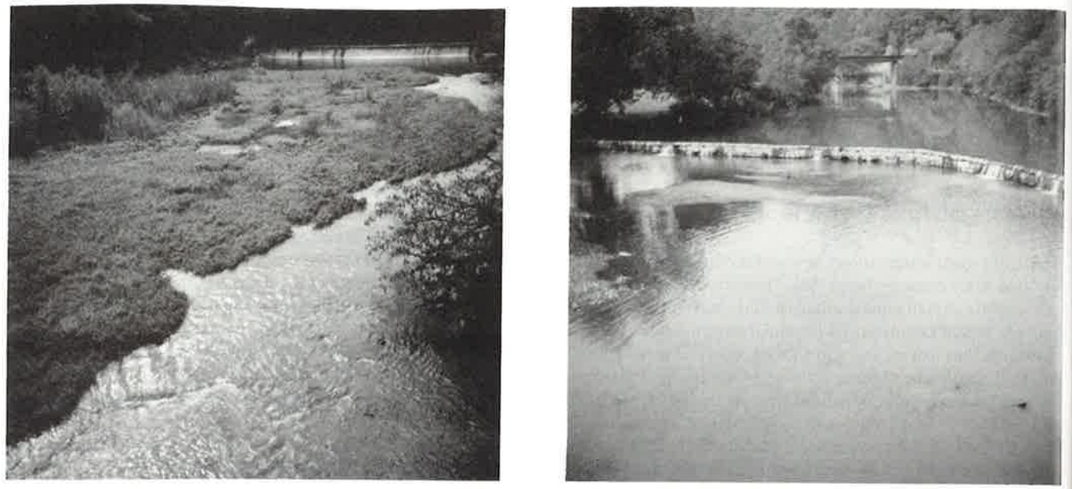


FIGURE 2. Two mill dam tailrace riffles on the West Fork River at low flow. (2a) A *Justicia americana* colonized riffle at stream km 77.4. (2b) A mine drainage polluted and barren riffle at km 15.3.

of plants were observed in the lower, mine drainage degraded portion of this stream. Similarly Clarkson and Moore (1971) found only 3 taxa of aquatic plants at only one location in the lower West Fork River. However, rather than present a general dissertation on the pollution tolerances of aquatic plants, the intention of this discussion is to draw attention especially to the sensitivity of *Justicia americana*. The pH sensitivity of this particular plant is especially noteworthy because of the prominence of *J. americana* in the riffle ecology of Appalachian streams and because of the widespread problem of acid mine drainage in the region.

EFFECTS ON CHANNEL MORPHOLOGY AND SUBSTRATE COMPOSITION OF RIFFLES

The West Fork River of north central West Virginia provides an excellent example of the effects of *Justicia* on channel morphology and substrate composition of stream riffles. The West Fork River is a sand and gravel based stream of moderate gradient (average slope 0.4 m/km). The river drains 2.283 km² and its mainstem is 170 km long. The West Fork receives mine drainage along most of its length but 52% (3,360 kg/day acidity as $CaCO^3$) of the river's acid load enters from one tributary at km 36. From km 36 downstream to the km 0, the stream experiences pH limiting water quality (Sack et al, 1976).

On the West Fork River, scattered *Justicia americana* was first observed near km 116. From km 103 to 52 this aquatic plant was exceptionally lush on all gravel bars and riffles. It was still relatively common between km 52 and km 36, where the river receives some acid pollution. In the significantly degraded reach below km 36, gravel bars and riffles were generally barren of *Justicia* or any other aquatic plant except for *Eleocharis acicularis*.

Table 2 is a tabulation of total and low-flow channel widths at riffles along the West Fork River. The measurements were taken during a low-flow period when the stream discharge was 0.0011 $m^3/s/km^2$ or 7% of the average annual discharge. In the *Justicia* colonized riffles between km 103 and km 52, the average width of the low-flow channel was 29% of the total channel width. Downstream of km 36, where the plant was eliminated, the average low-flow channel width of riffles increased to 71% of the total channel width. A comparison of the effects of *Justicia* at two nearly physical identical sites is also available on the West Fork River. Figures 2a and 2b are photographs taken on the same day at riffles below very similar mill dams at West Fork River km 77.4 and km 15.3 respectively. The principal difference between these two sites is that km 77.4 is not influences by mine drainage and has abundant *Justicia* while the site at km 15.3 is mine drainage degraded and has no aquatic plants. At the km 15.3 site, the low-flow channel was constricted to 81% of the total channel width while at the km 77.4 site a constriction of 24% of total channel width was evident. The comparison of physically similar sites and low-flow tabulations suggest that additional riffle constriction attributable to *Justicia* alone can range up to 57% of total channel width at low flows and it is our judgment that this degree of influence on channel width is not unusual.

It is also our judgment that *Justicia* colonized riffles such as shown in Figure 2a. are much more aesthetically pleasing than barren sites as exemplified by Figure 2b.

Low-flow channel constriction of the *Justicia* colonized riffles resulted in greater low-flow water depths and increased flow velocities in the riffles, with subsequently increased localized substrate scouring and sorting. The substrate of the higher velocity *Justicia* constricted riffles of the West Fork River were relatively well-sorted, clean rocks and gravel with heavy periphyton growth. The stream substate of the broad, shallow riffles in the lower section of the river on the other hand was generally unconsolidated with heavy deposition of fine sediment.

RELATIONSHIP TO RIFFLE FAUNA

Acid mine drainage adversely affects aquatic organisms in several different manners. Besides direct toxicities from acid and heavy metals, mine drainage associated siltation and metal hydroxide precipitates reduce cover and cover diversity, while often smothering periphyton, benthic invertebrates and eggs and larvae of gravel spawning fishes (Koryak et al 1972). For the most part these adverse effects can be related directly to the physical and chemical quality of the mine drainage polluted water. However, among the indirect and secondary biological impacts of mine drainage pollution on stream riffles of the Appalachian region, it appears that the losses of cover, food and low-flow channel definition that result when *Justicia americana* is inhibited are also very significant adverse impacts.

TABLE 3

Summary of macroinvertebrate data collected at three different habitat types of one Justicia americana constricted riffle in the Tygart River and also at a downstream riffle mildly degraded by mine drainage and barren of Justicia.

	At a Riffle Barren of *Justicia* (Tygart River km 55.5)	Within Different Portions of a Riffle Constricted by *Justicia* (Tygart River km 71.1)		
		At Point of Maximum Constriction of the Low-Flow Channel (29% of Total Width)	*At a Less Constricted Portion of the Low-Flow Channel* (55% of Total Width)	*Within Stolon-Rhizome Network of Justicia Bench*
Average Number of Taxa/Surber Sample	5	19	8	9
Average Number of Organisms/m²	167	5963	431	1458
Average Dry Weight of Organisms mg/m²	43	1376	218	367

An example of the degree and extent of influence *Justicia* channel constriction can have on riffle benthic macroinvertebrates can be seen in Table 3. This table is a summary of Surber sample macroinvertebrate results for two riffles of the Tygart River. The Tygart River drains 3560 km² of north central West Virginia. The main channel is 210 km long with an average slope of 2.5 m/km. One riffle sampled is located at km 55.5, in an intermittently and moderately acid degraded reach of the river which *Justicia* has only recently begun to colonize and where it is still sparse. The other riffle is located upstream of any significant mine drainage pollution at km 71.1 and is choked with *Justicia*. At the point of maximum constriction of the km 71.1 site, *Justicia* benches have constricted the low-flow channel to approximately 29% of the total channel width.

In terms of invertebrate dry weight as mg/m², the deepest, swiftest and coarsest substrate portion of the km 71.1 *Justicia* constricted riffle (cobble sized rocks colonized by *Podostemum ceratophyllum*) was 60.0% more productive than a considerably less constricted (approximately 55% of total channel width) clean gravel substrate portion of the same riffle complex and 3200% more productive than the moderately acid polluted riffle of the Tygart River 15.6 km downstream. The average invertebrate community in the area of maximum *Justicia* constriction was also more than 200% more diverse than at the broader portion of the *Justicia* riffle and nearly 400% more diverse than the riffle in the nearby mildly acid degraded reach. The invertebrate community with the *Justicia* stem-root network was also examined. While this area was not as productive and diverse as the low-flow channel in the area of maximum constriction, it was comparable to what was found in the less constricted portion of the same riffle complex and considerably more productive and diverse than the invertebrate community that occurred in the acid influenced downstream riffle.

The comparison of Tygart River benthic faunal communities in the area of maximum riffle constriction of the *Justicia* dominated riffle with the less constricted area of the same riffle is most likely a realistic reflection of the influence of *Justicia* constrictions of riffle fauna. The comparison of any *Justicia* constricted riffle with a riffle where the plant has been inhibited by mine drainage, however, would be necessarily complicated by differences in water chemistries between such sites. Generally, the same acid pollution that inhibits the growth of the macrophyte would also be expected to suppress the faunal community of the riffle. This consistent and significant variable makes it difficult to evaluate the effects of *Justicia* on riffle organisms independently of water chemistry. However, when the more easily determined effects of the *Justicia* constrictions on riffle channel morphology and substrate are considered, it is possible to draw some inferences from studies of channelized and silt polluted streams, which also typically are deficient in low-flow channel definitions. The substrates of these sites frequently consist of unconsolidated, abrasive mixtures of shifting sand, silt and small rocks not well suited for invertebrate colonization (Hynes, 1971; Congdon, 1971; Hanson and Muncy, 1971; Cordone and Kelley, 1961; and Tarpelee et al, 1971, cited in U.S. Army 1976). Conversely Brusven et al (1974) demonstrated that channel constriction in silted streams increases sediment transport and improves invertebrate and fish habitat. In terms of fish habitat, the significance of silt free riffles becomes apparent when it is considered that approximately 50 percent of the more than 100 species of fish known to inhabit the upper Ohio River drainage basin utilize clean gravel to reproduce.

In summary, the effects of *Justicia americana* on the riffle ecology of Appalachian streams appear to be very significant and complex and would likely be a fertile area for further research.

REFERENCES

Busuven, M. A., F. J. Watts, R. Luvdtke and T. L. Kelly. 1974. A Model Design for Physical and Biotic Rehabilitation of a Silted Stream, Project A-032-IDA. Idaho Water Resour. Res. Institute, Univ. of Idaho. Moscow, ID.

Burch, J. B. 1975. Freshwater Unionacean Clams (Mollusca: Pelecypoda) of North America. Malacological Publications. Hamburg, MI.

Clarkson, R. B. and J. A. Moore. 1971. Vascular Aquatic Plants in Acid Mine Water of the Monongahela River, West Virginia. West Virginia University Bull. Morgantown, WV.

Clovis, J. F. 1971. Aquatic Plant Distribution in Cheat Lake (Lake Lynn), West Virginia. *Castanea* (3): 153-163.

_____(Not Dated). Plants of West Virginia Waters. West Virginia Department of Agriculture. Charleston, WV.

Fassett, N. C. 1975. A Manual of Aquatic Plants. University of Wisconsin Press, Madison, WS.

Fernald, M. L. 1950. Gray's Manual of Botany, 8th Edition. American Book Co., New York, N.Y.

Hill, B. H. 1981. Distribution and Production of *Justicia americana* in the New River, Virginia. *Castanea* 46: 162-169.

Kondratieff, B. C., and J. R. Voshell. 1979. Influence of a Reservoir with Epilimnetic Release on the Life History and Ecology of Ephemeroptera. Symposium on Regulated Streams, 18-20 April 1979. Erie, Pennsylvania. North American Benthological Society.

Koryak, M., M. A. Shapiro, and J. L. Sykora. 1972. Riffle Zoobenthos in Streams Receiving Acid Mine Drainage. Water Research Vol. 6, pp. 1239-1247.

Koryak, M. 1978. Emergent Aquatic Plants in the Upper Ohio River and Major Navigable Tributaries, West Virginia and Pennsylvania. *Castanea* 43: 228-237.

Ortmann, A. E. 1919. A Monograph on the Naides of Pennsylvania. Pt. 3. Systematic Account of the Genera and Species. Mem. Carnegie Mus., 8: xiv + 384.

Sack, W. A., C. R. Jenkins, B. R. Chambers, and R. W. Lange. 1976. Modeling of Acid Mine Drainage and Other Pollutants in the Monongahela River Basin Under Low Flow Conditions. Division of Water Resources, West Virginia Department of Natural Resources. Charleston, WV.

Strausbaugh, P. D. and E. L. Core. 1952 et seq. Flora of West Virginia. West Virginia University Bull. Morgantown, WV.

U.S. Army Engineer District, Pittsburgh. 1976. Marianna and Vicinity, Pennsylvania, Local Flood Protection Project, Tenmile Creek, Final Environmental Statement, U.S. Army Corps of Engineers, Pittsburgh District. Pittsburgh, PA.

Wherry, E. T., J. M. Fogg, Jr., and H. A. Wahl. 1979. Atlas of the Flora of Pennsylvania. Morris Arboretum of the University of Pennsylvania, Philadelphia, PA.

Proceedings of the Pennsylvania Academy of Science 58: 61-66. 1984

EFFECTS OF EDGE, AGE, AND COVER TYPE ON WILDLIFE MICROHABITATS IN EVEN-AGED FOREST STANDS IN CENTRAL PENNSYLVANIA[1]

RICHARD H. YAHNER and JEFFREY W. GRIMM

Forest Resources Laboratory
School of Forest Resources
The Pennsylvania State University
University Park, PA 16802

ABSTRACT

Aspen and mixed-oak stands under even-aged management (1-and 5-year-old clearcuts) and in uncut mature stands (>55-years-old) were examined in central Pennsylvania to determine the differential effects of three factors on wildlife microhabitats. Age of stand and cover type in which microhabitats were located, rather than position of microhabitats relative to clearcut-forest edges, were major factors contributing to differences among microhabitats. Microhabitats in mature aspen stands were characterized by overstory *Populus* spp. and *Pinus rigida,* whereas those in mature mixed-oak stands were associated with *Quercus alba* and *Carya* spp. Microhabitats in aspen clearcuts contained abundant *P. tremuloides, Q. ilicifolia,* and *Q. prinoides* shrubs and understory trees; those in mixed-oak clearcuts contained abundant *Acer rubrum* shrubs. Current even-aged management and presumably historical land uses and disturbances are responsible for the creation of different microhabitats available to a variety of wildlife species.

INTRODUCTION

Vegetative structure and species composition are major determinants of microhabitat use by wildlife (1-5). Factors affecting structural and floristic features of microhabitats, and, hence, their use by wildlife, include location of microhabitats relative to an edge and/or position within a stand of a given age or cover type. Strekle and Dickson (6), for example, observed that both avifaunal use and vegetation of habitat within a 25-m juncture of a mature forest and a clearcut were different from areas farther from the juncture. Whitney and Runkle (7) found that differences in species composition of vegetation within small plots (200 m^2) were principally due to location of plots with respect to an edge rather than to age of stands.

Little is known about wildlife-clearcut relationships, particularly in reference to nongame species (8). However, before response by wildlife to habitat alterations created by even-aged management systems can be properly interpreted and understood, an initial step is to determine whether potential microhabitats available to various species of coexisting birds and mammals differ in structure or floristics. An ongoing forest-cutting practice at the Barrens Grouse Management Area (BGMA) in central Pennsylvania not only affords us with an ideal opportunity to compare microhabitats, but, perhaps more importantly, allows us to address the relative importance of 3 factors determining possible differences in microhabitats. To our knowledge, the relative effects of edge, age class, and cover type on microhabitat features important to wildlife have seldom been examined. Currently, we are examining avian and small mammal communities associated with various stands at the BGMA. However, before responses of wildlife communities to habitat alterations created by the even-aged management system at the BGMA can be properly interpreted and understood, an initial step is to determine whether or not potential microhabitats available to wildlife differ in vegetative structure and species composition. Thus, our objectives are to determine structural and floristic differences among microhabitats, and the extent to which any differences can be attributed to edge effect, age class, or cover type in an area undergoing even-aged management for ruffed grouse (*Bonasa umbellus*) habitat improvement.

STUDY AREA AND METHODS

The Pennsylvania Game Commission manages approximately 1,166 ha of forest land (BGMA) in central Pennsylvania. One half of the land area is managed for ruffed grouse using an even-aged system in a uniform pattern of 136 contiguous, square blocks (9,10). Each block is 4 ha in size and is subdivided into four square, 1-ha (100 x 100 m) stands (Fig. 1). Aspen *(Populus* spp.) is the desired cover type on 60 blocks, and mixed-oak *(Quercus* spp.) is the desired cover type on the remaining 76 blocks. The management plan is to have cutting rotations of 20 years in aspen stands and 40 years in mixed-oak stands. The northwestern stand of each block was clearcut in winter 1976-77 (5-year-old clearcuts), and the northeastern stand in aspen blocks only was clearcut in winter 1980-81 (1-year-old clearcuts). Uncut stands (southwestern and

[1]Received for publication February 13, 1984; reviewed; accepted April 23, 1984.

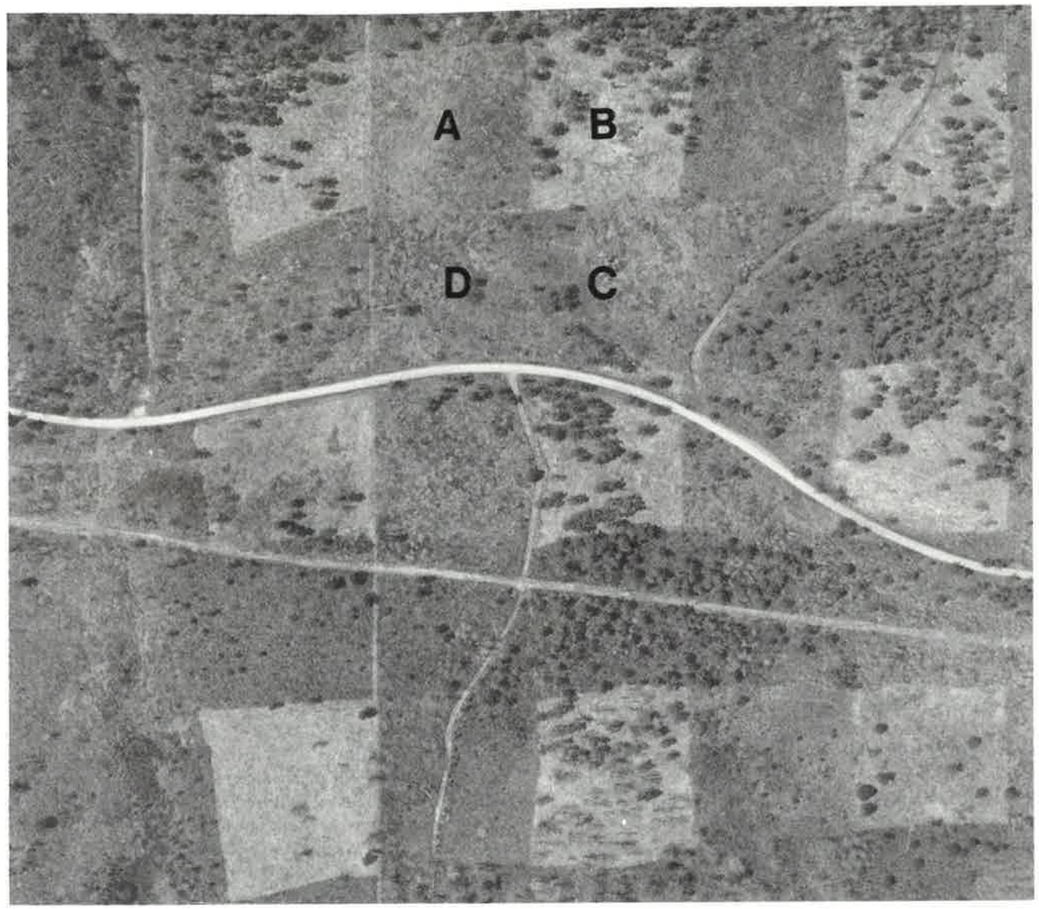


FIGURE 1. Aerial view of Barrens Grouse Management Area in aspen cover type take in June 1981. A = northwestern stand cut in winter 1976-77; B = northeastern stand cut in winter 1980-81; C and D = uncut stands. Most or all trees shown in B have been removed prior to this study.

southeastern) are approximately 55- to 60-years-old (11). The cutting practices have resulted in three age classes of aspen and two age classes of mixed oak. An unimproved dirt road traverses the center of the study area in an approximate east-west direction. The aspen cover type is generally less than 400 m from the road, whereas the mixed-oak cover type is usually more than 400 m.

Fifteen 1-ha stands were selected for study, including three stands per age class in aspen and mixed-oak cover types. Representative stands in each cover type were chosen to avoid stands containing frost pockets (12), transmission lines, or access roads. Each stand was divided into an edge zone and a central zone. The edge zone was a 25-m border (6) at the junction of a given stand with another stand of different age; the central zone was the remaining 50 x 50 m area in the interior of a stand bounded on all sides by the edge zone. Two random points were selected in the edge zone and two in the central zone of each stand. A 0.04-ha circular plot (4, 13, 14) (hereafter also termed a microhabitat) then was centered on each random point, resulting in 30 microhabitats in the edge zone and 30 in the central zone.

Seventy-seven variables related to features important to wildlife based on other studies (4, 13-15), were measured at each microhabitat in summer 1982 (Table 1). These included 24 overstory, 11 understory, 15 tall-shrub, 16 short-shrub, and 11 cover variables. Variables were compared among microhabitats grouped according to location within a stand (edge versus center), age class, or cover type; interactions of these three factors also were examined. Data were analyzed by Kruskal-Wallis tests using the NPAR1WAY Procedure (16). When necessary, *a posteriori* multiple comparisons were made by a *Z*-approximate test of average rank sums (17). All statistics throughout were considered significant at $p < 0.05$.

RESULTS

Overstory variables

Overstory variables did not differ between edge and center zones in uncut stands. With the exception of a few large *Pinus rigida* left as residual trees in some 5-year-old aspen clearcuts (10), overstory trees did not occur in clearcuts. Thus, microhabitats within stands of different age class in both aspen and mixed-oak varied due to several obvious variables characterizing overstory trees (Table 2). For example, differences within both aspen and mixed-oak stands due to age class were found in density, basal area, and mean dbh of overstory trees of all species combined, in number of different species of overstory trees, and in density and basal area of overstory *Populus grandidentata, Populus* spp., *Quercus coccinea,* and snags. In addition, density of *Quercus rubra* and *Acer rubrum* were greater in mature mixed-oak microhabitats than those in mixed-oak clearcuts.

A number of overstory variables also differed due to cover type of mature stands. Density and basal area of overstory *Carya* spp. and *Quercus alba* were significantly greater in microhabitats in mature mixed oak than mature aspen; a reverse trend occurred with *P. rigida.* Basal area of *P. grandidentata* was greater in microhabitats in mature aspen compared to those in mature mixed oak.

Understory variables

Density of understory trees in microhabitats in edge zones of mature aspen adjacent to 5-year-old clearcuts ($\bar{x}$ = 2637 trees/ha) was greater than that in microhabitats in center zones of mature aspen (110 trees/ha). Likewise, number of different species of understory trees was different in microhabitats in mature aspen positioned near 5-year-old clearcuts ($\bar{x}$ = 2.0 species) compared to number of species in center microhabitats of mature aspen (0.3 species).

Only three understory variables differed among microhabitats in the three age classes of aspen, and none varied between microhabitats in the two age classes of mixed-oak (Table 2). Density and number of different species of understory trees differed among age classes in aspen microhabitats due to the lack of trees of this size in 1-year-old clearcuts. Density of understory *Populus tremuloides* was considerably greater in 5-year-old aspen clearcuts compared to other age classes of aspen.

Tall-shrub variables

Density of *Q. ilicifolia* and *Q. prinoides* combined in 5-year-old mixed-oak clearcuts was greater within center zones ($\bar{x}$ = 0.66 stems/m²) than in edge zones (0.24 stems/m²). Density and number of different species of tall shrubs were less in 1-year-old aspen clearcuts compared to other aspen age classes (Table 2). In mixed-oak clearcuts, density and number of species of tall shrubs were greater than in mature stands. Further, number of species was greater in 5-year-old mixed-oak microhabitats compared to those in similar aged stands of aspen.

Density of *Q. ilicifolia* and *Q prinoides* combined and of *P. serotina* varied with age class in microhabitats in both aspen and mixed-oak cover types, and each of these variables was greater in microhabitats in mature aspen than in mature mixed oak (Table 2). Density of *P. tremuloides* differed among age classes of aspen. Density of *Prunus serotina, A. rubrum,* and *Q. ilicifolia* and *Q. prinoides* combined varied between mature aspen and mature mixed-oak microhabitats. Higher density of *P. tremuloides* and of *Q. ilicifolia* and *Q. prinoides* combined characterized microhabitats in 5-year-old aspen clearcuts versus those in 5-year-old mixed-oak clearcuts, whereas higher density of *A. rubrum* was found in 5-year-old mixed-oak clearcuts than in 5-year-old aspen clearcuts.

TABLE 1

Descriptions and sampling methods for 77 variables measured at 60 0.04-ha circular plots (microhabitats) in even-aged stands of aspen and mixed oak in central Pennsylvania

Variable description and sampling method
Overstory:
1-3) Density (no./ha), basal area (m²/ha), and mean dbh (cm) of overstory trees of all species combined within a 0.04-ha circular plot. An overstory tree is defined as ≥ 1.5 m tall and >7.5 cm dbh.
4) Number of different species of overstory trees, as in (1-3).
5-24) Density (no./ha) and basal area (m²/ha), respectively, within a 0.04-ha circular plot of overstory snags and of the following individual species of overstory trees: *Carya* spp., *Pinus rigida, Populus grandidentata, Populus tremuloides, Populus* spp. (*P. grandidentata* and *P. tremuloides* combined), *Quercus alba, Quercus coccinea, Quercus rubra,* and *Acer rubrum.*
Understory:
25-26) Density (no./ha) and number of different species of understory trees; taken from 4 transects (1 x 11.4 m), each at right angles to the other and extending the radius of the 0.04-ha circular plot (total area = 45.5 m²). An understory tree is defined as a shoulder-high woody stem (≥ 1.5 m tall) and 2.5 to 7.5 cm dbh.
27-35) Same as odd-numbered variables from (7) to (23) for density of individual species, but for understory trees.
Tall shrubs:
36-37) Same as for (25) and (26), but for density (no./m²) of tall shrubs in the four transects (1 x 11.4 m). A tall shrub is defined as a shoulder-high woody stem (≥ 1.5 m tall) and <.5 cm. dbh.
38-46) Same as odd-numbered variables from (7) to (23) for individual species, but for density of tall shrubs.
47-50) Same as (38) to (46), but for density of *Quercus ilicifolia, Quercus prinoides, Q. ilicifolia* and *Q. prinoides* combined, and *Prunus serotina.*
Short shrubs:
51-52) Same as (25) and (26), but for density (no./m²) of short shrubs taken from four plots (1-m²) (0.707 x 1.414 m) positioned 5 m from the center of the microhabitat site. A short shrub is defined as a woody stem from 0.5 to 1.5 m tall and <2.5 cm dbh.
53-65) Same as (38) to (50) for individual species, but for density of short shrubs.
66) Same as (53) to (65), but for *Vaccinium* spp.
Cover:
67-68) Mean (mm) and coefficient of variation (%), respectively, of litter depth, measured at 20 points, one every 2 m along transects used to derive (25).
69-74) Mean (%) and coefficient of variation (%), respectively, of percent coverage of grasses and sedges combined, forbs, and total vegetation (grass, sedge, forb, and woody vegetation), based on 20 ocular tube sightings taken 1 m above ground and every 2 m along transects used to derive (25).
75-76) Mean (%) and coefficient of variation (%), respectively, of percent canopy coverage measured 1.5 m above ground and every 2 m along transects used to derive (25).
77) Growth form diversity, based on presence of 4 growth forms, i.e., herbaceous vegetation, short/tall shrubs, understory, and overstory. Calculated by the Shannon index = $-\Sigma p_i \log_e p_i$ where p_i is the proportion of the 20 ocular tube sightings as in (69) to (74) that conatin the ith growth form [see Yahner (15) for details].

Short-shrub variables

No short-shrub variables differed between edge and center zones. Greater density of short shrubs was present in microhabitats in 5-year-old clearcuts than in mature stands in both cover types (Table 2). Microhabitats in mature aspen and in 5-year-old aspen clearcuts had higher density of short shrubs than comparable age classes in mixed oak. As with tall shrubs, number of different species of short shrubs was greater in 5-year-old mixed-oak clearcuts versus either mature mixed-oak or 5-year-old aspen clearcuts. For individual species groups, only density of *Vaccinium* spp. differed among age classes in aspen microhabitats. However, density of *Vaccinium* spp, *Q. prinoides,* and *P. serotina* varied between age classes in mixed-oak microhabitats. Density of *Vaccinium* spp., *Q. ilicifolia, Q. prinoides,* and *A. rubrum* differed between microhabitats in mature aspen and mature mixed-oak; with the exception of density of *Q. prinoides,* density of these species of short shrubs also varied between 5-year-old aspen and 5-year-old mixed-oak clearcuts.

Cover variables

Cover variables did not vary with respect to edge versus center zones. However, four cover variables differed significantly among age classes of aspen, including mean litter depth, mean canopy coverage, coefficient of variation of canopy coverage, and growth form diversity; but only the latter three varied between age classes of mixed oak (Table 2). Further, the first three of these four variables were different in microhabitats in mature aspen compared to those in mature mixed-oak. No cover variables segregated between 5-year-old clearcuts of different cover type.

TABLE 2

Mean ± SD of 40 significant variables (p < 0.05) measured at microhabitats (0.04-ha circular plots) in even-aged aspen stands of aspen and mixed oak in central Pennsylvania.

	Aspen			Mixed-Oak	
Variable[a]	Mature	5-year-old Clearcut	1-year-old Clearcut	Mature	5-year-old Clearcut
Overstory:					
Density total trees	416.7 ± 226.6[b]	2.1 ± 7.1	0.0	486.5 ± 148.2[c]	16.4 ± 32.1
Basal area total trees	11.2 ± 7.0[b]	0.01 ± 0.1	0.0	14.8 ± 7.7[c]	0.1 ± 0.2
Dbh total trees	17.5 ± 3.0[b]	0.8 ± 2.6	0.0	17.3 ± 2.6[c]	2.4 ± 4.4
Number species	2.9 ± 1.1[b]	0.1 ± 0.3	0.0	3.9 ± 1.4[c]	0.4 ± 0.8
Density *Carya* spp.	6.2 ± 15.3[d]	0.0	0.0	47.2 ± 32.3[c]	2.1 ± 7.1
Density *P. rigida*	67.7 ± 89.8[bd]	0.0	0.0	2.1 ± 7.1	0.0
Density *P. grandidentata*	156.0 ± 244.6[b]	0.0	0.0	57.5 ± 80.9[c]	0.0
Density *Populus* spp.	168.3 ± 238.5[b]	0.0	0.0	57.5 ± 80.9[c]	0.0
Density *Q. alba*	73.9 ± 111.6[d]	0.0	0.0	205.3 ± 85.5[c]	12.3 ± 24.6
Density *Q. coccinea*	34.9 ± 47.5	0.0	0.0	71.8 ± 83.1[c]	0.0
Density *Q. rubra*	0.0	0.0	0.0	10.3 ± 16.5[c]	0.0
Density *A. rubrum*	0.0	0.0	0.0	10.3 ± 16.5[c]	0.0
Density snags	49.3 ± 50.4[b]	0.0	0.0	59.5 ± 41.3[c]	0.0
Basal area *Carya* spp.	0.2 ± 0.5[d]	0.0	0.0	0.9 ± 0.6[c]	0.01 ± 0.04
Basal area *P. rigida*	2.5 ± 3.2[bd]	0.0	0.0	0.1 ± 0.3	0.0
Basal area *P. grandidentata*	2.4 ± 3.2[bd]	0.0	0.0	0.6 ± 0.9[c]	0.0
Basal area *Populus* spp.	2.6 ± 3.1[d]	0.0	0.0	0.6 ± 0.9[c]	0.0
Basal area *Q. alba*	2.7 ± 4.6[d]	0.0	0.0	6.8 ± 4.0[c]	0.2 ± 0.1
Basal area *Q. coccinea*	2.0 ± 3.2	0.0	0.0	4.4 ± 5.4[c]	0.0
Basal area snags	0.8 ± 0.9[b]	0.0	0.0	0.9 ± 0.9[c]	0.0
Understory:					
Density total trees	897.4 ± 1397.8[bd]	1062.3 ± 1008.6	0.0	531.1 ± 1262.4	769.2 ± 1134.3
Number species	1.0 ± 0.9[bd]	1.1 ± 0.7	0.0	0.5 ± 0.9	1.0 ± 1.1
Density *P. tremuloides*	91.6 ± 197.9[b]	824.2 ± 914.0[e]	0.0	0.0	36.6 ± 126.9
Tall shrubs:					
Density total shrubs	1.18 ± 0.59[bd]	2.33 ± 0.98	0.07 ± 0.11	0.59 ± 0.69[c]	1.96 ± 1.32
Number species	3.4 ± 1.3[bd]	3.0 ± 0.6[e]	0.8 ± 0.5	2.0 ± 1.3	4.3 ± 1.2
Density *P. tremuloides*	0.07 ± 0.18[b]	0.43 ± 0.39[e]	0.01 ± 0.03	0.00	0.01 ± 0.02
Density Q. ilicifolia/Q. prinoides	0.93 ± 0.56[bd]	1.31 ± 0.67[e]	0.02 ± 0.04	0.06 ± 0.06[c]	0.45 ± 0.35
Density *P. serotina*	0.07 ± 0.04[bd]	0.33 ± 0.29	0.04 ± 0.11	0.01 ± 0.01[c]	0.35 ± 0.50
Density *A. rubrum*	0.07 ± 0.14[d]	0.01 ± 0.01[c]	0.00	0.52 ± 0.67	0.83 ± 0.93

TABLE 2 (continued)

Mean ± SD of 40 significant variables (p < 0.05) measured at microhabitats (0.04-ha circular plots) in even-aged aspen stands of aspen and mixed oak in central Pennsylvania.

	Aspen			Mixed-Oak	
Variable[a]	Mature	5-year-old Clearcut	1-year-old Clearcut	Mature	5-year-old Clearcut
Short shrubs:					
Density total shrubs	7.83 ± 1.39[bd]	12.68 ± 2.00[e]	11.00 ± 0.56	5.08 ± 1.52[c]	10.04 ± 2.60
Number species	3.58 ± 0.79	4.84 ± 1.52	4.16 ± 1.12	4.76 ± 1.28[c]	6.08 ± 0.68
Density *Vaccinium* spp.	1.56 ± 1.04[bd]	0.88 ± 0.64[e]	0.24 ± 0.48	0.68 ± 0.64[c]	1.60 ± 0.88
Density *Q. ilicifolia*	3.36 ± 1.28[d]	5.21 ± 2.54[e]	5.24 ± 2.92	1.48 ± 1.40	2.16 ± 1.08
Density *P. serotina*	0.24 ± 0.28	0.68 ± 0.88	0.76 ± 1.16	0.36 ± 0.52[c]	0.76 ± 0.64
Density *A. rubrum*	0.16 ± 0.36[d]	0.00[e]	0.04 ± 0.08	0.16 ± 1.40	2.40 ± 0.84
Cover:					
Mean litter depth	49.5 ± 5.4[bd]	58.9 ± 6.1	68.7 ± 8.1	44.0 ± 11.9	53.0 ± 14.9
Mean canopy coverage	52.0 ± 10.7[bd]	8.3 ± 9.0	0.0	60.9 ± 7.9[c]	[22.2] ± 16.7
Growth form diversity	1.21 ± 0.10[b]	1.05 ± 0.22	0.69 ± 0.01	1.18 ± 0.10[c]	0.92 ± 0.16
Coefficient of variation of canopy coverage	49.4 ± 15.5[bd]	231.1 ± 134.6	—[f]	31.8 ± 12.1[c]	209.0 ± 141.3

[a]Units, complete description, and sampling method for each variable are given in Table 1.
[b]Significant difference among means of aspen age classes; $p < 0.05$ $\chi^2 > 5.99$, d.f. = 2.
Nonsignifcant means are underlined, based on multiple-comparison procedures (see text).
[c]Significant difference between means of mixed-oak age classes; $p < 0.05$, $\chi^2 > 3.84$, d.f. = 1.
[d]Significant difference between means of mature aspen and mature mixed-oak age classes; $p < 0.05$, $\chi^2 > 3.84$, d.f. = 1.
[e]Significant difference between means of 5-year-old aspen and 5-year-old mixed-oak age classes; $p < 0.05$, $\chi^2 > 3.84$, d.f. = 1.
[f]Coefficient of variation not determined due to no data for canopy.

DISCUSSION

Strekle and Dickson (6) and Whitney and Runkle (7) found that position of microhabitats relative to an edge contributed more to differences in species composition and structure of vegetation than other factors, such as age of plot. However, based on relative frequency of 40 significant variables measured at microhabitats in our study (Table 2), age class and cover type were major factors distinguishing microhabitats at the study area. Thirty-eight (95%) of these variables varied significantly with age in aspen and mixed oak, and 20 (50%) differed between microhabitats of the same age but of different cover type. In contrast, only three (8%) of the 40 variables varied with regard to position within a stand. Perhaps differences in features of microhabitats in edge versus central zones are not yet detectable because insufficient time has elapsed subsequent to initiation of the cutting rotation. For example, microhabitats in edges of mature aspen stands resembled an early stage of succession only in terms of a greater density of understory trees compared to central areas. Dense understory of woody species is generally one of the first response noted in vegetative structure of a newly-created forest edge (18), presumably due to increased light intensity at edges (7). In contrast, a greater density of *Q. ilicifolia* and *Q. prinoides* combined, categorized as tall shrubs, in central microhabitats of mixed-oak clearcuts compared to those in edge zones may be the result of reduced shading from overstory trees in central zones. Unlike aspen clearcuts, which are bounded only on two sides by mature stands with tall trees, mixed-oak clearcuts are surrounded on all sides by mature stands due to a different cutting rotation. Differential occurrence of tall *Q. ilicifolia* and *Q. prinoides* combined between edge and central zones of mixed-oak clearcuts is unlikely the consequence of deer browsing, despite *Q. ilicifolia* being an important wildlife food (19). Evidence for this comes from Hale (11) who reported that deer foraged indiscriminately in central and edge zones in nearby aspen clearcuts at the BGMA.

As a consequence of even-aged management, microhabitats in mature stands of both aspen and mixed-oak cover types afford greater vegetative complexity in a vertical dimension compared to microhabitats located in clearcuts. A by-product of this complexity in mature stands should be more vertical space, i.e., a greater variety of microhabitats, in mature stands than in clearcuts, thereby enabling more species of wildlife to coexist relative to as a simpler habitat (e.g., a clearcut) (5,8,15,20). Moreover, certain features of complex microhabitats in mature stands may be seasonally important to various types of wildlife. For instance, snags are important roosting and foraging sites for cavity-dependent wintering birds (21), but snags occurred only in mature stands of aspen and mixed oak at the study area.

Virtually all overstory aspen in mature microhabitats was *P. grandidentata; P. tremuloides* is typically located at lower elevations near the unimproved dirt road (12). These 2 overstory species and certain shrubs (e.g., density of *Q. ilicifolia* and *Q. prinoides* combined) characterizing microhabitats in mature aspen stands largely depend on fire or land disturbance for maintenance (22, 23). A railroad bed once occurred in the vicinity of the road at the study area, and high incidences of fire from locomotives during the 1800's and early 1900's were common along the bed (12, 24).

In contrast to microhabitats in mature aspen, microhabitats in 5-year-old aspen clearcuts primarily consisted of understory and tall shrubs of *P. tremuloides*. Johnson (25) also found *P. tremuloides* to be more abundant than *P. grandidentata* in New York clearcuts. She suggested that poor regeneration of *P. grandidentata* was principally due to greater intensity of deer browsing on this species compared to *P. tremuloides*. However, based

on relatively low deer densities and browsing intensity (11), we could not attribute differential abundance of these two species of *Populus* in 5-year-old aspen clearcuts to deer browsing.

In conclusion, a variety of different microhabitats are available to various species of wildlife, such as songbirds and small mammals. Features characterizing differences in microhabitats are primarily a consequence of an even-aged management system that has created different age classes of divergent vegetative structure, and perhaps historical land-use practices and disturbances. A knowledge of specific differences in structural and floristic features among available microhabitats found in this study gives valuable information to better interpret and understand the relationship between habitat alterations created by the forest management practice and patterns of wildlife abundance and dispersion.

ACKNOWLEDGMENTS

We thank T.W. Bowersox for reviewing the manuscript. This research was funded by the Pennsylvania Agricultural Experiment Station and the Max McGraw Wildlife Foundation. This is paper No. 6688 of the Pennsylvania Agricultural Experiment Station.

LITERATURE CITED

1. James, F.C. 1971. Ordinations of habitat relationships among breeding birds. *Wilson Bull.* 83:215-236.
2. M'Closkey, R.T. 1975. Habitat succession and rodent distribution *J. Mammal.* 56:950-955.
3. Wiens, J.A., and J.T. Rotenberry. 1981. Habitat associations and community structure of birds in shrubsteppe environments. *Ecol. Monogr.* 51:21-41.
4. Yahner, R.H. 1982a. Microhabitat use by small mammals in farmstead shelterbelts. *J. Mammal.* 63:440-445.
5. _____ 1982b. Avian use of vertical strata and planting in farmstead shelterbelts. *J. Wildl. Manage.* 46:50-60.
6. Strekle, W.K., and J.G. Dickson. 1980. Effect of forest clearcut edge on breeding birds in east Texas. *J. Wildl. Manage.* 44: 559-567.
7. Whitney, G.G., and J.R. Runkle. 1981. Edge versus age effects in the development of a beech-maple forest. *Oikos* 37:377-381.
8. Conner, R.N., J.W. Via, and I.D. Prather. 1979. Effects of pine-oak clearcutting on winter and breeding birds in southwestern Virginia. *Wilson Bull.* 91:301-316.
9. Liscinsky, S.A. 1980. Pennsylvania grouse management update. *Pennsylvania Game News* 51(5):44-46.
10. Yahner, R.H. 1983a. Breeding (1982) birds of the Barrens Grouse Management Area. *Amer. Birds.* 37:53-55.
11. Hale, V.M. 1983. White-tailed deer use of three ages of aspen. M.S. Thesis, Pennsylvania State Univ., University Park. 63 p.
12. Sidelinger, J.E. 1977. Composition and structure of vegetation and wildlife utilization of a scrub oak forest following a prescribed burn. M.S. Thesis, Pennsylvania State Univ. 91 p.
13. James, F.C., and H.H. Shugart, Jr. 1970. A quantitative method of habitat description. *Audubon Field Notes.* 24:727-736.
14. Dueser, R.D., and H.H. Shugart, Jr. 1978. Microhabitats in a forest-floor small-mammal fauna. Ecology 59:89-98.
15. Yahner, R.H. 1983b. Seasonal dynamics, habitat relationships, and management of avifauna associated with farmstead shelterbelts. *J. Wildl. Manage.* 47:85-104.
16. SAS Institute. 1982. *SAS User's Guide: Statistics.* SAS Institute, Inc. Cary, North Carolina.
17. Dunn, O.J. 1964. Multiple comparisons using rank sums. *Technometrics* 6:241-252.
18. Ranney, J.W., M.C. Bruner, and J.B. Levenson. 1981. Pages 67-95, in R.L. Burgess, and D.M. Sharpe (eds.). *Forest Island Dynamics in Man-dominated Landscapes.* Springer-Verlag, New York.
19. Hallisey, D.M., and G.W. Wood. 1976. Prescribed fire in a scrub oak habitat in central Pennsylvania. *J. Wildl. Manage.* 40:507-516.
20. Willson, M.F. 1974. Avian community organization an habitat structure. *Ecology* 55:1017-1029.
21. Jackson, J.A. 1970. A quantitative study of the foraging ecology of downy woodpeckers. *Ecology* 51:318-323.
22. Fowells, H.A. (ed.) 1965. *Silvics of Forest Trees of the United States.* USDA-For. Serv., Washington, D.C. Agric. Handk. No. 271.
23. Kerlinger, P., and C. Doremus. 1981. Habitat disturbance and the decline of dominant avian species in pine barrens of the northeastern United States. *Amer. Birds.* 35:16-20.
24. Conklin, G.W. 1943. Portions of the famous "Barrens" in Centre County acquired as State Game Lands. *Pennsylvania Game News*, 14(6-7):24-25.
25. Johnson, E.A. 1979. Development and maintenance of aspen (*Populus tremuloides* Michx. and *P. grandidentata* Michx.) in old fields in central New York. M.S. Thesis, Cornell Univ., Ithaca. 107 p.

Proceedings of the Pennsylvania Academy of Science 58: 67-69. 1984

GROWTH RATES OF NORWAY SPRUCE *(PICEA ABIES)* FROM 46 DIVERSE SEED SOURCES STUDIED IN MARYLAND'S APPALACHIAN REGION[1]

JOHN B. GENYS, DAN M. HARMAN and KENT B. FULLER

[2]*Appalachian Environmental Laboratory*
Center for Environmental and Estuarine Studies
University of Maryland
Frostburg, Maryland 21532

ABSTRACT

Norway spruce (*Picea abies*) from 46 European seed sources was studied for 15 years in Mount Savage, Maryland. Survival of the different populations ranged from 27% to 100%, and heights from 2.0 m to 5.0 m. In general, individual European regions were represented by populations with highly variable growth rates. Most outstanding were some strains from the German Jura region. Three populations from the Baltic region grew slowly and showed a poor survival.

Heights of the different populations at 15 years after planting were significantly correlated with their 8-year heights, but were not correlated with the geographic factors such as latitude, longitude and elevation of their provenance.

Additional key words: provenance, geographic variation.

INTRODUCTION

Norway spruce (*Picea abies* (L.) Karst.) is an important tree of Europe. It is found in a wide range extending from the Arctic Circle to southern France, and from near sea level to elevations of 2200 meters. It grows in three major geographic regions, the Baltic, the Carpathian, and the Alpine. In addition, it is found in several isolated areas of northern Germany, such as Harz Hills and Lüneburger Heide. Within Europe, Norway spruce is used primarily for lumber, and is a source of high-quality pulp for the manufacturing of paper. It is also highly valued as a beautiful ornamental and as a Christmas tree.

In the eastern United States, Norway spruce has been planted for over a century, and some specimens have grown into large and valuable trees. By 1965, the annual plantings of Norway spruce in the United States were nearly ten million trees (Abbott and Eliason, 1968). This ranks *Picea abies* among the most planted species of European trees within the United States and indicates a need for studies of its racial variation, and a need for selecting the most desirable seed sources.

[1] Received for publication November 28, 1983; reviewed; accepted February 27, 1984.
[2]Scientific Series No. 1521-AEL, Center for Environmental and Estuarian Studies of the University of Maryland.

Norway spruce has no described geographic varieties. However, many European studies have indicated a morphological and geographic variation (Kalela 1937, Krutzsch 1974, Langlet 1938, Rubner 1957, Schönbach 1957, Stern 1957). The first experiments with *P. abies* in North America were the 1938/39 International Provenance Trials with Spruce, sponsored by the International Union of Forest Research Organizations (Veen, 1952). These plantations provided some initial information, but their value decreased when the trees were damaged by white pine weevil, *Pissodes strobi* (Peck) (Heimburger 1944, Holst 1963, Slabaugh and Rudolf 1957).

A more recent and larger experiment with Norway spruce was started by Professor O. Langlet in Sweden in 1959. This study included about 1,000 seedlots, and numerous plantations were established in Europe and Canada. Due to quarantine regulations and other difficulties no seedlings were received in the United States, with the exception of a small share of seedlots acquired by the senior author.

MATERIALS AND METHODS

The Norway spruce experiment established in Maryland included 74 seedlots; 52 (Nos. 1-236) were obtained from Professor Langlet's collection and 22 (No. 833-873) from the late Dr. K. Stern of West Germany. These seed samples were expected to represent the native stands although there is no certainty because Norway spruce has been extensively planted for centuries.

On May 5, 1966, the experimental seeds were sown at the State Forest Tree Nursery in Harmans, Maryland, using a complete randomized block design. In the spring of 1968 (May 10-20), two-year-old seedlings were planted in two locations. One plantation was established in Howard County, a central county within Maryland (Genys, 1978). The second plantation, which is the subject of this study, was planted on the grounds of the Theodore Thoerig farm in Mount Savage, Allegany County, western Maryland. The site is a southwestern slope (10%), at an elevation of about 500 m in the Appalachian Mountain chain. It was formerly a farm field with a well drained and relatively shallow soil. The major pioneer species on the site was black locust, *Robinia pseudoacacia* L.

The plantation included three completely randomized blocks (two additional blocks of trees failed or were severely damaged

TABLE 1

Seed origin, 15-year survival and 17-year heights of 46 different populations of Norway spruce (Picea abies) *studied in the mid-Appalachian region, Mount Savage, Maryland.*

Region (G = Germany) seedlot No., and location or provenance	Seed origin: North latitude	East longitude	Elevation	15-yr survival	17-yr height: real	relative to mean = 3.77 m
	degree		*m*	%	*m*	%
Finland						
840 (location unknown)	—	—	—	27	2.0	53
Lithuania						
873 Labanoras	55.33	15.50	150	30	2.75	69
Poland						
235 Przerwanki	54.17	21.95	150	73	3.7	98
867 Rycerka	49.47	19.08	560	67	4.4	117
866 Istebna	48.58	18.92	500	61	3.6	96
Czechoslovakia						
870 Zwolen (Arboretum)	—	—	—		5.0	133
871 Zwolen (Arboretum)	—	—	—		4.4	117
Romania						
844 (Botanic Garden)	—	—	—	80	3.6	96
864 Dorna Cindreni	47.35	25.37	900	60	3.7	98
863 Toplita	46.92	25.42	850	—	4.3	114
Harz (G)						
24	51.78	10.15	200	67	4.3	115
860 Westerhof	51.78	10.15	200	53	4.0	106
19 Sieber	51.67	10.50	600	53	3.4	91
Western Hills (G)						
21 (Western Hills)	51.53	8.00	450	100	3.8	101
7 Beerfelden	49.58	8.98	450	53	4.5	120
Fichtel Highlands (G)						
53 Weissenstadt	50.10	11.93	850	60	3.4	90
Bavarian Morenes (G)						
134 Teisendorf	47.85	12.83	900	53	3.9	104
132 Seeshaupt	47.82	11.32	900	73	3.1	82
Northern Alps (G)						
80 Yelden	49.62	11.50	500	58	2.9	77
40 Eberbach	49.47	9.00	500	53	4.5	120
160 Freising	48.40	11.80	500	73	3.7	98
41 Illertissen	48.27	10.13	500	53	3.1	82
156 Burghausen	48.17	12.80	500	67	3.3	88
Franken Wald (G)						
95 Rossfeld	49.00	11.00	500	73	3.6	96
Bavarian Wald (G)						
32 Zwiesel-West	49.11	13.22	1000	73	3.7	98
120 Passau-North	48.67	13.58	1000	60	3.8	101
Jura Region (G)						
103 Oberkochen	48.78	10.14	500	92	4.2	112
98 St. Johann	48.46	9.13	750	73	4.0	106
47 Lichtenstein	48.40	9.23	650	47	4.4	117
96 Tailfingen	48.25	9.00	750	53	5.0	133
28 Muehlheim	48.02	8.90	750	87	4.3	114
97 Justingen	48.33	9.50	750	47	2.5	68
Black Forest (G)	48.58	8.35	500	87	3.2	85
92 Schönmünzach	48.58	8.35	500	87	3.2	85
44 Schönmünzach	48.58	8.35	700	60	3.8	101
77 Freudenstadt	48.33	8.50	500	47	3.4	90
5 Todtmoos	47.68	7.95	850	87	3.0	80
Boden Lake Region (G)						
111 Dietenheim	48.20	10.07	650	87	3.9	104
112 Mengen	48.03	9.32	650	93	4.1	109
76 Mengen	48.03	9.32	650	73	4.0	106
106 Ravensburg	47.78	9.67	750	67	4.1	109
Austria						
832 Tyrol	—	—	—	73	4.1	109
831 Böhmerwald	—	—	600	73	3.7	98
France						
855 (Central France)	—	—	—	86	3.0	80
Plantations						
869 (Hjulebereg, Sweden)	—	—	—	73	4.8	128
861 (Werder, N. Germany)	—	—	—	51	3.8	101
834 (Central Md., USA)	—	—	—	73	3.5	93
The least significant difference (at 0.05 level)				57	2.1	56
F-value (significant at 0.05 level)				1.6*	1.9**	—

*Significant at 0.05 level; ** significant at 0.01 level.

by deer) with 5-tree row-plots per seedlot in each block. Trees were spaced at 2.4 m between rows, and at 1.2 m within the rows. Heights of the trees were measured and their survival counted at 6 and 15 years after planting. Out of the 74 populations planted only 46 were present in all of the blocks. Only these 46 were used for an analysis of variance and for the discussions within this report.

RESULTS

Survival

The survival rate of the studied strains ranged from 17% (#840, Finland) to 100% (#21, Western Hills of Germany). There was a high inconsistency of the survival rates in different blocks. Consequently, only the most extreme survival values were found as significantly different (LSD at 0.05 level = 57%). Small trees from Finland and Lithuania showed the poorest survival. In general, survival rates were highly variable and were not correlated to geographic factors such as latitude, longitude or altitude. There was, however, a trace of relationship between the survival and the growth rate of young (8-year-old) trees ($r = 0.25$; $P = 0.049$). One of the major causes of mortality was injury to young trees by white-tail deer, *Odocoileus virginianus*.

Growth Rates

Heights of the different strains at 17 years ranged from 2.0 m (#840, Finland) to 5.0 m (#96, Jura Region, Germany). There was a large variation in height among the sources originating from the same regions. Also, there was a large variation in growth of the same populations in different study blocks. Statistical analysis indicated that only extreme values of the height differences were significantly different (LSD at 0.05 level = 2.1 m). Most regions included one or two strains which grew rapidly. The Jura Region in Germany was represented by five outstanding strains (6% to 34% larger than the study average) and by only one strain which grew poorly. Among the rapidly growing populations were two strains from plantations located in Hjuleberg, Sweden (#869) and Zwolen Arboretum in Czechoslavakia (#870). An above average growth was observed among the trees from Germany's Lake Boden region. The famous Black Forest region was represented by four strains that ranged from below average to about average (79% to 102% of the study mean).

The heights of different strains at age 17 were not significantly related to the factors of geographic origin, such as latitude, longitude or elevation ($r < 0.1$). They were, however, strongly correlated to the heights of the same strains measured at age 8 ($r = 0.63$), and showed a trace of relationship to the lateness of budset, or the day of season when trees formed their terminal buds ($r = 0.25$, $P = 0.057$) (Genys 1968). The heights of trees planted in the Appalachian Region of Maryland showed no significant correlation to the 8-year heights of the same strains planted in Maryland's Piedmont Plateau ($r = 0.23$; $P = 0.070$) (Genys 1979).

DISCUSSION

Results of this experiment confirmed previous information that Norway spruce is a genetically variable species, which indicates that it is very important to select appropriate seed sources for commercial and private use. This experiment also showed that the studies conducted in Maryland's Piedmont Plateau were not particularly helpful in the selection of the best seed sources for Maryland's Appalachian region.

The Jura region of Germany was represented by five outstanding populations, and one population that was extremely poor with respect to its growth and survival. This suggests that some sources of Norway spruce within Europe may not be indigenous and the selections cannot be based on broad regions, but must be specific to the individual source. A source worthy of notice is the Tailfingen source (#96), which was represented by seedlings that grew 33% above the study mean. Also, rapid growth was noticed in the trees from the Zwolen Arboretum in Czechoslovakia and from the Hjulberg plantation in Sweden. These sources would be easy to acquire for practical use. The trees from the Baltic region, Finland and Lithuania, grew slowly. It also appears that the populations from the famous Black Forest in Germany are not promising.

ACKNOWLEDGEMENTS

The authors wish to express their gratitude to Prof. O. Langlet and Dr. P. Krutzsch of Sweden, and the late Dr. K. Stern of West Germany for sharing with us their valuable seed lots. Also, thanks go to the administration of Maryland Forest Service for nursery space and Mr. T. Thoerig for offering the planting site for field studies.

LITERATURE CITED

Abbott, H. G. and E. J. Eliason. 1968. Forestry tree nursery practices in the United States. *J. Forestry* 66 (9):704-711.

Genys, J. B. 1968. Intraspecific variation among 200 strains of two-year-old Norway spruce. 11th Meeting of the Committee on Forest Tree Breeding in Canada:195-203.

Genys, J. B. 1979. Intraspecific variation in Norway spruce (*Picea abies)* from 74 different seed sources studied in Maryland. Proc. 1st North Central Tree Improvement Conf.:33-43.

Holst, M. J. 1963. Growth of Norway spruce (*Picea abies* L. Karst.) provenances in eastern North America. Can. Dep. Forest Publ. 1022. 15 pp.

Kalela, A. 1937. Zur Synthese der experimentellen Untersuchungen über Klima-Rassen der Holzarten. Comm. Inst. for. Fenniae, 26, Helsinki. 434 pp.

Krutzsch, P. 1974. The IUFRO 1964-68 provenance test with Norway spruce (*Picea abies* L. Karst.). *Silvae Genetica* 23:1-3.

Langlet, O. 1938. Proveniensforsok med olika tragslag. *Swenska Skogsvoirdsforeningens Tidskrift* 36:53-1938.

Rubner, K. 1957. Ergebnisse eines heute 20-jährigen Fichtenherkunftsversuches, I. Teil. Die Fläche in Bayern. *Silvae Genetica* 6:74-89.

Schönbach, H. 1957. Ergebnisse eines heute 20-jährigen Fichtenprovenienzversuches, II. Teil, Die Flächen in Thüringen und Sachsen. *Silvae Genetica* 6:74-89.

Slabaugh, P. E. and P. O. Rudolf. 1957. The influence of seed source on the development of Scotch pine and Norway spruce planted in Lower Michigan (fifteen-year results). Pap. Mich. Acad. of Sci., Arts and Letters XLII:41-51.

Stern, K. 1957. Über die Regression des Samengewichtes zur Keimpflanzengrösse bei der Fichte. *Silvae Genetica* 6:155-156.

Veen, B. 1952. Report of a tour of inspection along the test areas of the International Provenance Trials with larch, pine and spruce of 1938/39 and 1944/45, and suggestions for future treatment and assessments. I.U.F.R.O. (Section 22) leaflet. 44 pp.

Proceedings of the Pennsylvania Academy of Science 58: 70-72. 1984

THE INFLUENCE OF PHORID AND SCIARID POPULATIONS ON MUSHROOM YIELD AT COMMERCIAL MUSHROOM FARMS IN PENNSYLVANIA[1]

D. L. RINKER[2], R. J. FINLEY[3], P. J. WUEST[3], R. SNETSINGER[2], R. TETRAULT[2], and D. J. ROYSE[3]

The Pennsylvania State University
University Park, PA 16802

ABSTRACT

Lycoriella mali (Fitch) (Diptera: Sciaridae) and*Megaselia halterata* (Wood) (Diptera: Phoridae) are pests of commercial mushroom production. These pests were monitored in commercial mushroom crops over a two-year period near Kennett Square, Pennsylvania to determine their significance in mushroom production. The number of sciarid and phorid adults invading commercial mushroom houses varied for each crop, and with the season. Populations were lowest in winter and highest in fall. Total insects captured during cooldown and spawn run, when correlated with yield, accounted for only 24% of the mushroom yield variance. Addition of management practices to the model increased accountability for variance to 68%. In commercial mushroom production the overall pest influence is small, but significant.

INTRODUCTION

Insect pests have plagued mushroom farmers since mushrooms were first cultivated. At least 17% of commercial mushroom production in southeastern Pennsylvania was lost during a nine-month period in 1978 due to two arthropod pests, *Lycoriella mali* (Fitch) (Diptera: Sciaridae) and*Megaselia halterata* (Wood) (Diptera: Phoridae) (1).

Larvae of *L. mali* are polyphagous, consuming not only the sporocarps and mushroom primordia, but also the vegetative inoculum, mycelia, and compost (2). *Megaselia halterata* larvae, on the other hand, are oligophagous, feeding only at the growing hyphal tips (3). Adult sciarids are vectors of pathogenic nematodes (4). Adult phorids not only are vectors for mites (5), bacteria (6) and fungal pathogens (7), but also are a nuisance pest to both mushroom farm workers and the public.

Sciarids will infest the crop before the vegetative inoculum is placed into the pasteurized compost (8) and phorids migrate into the mushroom growing rooms, after the mycelium begins to colonize the compost (9). Populations, established during the vegetative stage of crop production, may significantly reduce mushroom yield (2, 10). In commercial mushroom cultivation, flies are only one factor contributing to the total yield. This paper discusses the contribution of phorids and sciarids to mushroom yield at commercial mushroom farms in southeastern Pennsylvania.

[1]Paper no. 6721 in the journal series of Pennsylvania Agricultural Experiment Station. Received for publication March 7, 1984; Reviewed; Accepted May 15, 1984.
[2]Department of Entomology.
[3]Department of Plant Pathology.

MATERIALS AND METHODS

Adult fly sampling

Adult sciarids and phorids were monitored for 67 mushroom crops in commercial growing room during a two-year period, August 1979 to August 1981, near Kennett Square (Chester County), Pennsylvania. A Pennsylvania Mushroom Fly Monitor, a light monitor which used a 15-watt blacklight fluorescent tube (F15T5/BL), mounted to a board (0.45 m by 0.45 m) and flanked with single strip (0.13 m by 0.45 m) of freezer paper sprayed with Tree Tanglefoot® (11), was used to sample adult fly populations. Each monitor was positioned 1.6 m from the floor, on the upper wharf end wall (9). Catch papers were removed daily and adult insects of both species counted. When the catch of either species was > 100 insects, the strip of paper was divided into 90 subunits and 18 were randomly selected, counted and the sum multiplied by five.

Mushroom Yield

Mushrooms were harvested by the cooperators and the yield information, computed as kilograms per m^2 of producing surface for each break, was obtained from farm records, and accumulated as total yield for the crop.

Statistical Analysis

Data were analyzed by regression analysis programs of the Statistical Analysis System (SAS Institute, Inc., Cary, NC). A regression analysis was made on the log of the number of either phorids or sciarids trapped during spawn run against the total five-break yield for each crop. A second regression analysis was performed on the crops for which each farm manager was responsible.

Since the mushroom farms studied were managed by eight different managers, each farm was assumed to have a unique management system. Categorical variables, P1, P2, P3, P4, P5, P6, and P7, were assigned to farm managers, 142, 266, 314, 512, 630, 700, and 743, respectively. Farm manager 801 became the excluded or reference category. Each categorical variable represented the presence or absence of a particular farm manager responsible for crop production. A multiple regression analysis including the log transformation of fly counts and the management practice variables was made against the total five-break yield for each crop.

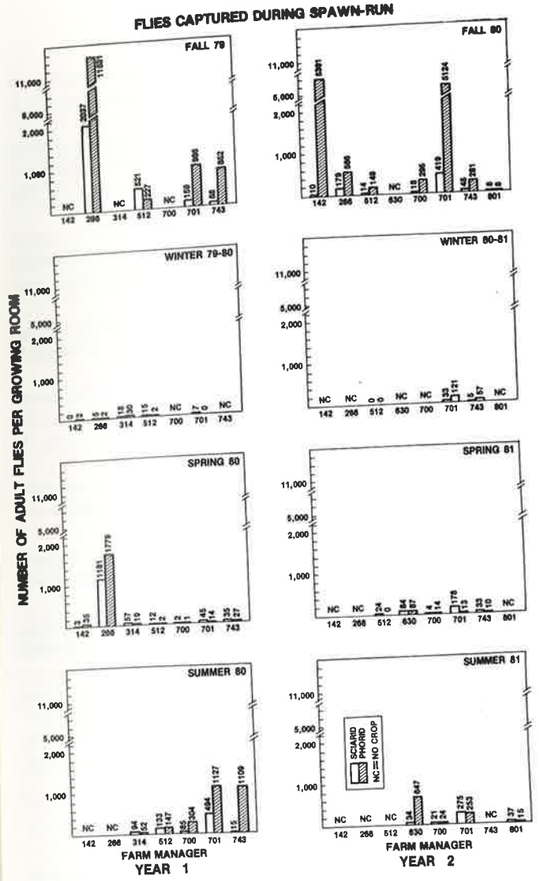


FIGURE 1. Mean numbers of phorids or sciarids captured per house (often more than one house was monitored per farm) by Pennsylvania Mushroom Fly Monitor trapped during spawn run in commercial mushroom growing rooms during the period August 1979-August 1981.

RESULTS

Variations in Fly Populations

The numbers of phorid and sciarid flies invading mushroom growing room before and during spawn run varied from farm-to-farm for each crop throughout the two-year period (Figure 1). Almost without exception all mushroom crops experienced fly pressure. Population levels of both species varied considerably among farms. Generally, the lowest ingressing populations were associated with the winter and spring mushroom crops, with the highest populations in the fall. Even with the low numbers of insects during the winter and spring crops, the recommended pesticide action level of 1 to 2 sciarids per day (12) was exceeded in most cases.

From Year-1 to Year-2, the ingressing populations were generally less. An increased awareness of fly problems by mushroom producers and the resultant measures taken to reduce fly invasion or a reduced background population of insects may account for the change from one year to the next.

TABLE 1

Mushroom yield as predicted by monitor catches of phorid and sciarid flies during spawn run.

Farm Manager	Flies	Intercept[a]	Slope[b]	R^{2c}
All Farm Managers	Phorid (P)	20.31	− 1.86	.21***
	Sciarid (S)	21.00	− 2.83	.24***
	Both (P + S)	21.19	− 2.05	.19***
266	P	10.64	− 0.63	.17
	S	11.67	− 1.17	.37
	P + S	11.13	− 0.73	.28
512	P	22.46	− 2.54	.51***
	S	23.53	− 2.98	.45***
	P + S	23.83	− 2.69	.49***
700	P	15.97	− 0.93	.07
	S	19.27	− 4.35	.53**
	P + S	16.65	− 1.22	.10
743	P	22.46	− 1.56	.32***
	S	22.20	− 1.95	.25**
	P + S	24.02	− 2.05	.36***

[a]Yield expressed in kilograms per square meter of growing surface.
[b]Fly counts transformed to $\log_{10}(x+1)$.
[c]**Indicates significance at 5% level; ***Indicates significance at 1% level.

Predictability of Mushroom Yield Based on Monitor Catches

Flies did not account for as much yield variance as had been anticipated. The total phorids captured during spawn run accounted for 21% of the yield variance while sciarids contributed 24% (Table 1). The combined effect of both species failed to account for any additional variance (R^2 = 19%). Yield prediction based on monitor catches was increased when selected farm managers, 512 and 743, were the exclusive source of data (Table 1). However, yields for farm managers 266 and 700 were not significantly correlated to the fly population during spawn run. These correlations suggested that though flies are significant problems to commercial mushroom production, there are other factors contributing more significantly to production.

Differences among farm managers' cultural practices were believed to account for a portion of the unexplained variance. When the categorial variable, farm manager, was included in the model with the fly counts, about 67% of the yield variance was explained. These models are presented as equations 1, 2, and 3.

(1) Phorids: R^2 = 67%

$$\text{Yield (Kg/m}^2) = 14.36 - 1.42\ \text{Log}_{10}(\text{Phorid} + 1) + 7.76P_1 - 1.56P_2 + 6.20P_3 + 6.84P_4 + 2.39P_5 + 2.44P_6 + 8.25P_7$$

(2) Sciarids: R^2 = 68%

$$\text{Yield (Kg/m}^2) = 14.99 - 2.10\ \text{Log}_{10}(\text{Sciarid} + 1) + 5.32P_1 - 1.22P_2 + 6.54P_3 + 7.37P_4 + 2.15P_5 + 1.76P_6 + 7.23P_7$$

(3) Phorids + Sciarids: $R^2 = 67\%$

$$\text{Yield (Kg/m}^2) = 14.99 - 1.61 \text{ Log}_{10} (\text{Total} + 1) + 7.52P_1 - 1.42P_2 + 6.35P_3 + 7.08P_4 + 2.49P_5 + 2.54P_6 + 7.86P_7$$

DISCUSSION

Trapping results suggest that the winter mushroom crop is subjected to the lowest insect pressure. During winter in Pennsylvania, insect migration between houses, blocks or farms is probably slowed by cold ambient temperatures. Rinker*et al.* (13) reported that both sciarids and phorids were trapped during spawn run when the outside air temperature was below 10°C. They suggested that migration may be occurring between houses in the more protected loft or breezeway sections of a growing room.

The predominance of one species on any one farm suggests that a farmer's management practices or the particular locale may favor one species over another. Farmers who traditionally fail to grow a summer crop frequently delay the recommended sanitation treatment, i.e., steaming spent compost and removing it from growing rooms. Such farms have a predominance of phorid flies during the fall crop. Growers included in the data base followed strict sanitary procedures with regard to removing compost from rooms where picking had been completed. However, neighboring farms with inadequate sanitation may be the sources of the elevated fall populations.

Lycoriella mali and *M. halterata* have been implicated in the past as major agents in mushroom yield reduction (1, 14). During our study, fly populations established during spawn run accounted for only 24% in the yield variation among growers. By including management practices as a variable into the fly infestation and yield model, 67% of the yield variation was explained. Mushroom cultivation is a complex science involving numerous inputs in addition to cultural and environmental ones operating throughout the pre-cropping and cropping phases of production. These may include the effectiveness of management and staff, the basic growing ingredients (compost or vegetative inoculum), the weather and incidence of diseases and pests (15, 16, 17).

Our study indicates that in commercial mushroom production the overall pest influence is small, but significant. Further investigations will be necessary to elucidate under commercial mushroom production the myriad of factors acting together that contribute significantly to mushroom yield.

ACKNOWLEDGMENTS

The financial support of the Pennsylvania Cooperative Extension Service, American Mushroom Institute, Canadian Mushroom Grower's Association and the Stroud Institute for Water Research is gratefully acknowledged. We thank Marie Ebbecke, Joseph Murphy, Albert Nakpil, Janet Robertson, and Jill Yeatman for their technical assistance in conducting this study.

REFERENCES

1. Cantelo, W. 1979. *Lycoriella mali:* Control in mushroom compost by incorporation of insecticides into compost. J. Econ. Entomol. 72:703-705.
2. Kielbasa, R., and R. Snetsinger. 1980. Life history of a sciarid fly, *Lycoriella mali*, and its injury threshold on the commercial mushroom. Bulletin 833, College of Agriculture, The Pennsylvania State University, University Park.
3. Hussey, N.W., W.H. Read, and J.J. Hesling. 1969. The pests of protected cultivation: biology and control of glasshouse and mushroom pests. American Elsevier Publishing Company, Inc., New York.
4. Rinker, D.L., and J. Bloom. 1982. Spread of free-living nematodes by sciarid flies in mushroom houses. J. Nematol. 14:599-601.
5. Norton, R.A., and G.S. Ide. 1974. *Scutacarus baculitarsus agaricus* n. subsp. (Acarina: Scutacaridae) from commercial mushroom houses with notes on phoretic behavior. J. Kans. Entomol. Soc. 44:527-534.
6. Gandy, D.G. 1968. A technique for screening bacteria causing brown blotch of cultivated mushrooms. Glasshouse Crops Res. Inst. Annu. Rep. 1967. pp. 150-154.
7. White, P.F. 1981. Spread of mushroom disease *Verticillium fungicola* by *Megaselia halterata* (Diptera: Phoridae). Prot. Ecol. 3:17-24.
8. Rinker, D.L., R. Tetrault, R.J. Snetsinger, P.J. Wuest, R.J. Finley, and D.J. Royse. 1984. Monitoring: a necessity in crop management decisions. Mushroom News 32(4):6-12.
9. Rinker, D.L. 1982. A phorid pest, *Megaselia halterata* (Wood), of the commercial mushroom: biology, damage potential, relationship to an endoparasitic nematode and techniques for control. Ph.D. thesis, The Pennsylvania State University, University Park.
10. Rinker, D.L., and R. Snetsinger. 1984. Damage threshold to commercial mushroom by mushroom-infesting phorid (Diptera: Phoridae). J. Econ. Entomol. (in press).
11. Wetzel, H.A. 1981. An introduction to integrated pest management for mushroom production. Master's thesis, The Pennsylvania State University, University Park.
12. Tetrault, R. 1983. Mushroom Grower's Guide to Fly Control. Cooperative Extension Service, The Pennsylvania State University, University Park.
13. Rinker, D.L., R.J. Finley, P.J. Wuest, R. Snetsinger, R. Tetrault, and D.J. Royse. 1983. Insect flight activity. Mushroom News 31 (3): 20.
14. Robinson, W. 1977. Phorids associated with cultivated mushrooms in the eastern United States. Proc. Entomol. Soc. Wash. 79:452-462.
15. Flegg, P.B. 1970. Cultural and environmental factors affecting the control of cropping of the cultivated mushroom. NASS Q Rev. 90:61-73.
16. Tschierpe, H.J. 1973. Environmental factors and mushroom growing: Part I. Mushroom J. 1:31-45.
17. Tschierpe, H.J. 1973. Environmental factors and mushroom growing: Part II. Mushroom J. 2:77-94.

Proceedings of the Pennsylvania Academy of Science 58: 73-78. 1984

TRENDS IN THE DISTRIBUTION OF BLACK AND WHITE POPULATIONS DURING THE SEVENTIES[1]

GEORGE A. SCHNELL

Department of Geography
The College at New Paltz
State University of New York
New Paltz, New York 12561

ABSTRACT

Black and white population trends in the United States from 1970 to 1980 are described and discussed at several levels—nation, region, state, metropolitan area, and city. Findings suggest that, although distributions show signs of some convergence in behavior between the white majority and our most numerous minority, blacks remain not only an urban population but mainly metropolitan in residence.

Among other objectives, the study reveals places at a variety of political levels (that is, particular states, metropolitan areas, and cities) in which the black-white trends in distribution are distinctive and, thus, warrant further in-depth study.

INTRODUCTION

In a recent Census Bureau study of our black inhabitants, the authors state that data "show improvement in income levels of black married-couple families, educational attainment and school enrollment, and home ownership among blacks during the 1970s. But the data also reveal setbacks influenced by high black unemployment, sharply increased divorce and separation rates, and a rise in family households maintained by black females"(1). Another very recent study concludes, in part, that "a few black Americans" make it "while the majority remain at the bottom of the ladder"(2).

Thus, results are mixed on the status of black Americans in the 1980s. Given the importance of residential location, housing, and associated indicators of social and economic status, this study examines, in a preliminary way, the degree to which black and white distributions relate geographically and the association between black and white population trends over the 1970-decade for Census regions, states, urban-rural residence by states, SMSAs, and selected cities (3). The assumption is that if blacks are in fact joining the American mainstream in greater numbers, their residential geography during the 1970s should show indications of convergence with that of the white majority.

[1] Received for publication March 19, 1984; reviewed; accepted April 5, 1984.

THE NATION AND CENSUS REGIONS

Table 1 describes black and white populations in 1970, 1980, and the trends over that decade by urban and rural residence for the nation and the four Census regions. The 1970-1980 comparison is quite straight forward. Among blacks, although all regions recorded gains of significance, the South remained dominant with over half the nation's black population in residence in both years, whereas the West was the only region in which the black share of inhabitants rose (from 7.5 to 8.5 percent). Whites remained less concentrated in any single region, as the percentages of the total declined in the Northeast and North Central, but the white population number declined (– 4.4 percent) in only the Northeast. As was the case with blacks, white numerical gains were greatest in the South, as was the percentage increase.

Urban population trends by race were quite disparate (Table 1). Urban black population accounted for 81 percent of all blacks in 1970 and 85 percent in 1980. Increasing in all four regions, urban black growth was led by a gain approaching 2.4 million in the South, and a percentage increase of almost 35 percent in the West. White urban trends were downward in the Northeast and North Central regions and significantly upward in the South and West; not surprising, given the Snow Belt-Sun Belt migrational stream of late. The rural comparison is quite distinctive among the facts presented on Table 1, as the black population recorded losses in three of four regions (only the West showing a gain, and that a modest 2,000 inhabitants), whereas the white rural trend was all positive, led by an increase of over 2.8 million in the South. White gains in the rural South stand in stark contrast to black declines in that region of the country—the black decline in the rural South amounted to 388 thousand and accounted for 96 percent of the rural change in America, whereas the white increase of 2.8 million in the rural South produced over half of the national trend. At the regional level, blacks have become more urban but the whites registered urban declines in the Northeast and North Central regions, despite almost equal gains exceeding 5 million in urban and rural white populations nationally.

As Table 2 illustrates, the black-white contrast is vast when metropolitan-nonmetropolitan populations are compared at national and regional levels. Indeed, the data indicate that, in addition to being an urban population, America's blacks are primarily

TABLE 1

Black and White Urban and Rural Population Trends, 1970-1980. Census Regions (in thousands)

	Black Population				White Population			
	Total	% of U.S.	Urban	% of Region	Total	% of U.S.	Urban	% of Region
				1970				
Northeast	4,342	19.1	4,215	97.1	44,266	24.9	34,883	78.8
North Central	4,571	20.2	4,447	97.3	51,641	29.1	35,773	69.3
South	12,064	53.2	8,064	66.8	50,327	28.3	32,212	64.0
West	1,695	7.5	1,641	96.8	31,377	17.7	25,905	82.6
United States	22,672	100.0	18,367	81.0	177,611	100.0	128,773	72.5
				1980				
Northeast	4,848	18.3	4,732	97.6	42,326	22.5	32,302	76.3
North Central	5,337	20.1	5,220	97.8	52,195	27.7	35,168	67.4
South	14,048	53.0	10,436	74.3	58,960	31.3	38,037	64.5
West	2,262	8.5	2,206	97.5	34,890	18.5	28,814	82.6
United States	26,495	100.0	22,594	85.3	188,371	100.0	134,321	71.3
				Population Change, 1970-1980				
	Black Population				White Population			
	Total		Urban		Rural	Total	Urban	Rural
	No.	%	No.	%	No. %	No. %	No. %	No. %
Northeast	506	11.7	517	12.3	−11 −8.7	−1,940 −4.4	−2,581 −7.4	641 6.8
North Central	766	16.8	773	17.4	−7 −5.6	554 1.1	−605 −1.7	1,159 7.3
South	1,984	16.4	2,372	29.4	−388 −9.7	8,633 17.2	5,825 18.1	2,808 15.5
West	567	33.5	565	34.4	2 3.8	3,513 11.2	2,909 11.2	604 11.0
United States	3,823	16.9	4,227	23.0	−404 −9.4	10,760 6.1	5,548 4.3	5,212 10.7

Source: Computed by author with data from the U.S. Bureau of the Census.

TABLE 2

Black and White Metropolitan and Nonmetropolitan Population Trends, 1970-1980. Census Regions (in thousands)

	Black Population				White Population			
	SMSA Population				*SMSA Population*			
	Total		Central City		Total		Central City	
	No.	as % of All Blacks	No.	as % of Blacks in SMSAs	No.	as % of All Whites	No.	as % of Whites in SMSAs
				1970				
Northeast	4,178	96.2	3,368	80.6	35,397	79.9	13,611	38.5
North Central	4,292	93.9	3,708	86.4	33,136	64.2	13,219	39.9
South	6,739	55.9	4,954	73.5	28,232	56.1	12,877	45.6
West	1,617	95.4	1,118	69.1	24,490	78.1	9,743	39.8
United States	16,826	74.2	13,148	78.1	121,255	68.3	49,450	40.8
				1980				
Northeast	4,757	98.1	3,618	76.1	35,098	82.9	10,921	31.1
North Central	5,108	95.7	4,132	80.9	35,534	68.1	11,537	32.5
South	9,416	67.0	6,188	65.7	39,093	66.3	13,952	35.7
West	2,197	97.1	1,359	61.9	28,340	81.2	10,537	37.2
United States	21,478	81.1	15,297	71.2	138,065	73.3	46,947	34.0

Population Change, 1970-1980

	Black Population								White Population							
	SMSA Population						Non-SMSA		SMSA Population						Non-SMSA	
	Total		Central City		Other				Total		Central City		Other			
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Northeast	579	13.9	250	7.4	329	40.6	−73	−44.5	−299	−0.8	−2,690	−19.8	2,391	11.0	−1,640	−18.5
North Central	816	19.1	424	11.4	392	67.1	50	17.9	2,398	7.2	−1,682	−12.7	4,080	20.5	−1,844	−10.0
South	2,677	39.7	1,234	24.9	1,443	80.8	−693	−13.0	10,861	38.5	1,075	8.3	9,786	63.7	−2,227	−10.1
West	580	35.9	241	21.6	339	67.9	13	16.7	3,850	15.7	794	8.1	3,056	20.7	−337	−4.9
United States	4,652	27.6	2,149	16.3	2,503	68.1	−829	−14.2	16,810	13.9	−2,503	−5.1	19,313	26.9	−6,048	−10.7

Source: Computed by author with data from the U.S. Bureau of the Census.

FIGURE 1. Maps of distributional patterns and trends by race on a state basis.

resident in the central cities of the nation's metropolitan areas. As the white central city population declined by more than 2.5 million from 1970 to 1980, the black central city population increased by more than 2.1 million so that, by 1980, the white-black central city ratio was just 3:1 (compared to a 7:1 ratio of all whites to all blacks in that year—188.4 million to about 26.5 million). In all, the only declines among the metropolitan populations shown in Table 2 are for the Northeast (total and central city whites) and the North Central (central city whites). SMSA populations for both races increased by large relative gains in South and West, and black gains were significant in Northeast and North Central regions. SMSA residence outside central cities increased for black and white inhabitants, but the black gains were much more impressive given their smaller base populations in 1970. Non-SMSA populations declined among whites in all four regions and declines were recorded for blacks as well in the Northeast and South (4).

THE STATES

National and regional trends are interesting but the area of each is vast and quite diverse demographically. In order to portray variations within regions, distributional patterns and trends by race on a state basis are mapped in Figure 1. In general, the black and white distributions are similar insofar as the populous northeastern states, those in the middle west, as well as California, Texas, and Florida have large black and white populations. The major difference is the concentration of blacks in the southern states. The Mountain states represent the other extreme—sparse populations—as the Dakotas, Idaho, Montana, Utah, and Wyoming reported fewer than 20,000 blacks in both years. Northern New England (Maine, New Hampshire, and Vermont) and Alaska and Hawaii joined the Mountain states in the under-20,000 category in both years. The same states were general-

TABLE 3

*Black and White Population Trends, 1970-1980, Selected *SMSAs (in Thousands)*

	Black SMSA Population						White SMSA Population					
	1970		1980		1970-1980		1970		1980		1970-1980	
	No.	% in Cent. City	No.	% in Cent. City	No.	% Change	No.	% in Cent. City	No.	% in Cent. City	No.	% Change
New York	1,883	88.5	2,069	85.4	186	9.9	9,449	63.8	7,646	56.2	−1,803	−19.1
Chicago	1,231	89.6	1,428	83.8	197	16.0	5,673	38.9	5,209	28.6	−464	−8.2
Detroit	757	87.2	887	85.6	130	17.2	3,420	24.5	3,074	13.5	−346	−10.1
Philadelphia	844	77.5	884	72.3	40	4.7	3,945	32.4	3,703	26.5	−242	−6.1
L.A.—Long Beach	763	68.5	944	57.8	181	23.7	6,006	41.7	5,074	41.1	−932	−15.5
Washington, D.C.	704	76.4	837	53.5	133	18.9	2,125	9.8	1,996	8.6	−129	−6.1
Houston	384	82.6	520	84.6	136	35.4	1,586	57.0	2,099	46.6	513	32.3
Baltimore	490	85.7	557	77.4	67	13.7	1,569	30.6	1,582	21.8	13	0.8
New Orleans	324	82.4	387	79.6	63	19.4	718	45.0	774	30.6	56	7.8
Memphis	289	84.1	346	89.0	57	19.7	479	79.1	473	70.6	−6	−1.3
10 SMSAs	7,669	83.3	8,859	77.4	1,190	15.5	34,970	42.4	31,630	35.8	−3,340	−9.6
United States	16,826	78.1	21,474	71.3	4,648	27.6	121,256	40.8	138,044	31.9	16,788	13.8

Source: Computed by author with data from the U.S. Bureau of the Census.
*SMSAs selected contained the ten leading central cities on the basis of black population in 1980.

TABLE 4

*Black and White Population Trends, 1970-1980, Selected *Cities and States (in Thousands)*

	Black Population						White Population					
	1970		1980		Change		1970		1980		Change	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
New York	2,169	100.0	2,402	100.0	233	10.7	15,791	100.0	13,961	100.0	−1,830	−11.6
New York	1,668	76.9	1,784	74.3	116	7.0	6,024	38.1	4,294	30.8	−1,730	−28.7
Illinois	1,426	100.0	1,675	100.0	249	17.5	9,600	100.0	9,233	100.0	−367	−3.8
Chicago	1,103	77.3	1,197	71.5	94	8.5	2,208	23.0	1,490	16.1	−718	−32.5
Michigan	991	100.0	1,199	100.0	208	21.0	7,833	100.0	7,872	100.0	39	0.5
Detroit	660	66.6	759	63.3	99	15.0	839	10.7	414	5.3	−425	−50.7
Pennsylvania	1,017	100.0	1,048	100.0	31	3.0	10,738	100.0	10,652	100.0	−86	−0.8
Philadelphia	654	64.3	639	61.0	−15	−2.3	1,279	11.9	983	9.2	−296	−23.1
California	1,400	100.0	1,819	100.0	419	29.9	17,761	100.0	18,031	100.0	270	1.5
Los Angeles	504	36.0	505	27.8	1	0.2	2,173	12.2	1,817	10.1	−356	−16.4
Washington, D.C.	538	100.0	449	100.0	−89	−16.5	209	100.0	172	100.0	−37	−17.7
Texas	1,399	100.0	1,710	100.0	311	22.2	9,697	100.0	11,198	100.0	1,501	15.5
Houston	317	22.7	440	25.7	123	38.8	904	9.3	978	8.7	74	8.2
Maryland	699	100.0	958	100.0	259	37.1	3,193	100.0	3,159	100.0	−34	−1.1
Baltimore	420	60.1	431	45.0	11	2.6	480	15.0	345	10.9	−135	−28.1
Louisiana	1,087	100.0	1,237	100.0	150	13.8	2,541	100.0	2,912	100.0	371	14.6
New Orleans	267	24.6	308	24.9	41	15.4	323	12.7	237	8.1	−86	−26.6
Tennessee	621	100.0	726	100.0	105	16.9	3,284	100.0	3,835	100.0	551	16.8
Memphis	243	39.1	308	42.4	65	26.7	379	11.5	334	8.7	−45	−11.9
9 States and Wash. D.C.	11,347	50.0	13,233	49.9	1,876	16.5	80,647	45.4	81,025	43.0	378	0.5
10 Cities	6,374	28.1	6,820	25.7	446	7.0	14,818	8.3	11,064	5.9	−3,754	−25.3
United States	22,672	100.0	26,488	100.0	3,816	16.8	177,612	100.0	188,370	100.0	10,758	6.1

Source: Computed by author with data from the U.S. Bureau of the Census.
*Cities selected were the ten leading black population centers in 1980 among all U.S. cities.

ly least populated by whites too, although only Alaska, Hawaii, Nevada, Vermont, and Wyoming were in the lowest class (less than 500,000 white inhabitants) in 1970. In 1980, this category declined, including only Alaska, Hawaii, and Wyoming (5).

Turning to population trends, black growth reported as a percentage was concentrated mainly in the northern sections of the country, as states in New England, the upper middle west, and the Mountain divisions accounted for most of the states in the highest class, more than 30 percent. White gains exceeding 30 percent were found in Alaska, Arizona, Florida, Nevada, Utah, and Wyoming. Black losses were restricted to Montana, Washington, D.C., and West Virginia, whereas white declines were reported widely in states in the New England and Middle Atlantic division, as well as in Illinois, Maryland, and the District of Columbia. Indeed, the area of white decline is shown as a series of contiguous states extending from southern New England westward to Ohio and southward to Maryland and Washington, D.C.

SMSAs AND CITIES

Table 3 lists for the ten SMSAs with the leading central cities in terms of black population in 1980, the black and white numbers and their trends from 1970 to 1980. In each instance, the black SMSA population increased; however, in all but the Houston and Memphis SMSAs, the black central city population as a percentage of black population in the SMSA diminished. The Houston SMSA's increase (of some 136 thousand blacks) stood alone in relative gain among the ten SMSAs at over 35 percent. By contrast, only three of the ten metropolitan areas shown on Table 3 recorded white gains (Houston, Baltimore, and New Orleans) and, except for Houston's, they were modest. Taken together, these SMSAs had very different experiences for blacks and whites—whereas just 35.8 percent of the whites resided in central cities in 1980 (the figure was 31.9 percent nationally) more than 77 percent of the blacks lived in central cities (the U.S. figure was 71.3 percent). Moreover, the white population declined in these ten SMSAs by about 10 percent while the black number grew by more than 15 percent. The fact that blacks are less concentrated in the largest SMSAs is suggested by the comparison of populations in the ten SMSAs in 1970 and 1980 with the national totals for metropolitan blacks—the number fell from about 46 percent of all metropolitan blacks residing in the ten leading SMSAs in 1970 to about 41 percent in 1980, despite an increase in the black population living in the ten SMSAs of almost 1.2 million.

Although relative changes in small populations are more likely to be dramatic than those in large populations, it is obvious that absolute trends of import occur almost invariably in great populations, despite the often less-than-exciting percentage gains or losses. That is not to say that, collectively, changes among the myriad small populations resident in sparsely populated civil divisions do not become significant in the nation's trends. However, this section deals with the ten leading urban centers of black population in 1980, and lists numbers of blacks and whites for 1970, 1980, and the trends for each (6). For comparison, data for the states in which each of the ten cities is located (except for Washington, D.C.) are shown as well.

It is noteworthy that for cities shown on Table 4, only Philadelphia and Washington, D.C. recorded black declines, as all other cities and states shown registered gains. The Commonwealth of Pennsylvania and the cities of Los Angeles and Baltimore were the only places which recorded slight increases in their respective black populations, as all other units shown reported growth of absolute or relative significance. The trend toward deconcentration among blacks mentioned earlier, is reiterated by the collective change for both the states and the leading cities—although numerical gains were reported for states and cities, the percentage of blacks resident in these units declined, albeit slightly, and the percentage growth among the ten cities was just 7 percent, less than half the increase in the states and Washington, D.C. By contrast, only the city of Houston reported white increases. The collective figures amount to a loss approaching 4 million whites in these ten cities, a decline of more than 25 percent (Table 4). Thus, the fact remains that America's blacks continue essentially to reside in cities within metropolitan areas, while for whites that defintely is not the case.

CONCLUDING REMARKS

Table 5 summarizes the geographic assocation between black and white trends by state for a variety of residential types (7). For total state black and white populations as well as trends by race for urban, SMSA, central city, and non-SMSA black populations regressed on white, the coefficients are positive and sufficiently high to suggest convergence in black and white trends, especially in SMSAs and central cities. Rural populations are illustrative of a slightly negative geographic relationship, as black populations registered rural declines in most states compared to white gains in almost all. The non-central city black and white populations of SMSAs related in a modest, negative manner too, as all such populations recorded increases over the 1970 decade but white gains of note often occurred in places where black increases were slight, and vice versa. The rural differences by race described above seem to be especially important—given that the current growth in rural and less-urban places at the expense of urban/metropolitan places is descriptive primarily of white population dynamics, since black rural numbers are in decline in the majority of states.

TABLE 5

Coefficients of Correlation, Black and White Population Trends, 1970-1980 By State

Population	Coefficient	Population	Coefficient
Total	0.57	SMSA	0.74
Urban	0.52	Central City	0.78
Rural	−0.20	Other	−0.09
		Non-SMSA	0.67

Source: Computed by author from data from The U.S. Bureau of the Census.

A second phase of this study will be undertaken in which a variety of statistical-geographical units will be examined in greater detail and selected physical, demographic, and socioeconomic factors will be explored as possible influences in the distributional evolution of black and white Americans. The units selected from among the nation's states, cities, counties, and SMSAs will represent noteworthy gains or losses in black or white populations, or those in which black-white trends differ significantly from national norms. The point is that blacks, if becoming truly assimilated, should behave in ways which differ little from the white majority in residential preferences and, ultimately, in selection of residential sites.

REFERENCES AND NOTES

1. Matney, W. C. and Johnson, D. L. 1983. America's Black Population: 1970 to 1982. *Special Publication*, U.S. Bureau of the Census, PIO/POP-83-1:1.
2. Reid, J. 1982. Black America in the 1980s. *Population Bulletin.* 37: 3-4.
3. Data used throughout are drawn from the U.S. Bureau of the Census.
4. A change in definition for SMSAs contributed to an increase in the number of metropolitan areas from 287 in 1970 to 323 in 1980. Therefore, the discussion of trends at national and regional levels for SMSAs is likely to suffer from comparisons of uncommon base populations as well as the dilution of the concept of SMSA by the new definition. For a review of the new definition and a list of new SMSAs, see Executive Ofice of the President, Office of Management and Budget. 1981. *Information Office Press Release,* OMB-81-5.
5. The small change in black distribution from 1970 to 1980 is

confirmed, at least among states with 100,000 or more black inhabitants, by the high, positive coefficient of correlation describing the association (0.99). Schnell, G. A. and Monmonier, M. S. 1983. *The Study of Population: Elements, Patterns, Processes.* Charles E. Merrill, Columbus, Ohio, 294-295.

6. As the method of measuring importance varies, the list of cities which emerge as the leading black population centers changes somewhat too. For example, Reid, cited in note 2 above, used central cities of at least 100,000 blacks *with black majorities*. These factors yielded the following list: Gary, Washington, D.C., Atlanta, Detroit, Newark, Birmingham, New Orleans, Baltimore and Richmond. The same criteria produced just one such city in 1960—Washington, D.C. See Reid, J. 1982. p. 7.
7. In order to dampen the potential for great percentage changes which often occur in small base populations, the product moment correlation coefficients listed in Table 5 were calculated only for states having a minimum of 20,000 blacks in the specific residential category (that is, central cities, SMSAs, rural, and so forth).
8. Brown, D. L. and Wardwell, J. M. (eds.) 1980. *New Directions in Urban-Rural Migration: the Population Turnaround in Rural America.* Academic Press, New York.

Proceedings of the Pennsylvania Academy of Science 58: 79-83. 1984

MAPS IN *THE NEW YORK TIMES*, 1860-1980: A STUDY IN THE HISTORY OF JOURNALISTIC CARTOGRAPHY[1]

MARK STEPHEN MONMONIER
Department of Geography
Syracuse University
Syracuse, New York 13210

ABSTRACT

As photoengraving replaced woodcut engraving in the late nineteenth century *The New York Times* increased its use of maps to illustrate news stories and feature articles. Map use increased substantially from an average of less than one map-illustrated article per issue in 1930 to over three mapped articles per issue in 1940, principally because of the addition of a daily weather map in 1934 and increased coverage of events leading to American involvement in the Second World War. Another increase, to an average of nearly five map-illustrated articles per issue, occurred in 1960 and reflected an increased investment in science reporting, recreation and travel features, and articles on neighborhoods and the environment. The Sunday edition carries about three times as many maps as the average weekday edition. Most maps are a single column wide, and less than one map in seven now appears on the front page or the first page of an interior section. In recent years maps in *The Times* have addressed national and local themes more frequently than global or foreign themes, and large- and intermediate-scale maps have become proportionately more common.

INTRODUCTION

The present study is an empirical examination of change in the use and subject matter of maps in newspapers. It examines a single journal, *The New York Times*, widely regarded as the nation's preeminent daily newspaper (1). Emphasis is on the frequency with which maps appear and the types of story for which maps are used. The prominence of maps in the paper is also examined to address the notion that maps might be used as much for visual appeal as for communication.

The area to which this paper contributes might be called "mass cartography," to borrow the adjective from "mass media." Mass cartography can be defined to include such common, widely available cartographic products as the urban street map and the road map, as well as tourist maps, advertising maps, and maps in newspapers, in magazines, and on television.

This latter group, comprising maps actually distributed through the mass media, has been neglected by cartographic scholars. The five-volume *Bibliography of Cartography* produced by the Library of Congress and covering the period through the early 1970s, lists but one study of maps in newspapers, Walter Ristow's paper on "Journalistic Cartography," published in 1957 (2). Ristow was concerned with map design and focused on the cartographic coverage of the Second World War and the "Cold War" that followed. He accorded daily newspapers much less attention than more carefully prepared and more elegantly printed weekly magazines such as *Fortune, Holiday, Life, Time,* and *Newsweek*. Among the six newspapers Ristow mentioned by name, *The New York Times* received the most enthusiastic endorsement for its coverage of the war. Other, more recent contributions to mass cartography, which suggest a renewed interest in journalistic cartography, include Leimer's study of personnel and graphic arts limitations on the cartographic efforts of newspapers (3) and Chappell's investigation of reports by American weekly news magazines on the 1982 Falkland Islands war between Britain and Argentina (4).

DATA

Data for this study were collected from microfilm copies of *The Times* (5). All daily editions were examined for January and July at a ten-year interval beginning in 1860 and continuing through 1980; the sample thus attempts to represent the complete history of *The Times* since its founding in 1851 (6). Advertising maps were excluded, as were floor plans of new homes and map-like elements of decorative artwork. The data unit is the article, not the map, in order that tabulations might not be biased toward stories with multiple maps or inset maps. Where a map was associated with more than one article, the map was assigned to the more prominent article. Articles and maps were coded according to sets of tentative working categories. Comparatively rare or somewhat ambiguous categories were later merged with related groups to yield the classifications discussed in this paper (7).

RELATIVE FREQUENCY AND THEME OF ARTICLE

Since the mid-nineteenth century *The Times* has increased greatly its use of maps, as demonstrated by Figure 1. To adjust for variations from year to year in the number of such high-map-use days as Sunday, adjusted daily means were obtained for each sampled year by computing separate averages for each day of the week, summing these daily averages, and dividing by 7. The resulting graph shows a minimal use of maps in the nineteenth and early twentieth centuries. As late as 1930 the mean was less than one map per issue. A sharp rise occurred between 1930 and 1940, and

[1] Received for publication April 2, 1984; reviewed; accepted April 16, 1984.

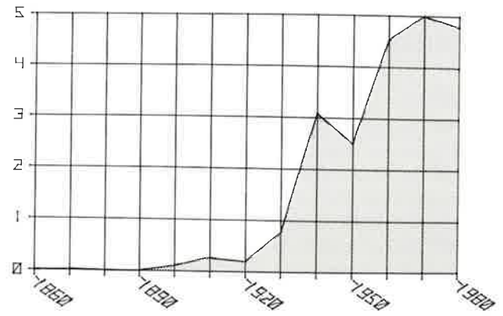


FIGURE 1. Mean number of articles with maps per issue, 1860-1980. Mean is based on sample of all issues for January and July, and is adjusted for variation in the numbers of individual weekdays for the months sampled.

a second prominent increase occurred between 1950 and 1960. Average daily frequency rose again by 1970 but dropped slightly by 1980, albeit not to the level of 1960.

The increased use of maps in *The Times* is related at least partly to technological improvements in printing, photography, and graphic illustration. In the mid-nineteenth century map making was tedious and slow. Plates for printing illustrations were engraved on a wood block by carving away the wood in areas not to be inked (8). A fuller use of maps in journalism awaited the development in the late nineteenth century of photoengraving methods adaptable to the rotary press (9). Yet, these advances in graphic arts technology were reflected more readily in magazines such as *Harper's New Monthly Magazine* than in daily newspapers (10).

In many ways *The Times's* use of maps parallels its use of other graphics. The issues for January and July 1860 had no photographs and no engraved pictures other than small type blocks about 3 cm wide. In 1870 there were more engraved blocks, and in 1880 still more engravings, including a cartoon for a clothing ad. Little improvement occurred between 1880 and 1890, but by 1900 graphs were common in the financial pages, engravings were more abundant than before, a greater variety of type was used, and simple line maps illustrating property boundaries appeared in referees' and surrogates' notices. By 1910 photographs were featured in the Sunday Pictorial Section. Only slightly more common in 1920, photographs were used frequently throughout the paper in 1930 (11).

Use of maps in *The Times* is related also to an increased involvement of the United States in world affairs, as shown by Table 1, which lists percentage frequencies, by year, for eleven categories that describe subject matter. For the period before 1940, when map use was comparatively low, few trends are apparent. Crime was the theme of the single map coded for 1870, a floor plan illustrating an article about the murder "in his own house" of a prominent broker. Maps showing British military engagements in southern Africa and China accounted for all cartographic art offered during January and July 1900. The more varied group of themes supported by maps in 1910 included flooding in Paris, exploration of Mars by telescope, 'summering' by the City's elite, auto trips through suburban Westchester county, and infant deaths in congested neighborhoods. The America's Cup yacht race dominated the maps in the 1920 sample, and the exploration of Antarctica and the development of local highways, tunnels, and parks were prominent events treated cartographically in 1930. After 1930 *The Times'* increased cartographic coverage of foreign military and political events reflected the nation's interest in the war in Europe in 1940, the Korean Conflict in 1950, and the Vietnam War in 1970. Each of these wars was covered cartographically almost daily. In 1960 and 1980, when the United States was less involved in overseas military conflict, maps in *The Times* still reflected a concern with riots, armed conflict, and geopolitical threats elsewhere in the world.

The combined percentage frequencies for military, defense, and related geopolitical themes declined from a high of 45 percent in 1950 to a low of 21 percent in 1980. The comparative peace of 1980 as well as greater affluence and increased concern for local affairs and environmental threats explain other post-1930 trends. Between 1940 and 1980 cartographic coverage increased for crime, tourism and recreation, political affairs such as redistricting and elections, and science and technology in general and environmental hazards in particular. Public works and urban development rose to prominence in 1960, when federal support for new local and national development projects became relatively abundant, but dropped somewhat thereafter. In 1970 many maps illustrated feature articles about individual neighborhoods. Articles on economic resources, development, and transportation also received enhanced cartographic support between 1950 and 1960, and accounted for 6 to 8 percent of all mapped articles sampled for 1960, 1970, and 1980. The weather, first covered by maps on a

TABLE 1

General Theme as a Percentage of All Sampled Articles with Maps, 1870 and 1900-1980

Theme of Article	1870	1900	1910	1920	1930	1940	1950	1960	1970	1980
Crime	100	0	0	0	0	1	1	1	3	4
Public works, planning, and neighborhoods	0	0	28	8	27	3	1	12	8	8
Tourism, travel, recreation, and sports	0	0	17	67	27	21	3	8	9	14
Politics, elections, and legal matters	0	0	0	0	2	1	1	5	5	7
Military conflict: battles, attacks	0	57	0	0	0	19	25	12	23	7
Defense, geopolitics, threats, and riots	0	29	17	17	13	20	20	21	11	14
Economic resources, development, and transportation	0	0	6	8	4	2	2	8	6	8
Accidents and natural disasters	0	14	6	0	7	0	4	6	5	5
Science, exploration, and environmental hazards	0	0	17	0	7	1	1	3	9	10
Education: history, demography, health, and so forth	0	0	11	0	13	1	3	3	1	2
Weather	0	0	0	0	0	33	39	22	21	21

Because of rounding, columns might not sum to 100.

TABLE 2

Proximity Category as a Percentage of All Sampled Articles with Maps, 1870 and 1900-1980

Proximity Category	1870	1900	1910	1920	1930	1940	1950	1960	1970	1980
New York City or Nearby	100	0	39	75	27	19	4	15	11	21
United States or Canada	0	0	28	0	22	40	46	38	38	44
Foreign or Whole World	0	100	28	25	51	41	50	48	51	35
Extraterrestrial	0	0	6	0	0	0	0	0	<1	0

Because of rounding, columns might not sum to 100.

TABLE 3

Scope of Coverage as a Percentage of All Sampled Articles with Maps, 1870 and 1900-1980

Scope-of-coverage Category[a]	1870	1900	1910	1920	1930	1940	1950	1960	1970	1980
Large scale	100	0	6	8	2	19	2	1	1	3
Medium scale	0	86	44	67	27	4	6	19	15	26
Small scale	0	14	44	25	71	78	92	80	83	71
Extraterrestrial	0	0	6	0	0	0	0	0	<1	0

Because of rounding, columns might not sum to 100

[a]Large scale includes floor plans (but not for model homes) and maps showing individual buildings on a block; medium scale includes maps covering a neighborhood, a borough, the city, the metropolitan area, or their equivalents; small scale includes maps of a region, a nation, or the entire world. "Scale" is not used here in its general cartographic sense as a ratio of map distance to ground distance.

daily basis in 1934, has accounted for about 20 percent of mapped stories since 1960, and accidents and natural disasters, accorded no maps in the 1940 sample, have been the theme of about 5 percent of the maps sampled for 1960 and later years (12).

The historical pattern of proximity to New York City of the area mapped, as shown in Table 2, exhibits little pattern for the years before 1940. Because the daily map locating the day's events at the World's Fair during the summer of 1940 accounted for all of the local maps in that year's sample, the right half of the top row in Table 2 can be interpreted as a rising trend in local cartographic coverage. Stabilized by the daily weather map, North American coverage has been comparatively consistent since 1940. The relative frequency of non-weather North American articles with maps doubled from 7 percent in 1940 and 1950 to about 16 percent in 1960 and 1970, with a further rise to 23 percent in 1980. Weather aside, though, foreign or global themes are more frequent than national themes, although national and local domestic themes combined are more frequent than foreign themes.

Given these trends, it is not surprising that most newspaper maps are small scale, defined for Table 3 as maps of a region, a nation, or the entire world (13). Comparatively few maps have a scale sufficiently large to show individual buildings on a block, although large-scale maps have increased their proportion in recent years, largely because of cartographic support for stories on crime and urban development. The apparent anomaly for 1940, when 19 percent of all maps were large scale, is a result of the daily map during July of buildings at the 1940 World's Fair. Yet perhaps the most prominent trend in Table 3 is the increase over the past fifty years in the proportion of intermediate-scale maps, sub-regional in scope but sufficiently detailed to cover a neighborhood or metropolitan area. Although small-scale maps still are dominant, in general maps in *The Times* have become more geographically detailed.

POSITION AND SIZE

Maps in newspapers can serve two purposes, to inform the reader and to make the paper more attractive to the buyer. An analysis of the prominence and consistency with which *The Times's* editors have positioned maps in the paper is included to illuminate further the role of the newspaper map.

Maps can illustrate both timely news stories and more carefully prepared, and often more entertaining, feature articles. Because the latter appear more abundantly in the massive Sunday edition, rich as well in advertising, maps have appeared with greater frequency on Sunday than on any other day of the week. As shown in Figure 2, this phenomenon was well established by 1930, when over half of the week's maps appeared in the Sunday edition. Between 1970 and 1980 map use had declined on weekdays but had risen on Sundays. Among the weekday editions, the Friday paper employed maps with a noticeably greater frequency, to locate forthcoming weekend recreational activities as well as newsworthy events of the previous day.

The first page is the most prominent position in a newspaper.

TABLE 4

Position of Article in the Issue, 1870 and 1900-1980

Year	Percentage of All Sampled Articles with Maps[a]			Average Number of Articles with Maps per Issue[b]		
	First Page		Not a First Page	First Page		Not a First Page
	First Section	Other Section		First Section	Other Section	
1870	100	0	0	.02	0	0
1900	14	0	86	.02	0	.10
1910	0	11	89	0	.03	.26
1920	8	0	92	.02	0	.18
1930	4	2	93	.03	.02	.68
1940	0	2	98	0	.06	2.95
1950	3	5	92	.06	.13	2.37
1960	3	6	91	.15	.29	4.18
1970	3	4	93	.15	.18	4.61
1980	1	12	87	.05	.55	4.06

[a]Because of rounding, percentages might not sum to 100 for individual years.

[b]Because these rates are not adjusted for differences in days of week, rates summed for individual years are not comparable with yearly rates portrayed in Figure 1.

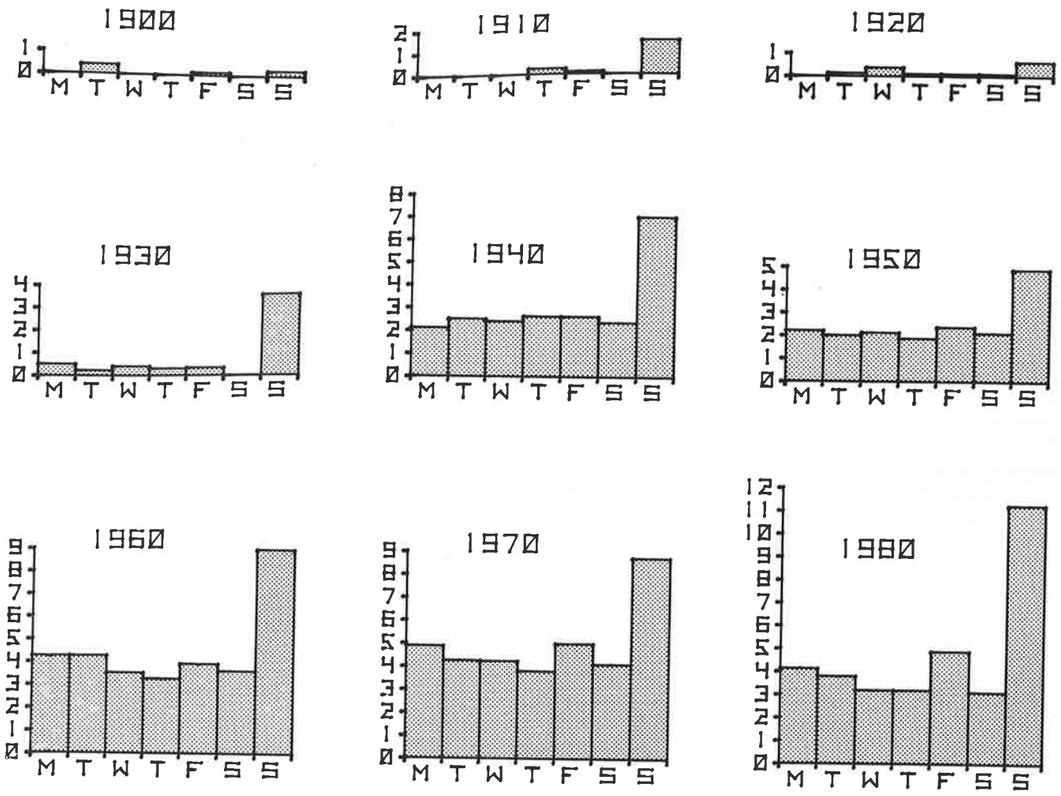


FIGURE 2. Mean number of articles per issue by day of week, 1900-1980. Mean is based on all issues for January and July.

In more recent decades, though, multiple sections have been common, and the first page of an interior section has emerged as a secondary prominent position. Table 4, which shows temporal trends in the placement of articles illustrated with maps, suggests that although its editors must be well aware of the visual attractiveness of maps, *The Times* has not unduly exploited cartographic art by placing it on the first page. Indeed, in recent decades use of maps on page one has declined. This decline, though, has been balanced by a significant increase in the use of maps on the front of interior sections—further evidence of a trend toward the increased use of maps with feature articles, for analysis or entertainment. Moreover, between 1970 and 1980, the proportion of map-illustrated articles on the first page of any section, first or interior, increased from 7 to 13 percent, to suggest an enhanced appreciation by the editors of maps and geography.

As maps in *The Times* have become more frequent and more prominent, they also have become smaller, as shown in Table 5. Between 1950 and 1980, for instance, maps four or more columns wide declined from 8 to 2 percent of all uses in the sample, whereas the proportion of single-column maps rose from 13 to 49 percent. This trend cannot be traced to a design change from eight to six columns across the page because the width of the page had declined as well (14). Table 5 also indicates that much of the growth in the use of maps between 1950 and 1960 was in small, relatively inconspicuous but nonetheless useful, single-column maps. The simple cartographic statement of geographic fact had become an accepted element in American journalism.

TABLE 5

Width in Columns of Principal Map in Article, 1870 and 1900-1980

	Percentage by Year[a]				*Mean Number of Articles per Issue*[b]				
	No. of Columns Wide				No. of Columns Wide				Usual
Year	1	2	3	4 or more	1	2	3	4 or more	Number of Columns
1870	100	0	0	0	.02	0	0	0	7
1900	0	86	0	14	0	.10	0	.02	7
1910	6	17	50	28	.02	.05	.15	.08	7
1920	0	83	8	8	0	.16	.02	.02	8
1930	0	31	31	38	0	.23	.23	.27	8
1940	14	38	41	6	.44	1.15	1.24	.19	8
1950	13	13	66	8	.32	.34	1.69	.21	8
1960	45	21	28	7	2.06	.95	1.29	.31	8
1970	54	19	24	3	2.66	.95	1.19	.13	8
1980	49	22	27	2	2.31	1.02	1.24	.10	6

[a]Because of rounding, percentages might not sum to 100 for individual years.

[b]Because these rates are not adjusted for differences in days of the week, rates summed for individual years are not comparable with yearly rates portrayed in Figure 1.

CONCLUDING REMARKS

The next decades should bring further significant change in *The Times'* use of maps, particularly as the newspaper adapts to modern technology and competition from other information vendors. The most visually striking change, perhaps, will be a shift to color graphics in response to improved lithographic printing and the standard being set by *USA Today* (15). Another challenge is electronic publishing and the instantaneous delivery of text and graphics by cable or airwave rather than their comparatively slow dissemination by paper and truck. Videotex and a home hard-copy printer might be a formidable challenge to the traditional newspaper (16).

REFERENCES AND NOTES

1. See, for example, Todd, A. 1979. *Finding Facts Fast.* Berkeley, Ten Speed Press, pp. 26-27.
2. Ristow, W. W. 1957. Journalistic Cartography. *Surveying and Mapping.* 17:369-390.
3. Leimer, J. 1982. The Influence of the Technical Constraints and Personnel Limitations on the Quality of Maps in American Newspapers. Unpublished masters thesis, Dept. of Geography, Univ. of Wisconsin—Madison.
4. Chappell, G. B. 1983. Newsweekly Magazine Maps: Coverage of the Falkland Islands Crisis in *Newsweek, Time,* and *U.S. News and World Report.* Unpublished masters thesis, Dept. of Geography, Univ. of Wisconsin—Madison.
5. Microfilm editions for the years before 1938 were those provided by Recordak Corporation, New York, N.Y. Microfilm for 1939 through mid-1966 was from University Microfilm, Ann Arbor, Michigan, and microfilm for mid-1966 through the 1980s was that supplied by the Microfilming Corporation of American, Glen Rock, N.J. (a subsidiary of *The New York Times*).
6. For a well-written, probing history of *The New York Times,* particularly its rise to prominence in the twentieth century, see Talese, G. 1969. *The Kingdom and the Power.* New York, The World Publishing Company. For more thorough treatment of *The Times'* early history, in a centennial volume commissioned by the publisher, see Berger, M. 1951. *The Story of the New York Times, 1851-1951.* New York, Simon and Schuster.
7. A graduate assistant first scanned the microfilm reels, identified articles with maps, and recorded article titles, dates, and page numbers. The principal investigator then scanned the reels a second time, to detect maps missed on the first scan and to assign category codes. For consistency and reliability, only the principal investigator coded the data. In addition to the data used to compile the tables and figures included with this paper, maps also were classified according to type of symbolism, but the single-factor classification employed was not suitable for the multiple-factor maps encountered. These data were judged unreliable and were not analyzed.
8. Woodward, D. 1975. The Woodcut Technique, pp. 25-50 in Woodward, D., ed. *Five Centuries of Map Printing.* Chicago, University of Chicago Press.
9. Emery, E. 1962. *The Press and America: An Interpretative History of Journalism,* 2nd ed. Englewood Cliffs, N.J., Prentice-Hall, pp. 404-408.
10. Woodward, D. 1974. The Decline of Commercial Woodengraving in Nineteenth-century America. *Journal of the Printing Historical Society.* 10:56-83.
11. By 1930 the front page of *The Times* looked very much like the front page of present-day editions in layout, use of photographs, and overall design.
12. The first daily weather map appeared on Saturday, August 4, 1934. A week later, in the Sunday edition for August 12, 1934, a feature article by C. F. Talman, of the U. S. Weather Bureau, discussed weather maps and their use in forecasting. See Talman, C. F. 1934. What Weather Maps Reveal: The Elements of Forecasting. *New York Times.* 12 August 1934, Section 8, p. 2.
13. Table 3 rightly uses 'scope of coverage' in its title, not 'scale.' Defined as the ratio of a distance on the map to the corresponding distance on the earth, scale considers not only the area represented but also the size of the map. Because the maps were on microfilm, scale could not conveniently have been measured directly. Nonetheless, the terms 'scale' and 'scope of coverage' are generally equivalent because variation in map size was insufficient to undermine substantially the three general categories used in the table.
14. During the early 1970s most broadsheet newspapers, including *The Times*, reduced page size and cut the width of a roll of newsprint to cope with the rising cost of paper. See, for example, Rupp, C. M. 1974. Publishers Order Narrower Roll Widths to Cut Costs. *Editor and Publisher* 107, No. 41 (October 12, 1970): 10 and 34.
15. See, for example, Gloede, B. 1983. What's Black and White and *Red* All Over? *Editor and Publisher* 116, No. 39 (September 24, 1983): 15-16.
16. For a comprehensive treatment of videotex, see Gecsei, J. 1983. *The Architecture of Videotex Systems.* Englewood Cliffs, N.J., Prentice-Hall. For an exploration of possible effects of electronic publishing on newspapers, see Smith, A. 1980. *Goodbye, Gutenberg: The Newspaper Revolution of the 1980's.* New York, Oxford University Press.

Proceedings of the Pennsylvania Academy of Science 58: 84-88. 1984

PRESSURE SOLUTION SHORTENING IN THE MARTINSBURG SLATE, NEW JERSEY

ERIC ERSLEV and CAROL MANN

Department of Earth Resources
Colorado State University
Fort Collins, CO 80523
and
Department of Geophysics
Stanford University
Palo Alto, CA

ABSTRACT

The mechanism for the development of slaty cleavage within the Martinsburg Formation has been extensively debated. In order to quantify volume-loss due to pressure solution, the element distribution in slates was analyzed using an energy dispersive system attached to a scanning electron microscope (SEM-EDS). Samples were collected from an outcrop with tightly-folded dolomite beds indicating a minimum of 40% shortening perpendicular to the cleavage. The analytical method allowed the determination of the difference in composition between cleavage zones and intervening microlithons. The data indicate that K, Al, Ti and, in some cases, Fe are relatively immobile, being neither enriched nor depleted in the cleavage zones. The abundance of Si, Ca and S vary in the cleaved rocks, but not as much as has been predicted. By using atomic percents obtained through a quantitative program on the EDS, 5% volume loss by pressure solution was calculated assuming that Al was immobile and volume loss was restricted to cleavage zones. These results do not support the hypothesis of large-scale element removal from cleavage zones in slates by pressure solution. If the shortening in the slates was accomplished by volume loss, this loss must have been distributed through the entire rock and not restricted to the cleavage zones.

INTRODUCTION

Slates are characterized by a well-developed cleavage defined by mineral grains in preferred orientations. Since the early 19th century, the mechanism involved in the development of slaty cleavage has been a source of controversy (1, 2, 3, 4). Most research done on slaty cleavage has been based on fabric analysis, with only a few compositional studies conducted using the electron microprobe or scanning electron microscope. This study used a scanning electron microscope and energy dispersive system (SEM-EDS) to study the bulk composition of the cleavage zones in slates of the Martinsburg Formation near Belvidere, New Jersey.

Most of the Martinsburg is characterized by a well-developed slaty cleavage. The age of the cleavage has not been established, with estimates ranging from Taconic (5, 6) to Alleghanian (7, 8, 9, 10). Using conodont color-alteration geothermometry, Epstein (11) determined that the cleavage began to develop in the Martinsburg at approximately 200°C.

Deformation in the Martinsburg Formation has been accompanied by large amounts of penetrative strain. Beutner et al. (12) calculated 52% shortening in the Delaware Water Gap. Recently, Wright and Platt (9) used graptolites as a strain gauge and determined that the volume loss accounted for 90% of the finite strain in scattered localities from Pennsylvania to Virgina. They estimated that 50% of the original volume of the rocks studied was removed by pressure solution.

At present, many mechanisms have been proposed as the cause for cleavage lamallae in the Martinsburg Slate: pressure solution (9, 11), recrystallization (4, 8), oriented grain growth (4, 13) and grain-boundary sliding (4). The purpose of this study was to determine if pressure solution in cleavage zones was responsible for the volume loss associated with slaty cleavage. The SEM-EDS analysis was used to determine if elements are enriched or depleted in cleavage areas. By comparing the compositions of the microlithons and adjacent cleavage zones, the mode of formation can be constrained and the volume loss calculated. In this way, the hypothesis of pressure solution can be tested quantitatively. If pressure solution was the major factor in cleavage development, then the change in the bulk composition in the cleavage zones should be proportional to the volume loss.

SAMPLE DESCRIPTION

The sampled exposure of the Martinsburg Formation is 4 kilometers north of Belvidere, New Jersey adjacent to Route 46 (Fig. 1). The locality was described as stop 12 of field trip 1A of *Geology of selected areas in New Jersey and eastern Pennsylvania and guidebook of excursions*, edited by Subitzky (1969).

On the outcrop scale, inhomogeneous strain is indicated by the contrast between planar pelitic beds oriented at a high angle to cleavage and ptygmatic folding of practically monomineralic dolomite interbeds.

Offset sandstone beds are seen in the slate on the macroscopic and microscopic level (Fig. 2). The uniform sense of the offsets regardless of the orientation of the displaced surfaces indicates rotation or shear, not solution.

Groshong (13) calculated 40% minimum shortening at the Belvidere locality using the folded dolomite beds and assuming no volume loss or layer-parallel shortening. Field measurements of folded bed length during this investigation showed that minimum shortening perpendicular to cleavage averaged 43%, with a standard deviation of 2%. Measurements on stacked, imbricate beds in thin section CM3A (Fig. 2) show a minimum of 37% shortening perpendicular to cleavage

The thin sections contain quartz, white mica, chlorite, albite and in some samples, dolomite. In all thin sections, the cleavage zones show parallel extinction due to preferred orientation of phyllosilicates. Platy chlorite grains are parallel in the cleavage zones and unoriented elsewhere. As grain size increases, the degree of preferred orientation decreases. In fine grained samples, cleavage is present as closely spaced, anastomosing planes which create a homogeneous fabric with little resolution between cleavage zones and microlithons. Cleavage zones thin and fan as they cut finer-grained beds. In general, the cleavage zones are evenly spaced except where they are wrapped around competent features such as quartz bands, creating strain shadows of equant minerals (Fig. 3). Thin dolomitic sandstone beds are offset along coalesced concentrations of cleavages (Fig. 2).

SEM-EDS METHODS

Seven oriented samples were collected from the lowermost part of the Bushkill Member (7) of the Martinsburg Formation. Thin sections were oriented perpendicular to the intersection of bedding and cleavage.

The method used for determining the elemental distribution on polished surfaces was originally derived for a similar study of solution cleavage in marly limestones (14). An energy dispersive system (EDS) attached to a scanning electron microscope

[1] Received for publication February 2, 1984; reviewed; accepted March 15, 1984.

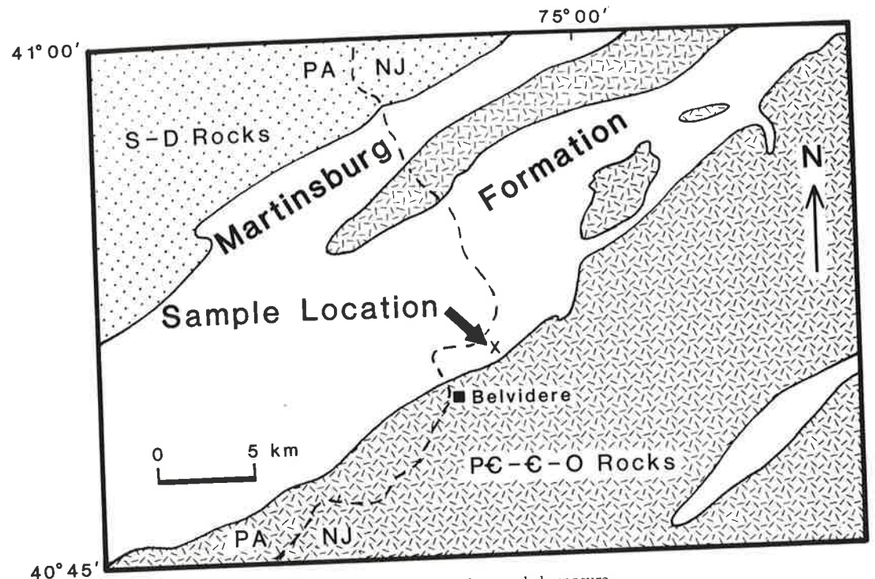


FIGURE 1. Geologic map of the region surrounding the sampled exposure of the Martinsburg Formation (from Epstein et al.(7)).

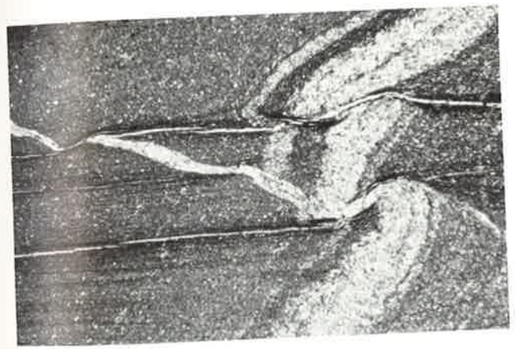


FIGURE 2. Bedding and a pre-tectonic vein offset by dark cleavage zones in sample 3A. Note that the sense of offset is consistent with shear, not pressure solution. Traverse 3A was located within the large pelitic bed. Photomicrograph width = 11 mm.

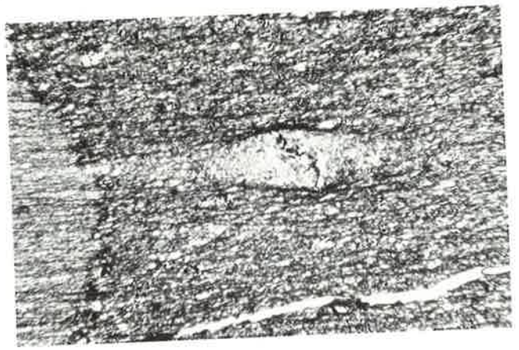


FIGURE 3. Strain shadow in sample 4A defining a lensoidal microlithon. Traverse 4A crossed this microlithon. The arcuate contact on the right side of the photograph is bedding. Photomicrograph width =3 mm.

(SEM) was used to determine the element distribution in adjacent cleavage zones and microlithons. The resulting element distribution was used to identify and quantify the mineral species undergoing dissolution during cleavage formation.

Three methods were used in this study to gather compositional data from polished thin section chips: EDS line profiles, individual EDS spectra and spectra taken of adjacent areas along a traverse. The line profiles did not yield any easily interpretable information because of compositional scatter due to the grain size of the slate. Individual mineral grains were being analyzed rather than the difference in composition between the microlithons and cleavage zones.

Twenty-six spectra were taken on equal areas of adjoining cleavages zones and microlithons in two thin section chips. The peak heights of each element were recorded from the spectra taken. Pairs of data from adjacent areas were compared to determine compositional differences between a cleavage zone and the corresponding microlithon.

The two traverses were made on thin section chips CM3A and CM4A. Traverses consisted of spectra of evenly spaced areas of equal dimension along a previously designated line. The chosen traverse lines were contained within a single sedimentary bed of uniform original composition. Each spectra area was overlapped by one-third. The size of the area analyzed was determined by the width of the cleavage zones. The area analyzed was maximized in order to reduce the effect of compositional heterogeneities. Care was taken to ensure that a spectra was taken for each cleavage zone that did not include areas of adjacent microlithons.

SEM-EDS SPECTRA

After each individual spectrum was taken and the major elements identified, the peak heights were measured (uncorrected for background). The peak heights of each element were then ratioed to the peak height of Al. Al was chosen because it appeared to be the least mobile of the major elements examined in this study. When ratioed with each other, Al, Fe, K and Ti showed minimal fluctuation and Al was the most abundant of these elements. Within a single bed, the ratio of each element to Al in the cleavage area was divided by the same ratio in an adjacent microlithon. The results are an indication of what elements are

TABLE 1

*Ratios of characteristic peak heights normalized to Al.**

Sample	Ratioed Spectra	(x/Al) cleavage/ (x/Al) microlithon Si/Al	K/Al	Fe/Al	Ca/Al	Ti/Al	S/Al
CM3A	2/1	.7229	1.097	.9724	.8063	1.017	.8532
	6/7	.5585	1.162	.8606	.6762	.9734	.9401
	10/8	.7021	1.118	.8430	.6493	.9767	.6776
	11/9	.7184	1.064	.8036	.6194	1.031	1.262
MEAN		.6755	1.110	.8699	.6878	.9995	.9287
S.DEV.		.0785	.0410	.0724	.0823	.0289	.2470
CM4A	7/5	.9333	1.066	.9543	1.061	1.061	1.102
	9/8	.8962	1.125	.9647	1.025	.9447	.8345
	10/11	1.006	1.153	.9628	1.264	1.222	.9755
MEAN		.9452	1.115	.9606	1.117	1.076	.9707
S.DEV.		.0559	.0444	.0055	.1289	.1392	.1338

*For each spectra, characteristic peak heights for each element are ratioed to the peak height for Al. Values for adjacent cleavage zones and microlithons are ratioed to document element mobility. Ratios less than 1 indicate element removal from cleavage zones.

TABLE 2

Semiquantitative volume calculation for sample 3A

Oxide	Cation %[1] Microlithon Mean	S.Dev.	Cleavage Zone Mean	S.Dev.	Oxygen %[2] Micro-lithon Mean	Cleavage Zone Mean
SiO_2	65.3	3.8	53.9	5.1	63.3	53.4
Al_2O_3	13.1	1.6	16.2	3.5	19.1	24.0
K_2O	7.9	1.4	10.5	.5	3.8	5.2
FeO	6.6	1.4	8.9	.5	3.1	4.3
CaO	4.1	.8	4.3	2.4	2.0	2.2
TiO_2	.8	.3	1.3	.3	0.8	1.3
S	2.2	.8	4.9	2.7	0	0
H_2O[3]					3.8	5.2
CO_2[4]					4.0	4.3

1. From E.D.S. semiquantitative analyses, background and matrix corrected. Analyses not compared to standards.
2. Oxygen % = (Cation % • oxygen per cation) normalized to 100%.
3. $H_2O = K_2O$. Assumes H_2O in illite only.
4. $CO_2 = CaO$. Assumes all CaO in carbonate.

Calculation:

X = inert element
Om = calculated oxygen in microlithon
Oc = calculated oxygen in cleavage zone
Δ Oxygen = change in volume of cleavage zones

$$\Delta \text{ Oxygen} = \frac{Om - (Oc \cdot Xm/Xc)}{Om}$$

% volume loss, sample 3A = Δ Oxygen • % cleavage (assuming Al inert) = .20 • 25%
= 5.0%

enriched and depleted in the cleavage zones. The peak heights and ratios of cleavage zones to microlithons are shown in Table 1.

In thin section chip CM3A, Si, Fe and Ca are depleted with respect to Al within the cleavage areas. K is enriched slightly and Ti and S are relatively stable. In sample 4A, the same is true, the Ca is enriched in the cleavage zones and, in general, the ratios are closer to 1, indicating less relative changes in concentrations.

After the traverse spectra had been taken, each was analyzed using a quantitative program that subtracts the background radiation and peak overlap, determines the volume of the peaks and then calculates the theoretical atomic percent of each element. The absolute accuracy of the quantitative program is poor due to the fact that analyses are not compared to standards of predetermined composition and are normalized to 100% without regard to unanalyzed H_2O and CO_2. However, the major results of this study are based on element ratios which are dependent on the relative proportions of the elements, not the absolute abundances.

The major area of original composition in traverse 4A is within a strain shadow shown in Figure 3. It is associated with an enrichment of Fe and S, a slight depletion of Si and Ti, and no significant changes in Ca and K (Fig. 4). These results are in contrast to observations by Watters et al. (15), who showed that pyrite is passively concentrated in areas of high dissolution and calcite is the mobile component in the Martinsburg Formation in northern Virginia. In addition, Fe and S are not correlative outside the microlithon, suggesting that they are not present in the cleavage solely as an iron sulfide. (Fig. 4).

Traverse 3A is the best constrained traverse due to the larger area analyzed and the existence of wide, distinctive areas of cleavage and microlithon (Fig. 2). The ratios of Fe, K and Al are

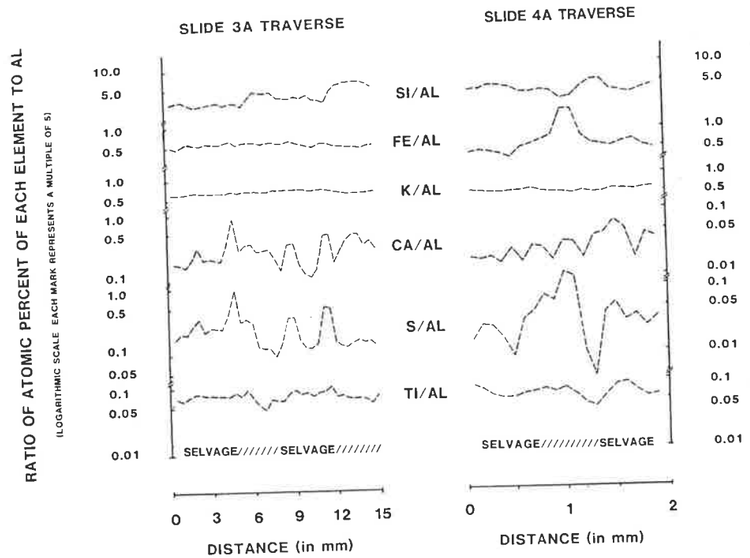


FIGURE 4. Element ratio (X/A1) versus distance. Slide 3A traverse: microlithons extend from 6 to 7.3 mm and 12 to 15 mm on scale. Slide 4A traverse: microlithon extends from .9 to 1.3 mm on scale.

constant relative to each other and Si is depleted in the cleavage zones (Fig. 4). S and Ca show parallel changes in distribution within the cleavage zones, but not in the microlithons. As in traverse 4A, S and Fe are not distributed in a parallel fashion.

VOLUME LOSS CALCULATIONS

The quantitative data can be used to calculate a minimum volume loss. The data and calculations are shown in Table 2. The average compositions of cleavage and microlithon areas for the 3A traverse were used for the calculations. Calculations were made based on the following assumptions: (1) Al was an immobile element, and (2) volume is proportional to the number oxygen atoms in each oxide, adjusted for unanalyzed H_2O (equal to 2K) and CO_2 (equal to Ca). The resulting calculation indicates that there was 20% volume loss within the cleavage zones. Therefore, if 25% of the rock is represented by cleavage zones, the volume loss (and, consequently, the percent shortening due to volume loss in cleavage zones) is reduced to 5%. Si decreased by only 16% within the cleavage zones.

DISCUSSION

If pressure solution was the major mechanism for the development of the slaty cleavage, then a significant change in the element distribution between the cleavages and microlithons would be expected. Similarly, if some kind of metamorphic reaction had occurred, a change in the distribution of elements would also be expected; for example, enrichment of Fe in the cleavages due to the formation of chlorite or, similarly, enrichment in K due to the formation of illite.

If pressure solution was the only cleavage-forming mechanism and solely responsible for bulk shortening by volume loss, the volume loss associated with the formation of cleavage should be approximated by the previous calculations. As shown in the calculations in Table 2, when the percentage of cleavage areas is taken into account, the volume loss reduces from 20% to 5%. The calculated 5% loss in the cleavage zones is much too low to account for the 42% minimum shortening determined at this exposure of the Martinsburg Slate by the folded dolomite beds. The lack of major depletion of either Ca or Si indicates that the dissolution of quartz and carbonate in cleavage zones was not the dominant factor in the volume loss associated with cleavage formation in the Martinsburg Formation. This conclusion strongly contrasts with the substantial volume loss by the dissolution of calcite in the spaced cleavage of marly limestones 20 kilometers NW of the studied outcrop (Erslev et al. (14)).

The lack of volume loss due to pressure solution in cleavage zones is not necessarily in conflict with the 50% bulk volume loss documented by Wright and Platt (9) in the Martinsburg Formation of central Pennsylvania. It is possible that differences in cleavage mechanism are responsible for the disagreement. However, similarities in the age, composition, deformation history and strain in the slates of both studies suggest that the cleavage mechanism was probably uniform throughout the pelitic rocks of the Martinsburg Formation.

We favor the hypothesis that the volume loss in these slates was distributed throughout the entire rock and was not restricted to the cleavage zones. The method detailed in this paper assumes that the microlithons represent the original composition of the bed being analyzed. If the microlithons also underwent substantial volume loss due to pressure solution, then the difference in composition between the cleavage zones and the microlithons would underestimate the total volume loss. The removal of water during the dehydration of a clay-rich protolith or the dissolution of an unstable mineral could cause the volume loss documented by Wright and Platt (9).

Evidence is lacking for metamorphic reactions which might

cause the development of cleavage. The data in Table 1 and the graphs of the traverses in Figure 4 indicate small relative changes in the amount of Al, K and Fe in the cleavage zones.

The interrelationship between slaty cleavage development, shortening and volume loss in the Martinsburg Formation is still uncertain. At the studied locality, compositional data have shown that pressure solution in the cleavage zones was not responsible for the shortening associated with slaty cleavage. This is supported by the geometry of offset sandstone beds (Fig. 2). Oriented grain growth could be responsible for cleavage development in the Martinsburg Formation but this mechanism cannot cause volume loss commensurate with the shortening associated with slaty cleavage.

ACKNOWLEDGEMENTS

The authors gratefully acknowledge the support of the Department of Geology and the Committee on Advanced Study and Research of Lafayette College.

REFERENCES

1. Sorby, H. C. 1853. Edinburg New Philosophical Journal 55:137-148.
2. Geiser, P. A. 1975. Geology. 5:717-720.
3. Hobbs et al. 1976. An Outline of Structural Geology. John Wiley and Sons, 571 pp.
4. Woodland, B. G. 1982. Tectonophysics. 19:89-124.
5. Maxwell, J. C. 1962. In "Petrologic Studies: A volume in honor of A. F. Buddington." Engel, A. E., James H. L. , and Lenard, B. F., Editors, Geol. Soc. America, 660 pp.
6. Carson, W. P. 1968. Tectonophysics. 5:531-541.
7. Epstein, J. B. et al. 1969. In "Geology of Selected Areas in New Jersey and Eastern Pennsylvania and Guidebook for Excursions," Subitzky, S. Editor. Rutgers University Press, 132-205.
8. Holeywell, R. C. and Tullis, T. E. 1975. Geol. Soc. Bull. 86:1296-1304.
9. Wright, T. O. and Platt, L. B. 1982. Am. Jour. Sci. 282:122-135.
10. Stephens et al. 1983. Geol. Soc. America Abst. with Prog. 15:190.
11. Epstein, J. B. 1974. Geol. Soc. America Abst. with Prog. 6:724.
12. Beutner et al. 1977. Geology 5:118-122.
13. Groshong. R. H. 1976. Am. Jour. Sci. 276:1131-1146.
14. Erslev et al. 1983. Geol. Soc. America Abst. with Prog. 15:175.
15. Watters et al. 1983. Geol. Soc. America Abst. with Prog. 15:175.

Proceedings of the Pennsylvania Academy of Science 58: 89-91. 1984

INTERACTION OF METALLIC IONS WITH RED BLOOD CELLS AND STROMA[1]

ROBERT WEISBROD,[2] DAVID ZERCHER,[2] GERALD HESS,[2] and RAY H. CRIST[3]

ABSTRACT

Adsorption in μMol G^{-1} of metallic ions at 0.005M was found for red blood cells (RBC's) and stroma, respectively, to be: Cu – 341, 134; Zn – 46, 33; Mg - negligible. Only copper displaced protons giving ratios of protons displaced to copper adsorbed, H/Cu, of 0.45 for RBC's and 0.48 for stroma. In pH titrations the NaOH required to change pH from 4 to 7 was 750μMol G^{-1} for RBC's while for stroma it was 400. The larger values for RBC's over those for stroma, except in the case of H/Cu, could indicate an active role for the cell contents though the data are not yet precise enough for this conclusion. Adsorption of copper and zinc, strong coordinating elements, probably represent covalent bonding, while lack of adsorption for magnesium may indicate no covalent bonding and further that any electrostatic bonding with surface negative charges is minimal.

INTRODUCTION

Heavy metals once filled a prominent role in therapeutic medicine. Because of lack of care in human exposure in industrial and environmental settings they have now become of major toxicological significance. In recent years a growing awareness of the implications of bioconcentrations of metallic elements in ecological food chains has increased interest in their role in biological processes. Also, certain metals known to be involved in the usual cellular functions have been studied extensively, for example, the role of iron in respiratory pigments (hemoglobin, cytochrome), of magnesium in chlorophyll, and of copper in the respiratory pigments of lower animals. Though transport of some metals, Ca, Na, K, and Mg has been a favorite topic of study, their direct interaction with cell surfaces has received little attention.

The cell membrane contains functional groups with ligands such as nitrogen, sulfur, and oxygen that may form stable complexes with heavy metals. However, their alkali and alkaline earth elements form only weak complexes,[2] if any, which at the same time may enable their more ready transport through the membrane.

It was hoped that a better understanding of the cation-cell membrane interaction could be achieved through a study of properties membranes have in common with algae and inorganic oxides. Thus they all have a surface charge exhibited by electrophoresis, and in addition, algae are composed of proteins, lipids and polysaccharides as compared to proteins, glycoproteins and lipids for RBC's. These substances contain functional groups capable of metallic ion interactions through covalent as well as electrostatic bonding. Work on cation-algae cell wall interactions has been reported recently.[3] It was found that both proton and cation exchanges together with adsorption of cations and of their stable ion complexes were reasonably well explained by concepts from inorganic oxide chemistry.[4] In line with this, work reported here on RBC's and stroma involves pH titrations and adsorptions of copper, zinc and magnesium together with proton displacements and hemolysis studies with metals.

[1] Received for publication April 12, 1983; revised; accepted September 2, 1983.
[2] Department of Natural Science, Messiah College, Grantham, PA 17027
[3] 619 Devonshire Drive, Carlisle, PA 17013

MATERIALS AND METHODS

Earlier work in this area was done with rat blood. However, because of the need for large volumes in preparation of stroma, citrated human blood was used here. It was washed three times with 0.15M $NaNO_3$ to remove plasma and then diluted with an equal volume of this solution for convenience in handling. Stroma were prepared by hemolysis of the washed red cells.

For the pH titrations a sample of 10 to 50 mg (dry weight) was added to enough 0.15M $NaNO_3$ to give a final volume of 20 ml. The operation was carried out under a nitrogen blanket to avoid carbon dioxide interference. The pH was reduced from 6-7 to 4 by addition of 0.10M HCl. With stroma equilibration was fairly rapid. With RBC's, however, it was slow, probably due to transport of protons into the cell's buffer system becoming stable after about 10 minutes when the titration with 0.10M NaOH was performed promptly. The dry weight for the proton yield experiments was that of the stock suspension used.

To determine the proton displacement with copper a sample of 50 to 100 mg dry weight was put in 0.15M $NaNO_3$ to give a volume of 10 ml. The pH was adjusted to 4.5 as was that of the 0.10M $CuSO_4$ solution. On adding 1 ml of the Cu^{2+} solution giving a concentration of 0.01M the pH decreased to around 4.0. The solution was then back-titrated to 4.5 thus obtaining a measure of the protons displaced. The data are based on dry weights determined as follows: for the protons displaced it was obtained from the dry weight of the stock suspension; for the metal, since material was lost due to pressing with paper to remove adhering solution, the procedure was as described below for metal adsorptions.

For the adsorption of metallic ions about 40 mg (dry weight) of red cells or stroma were added to enough 0.15M $NaNO_3$ to give a final volume of 20 ml. After adding the metal which ranged from 0.0005 to 0.001M, and standing for about 15 minutes for equilibration the mixture was centrifuged. The sample was removed and pressed with a spatula on hardened filter paper to remove adhering solution. It was then divided into two parts, the one for treat-

ment with EDTA for analysis by atomic adsorption and the other for drying in the oven at 60°C to obtain a dry weight. This procedure was necessary because the dried sample could not be extracted directly with EDTA, nor could the ash from a furnace treatment at 400°C be dissolved readily in HNO_3.

The hemolysis study was done in the usual manner. For this 0.15 ml of fresh RBC's were put into 15 ml of $NaNO_3$ solutions ranging in concentration from 0.0 to 0.15M with the pH controlled at 4.5 using MES buffer. After standing an hour the samples were centrifuged for 15 minutes at 2000xg and the supernatant solution of hemoglobin was analyzed with a Spectonic 20 photometer. For the effect of metals the concentrations used were: Cu—0.0002, 0.002; Zn—0.001, 0.005.

Data were obtained from duplicate runs with errors generally in the 10% range.

RESULTS AND DISCUSSION

Retention of metal from adhering solution. This is shown for 0.001M zinc in the following table.

TABLE 1

Solute retention for zinc.

	Oven (1)	EDTA (2)
Moist sample, g	0.0138	0.0175
Dry sample, g	0.0045	0.0057 calc.
Residual sol'n g(ml)		0.0118
Moles Zn from residual sol'n x 10^6		0.0118
Moles Zn on EDTA sample x 10^6		0.0289
Moles Zn on EDTA-Moles sol'n x 10^6		0.0171
Moles Zn per gm dry wt. x 10^6		3.0

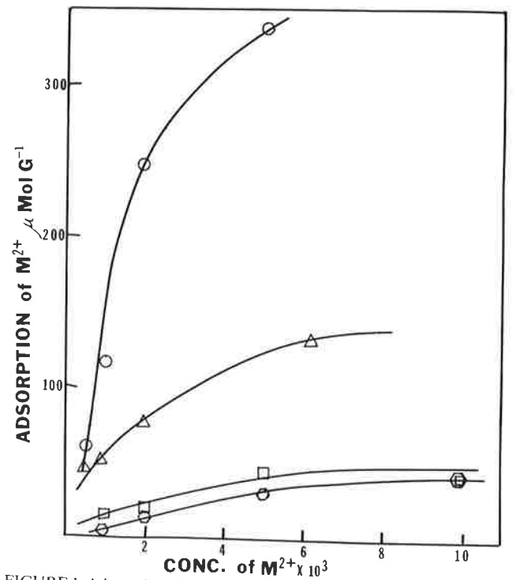


FIGURE 1. Adsorption of metallic ions by RBC and Stroma. About 0.040 g dry weight of sample was mixed with water and the metallic ion solution to give concentrations as indicated. The pH was adjusted to 4.5. After about 14 minutes the sample was removed and analyzed. Data in $\mu MolG^{-1}$ are based on dry weights. Curves are as follows: ⊙ Copper on RBC, △ Copper on stroma, ⊡ Zinc on RBC, ○ Zinc on stroma.

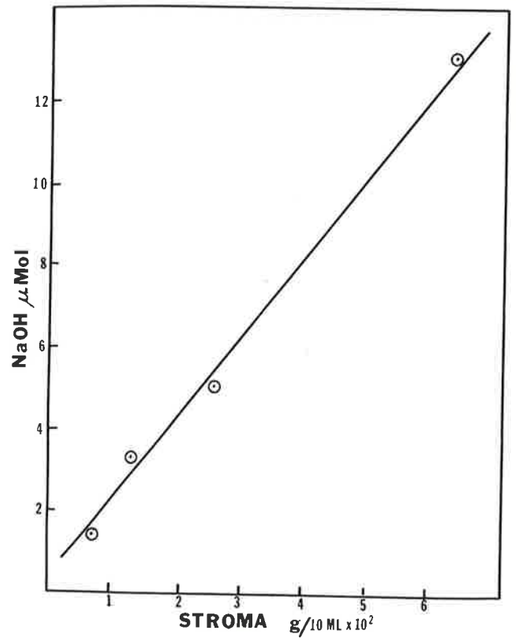


FIGURE 2. Proton displacement from stroma vs. sample size. Since the relation is linear, sample size can be selected to suit analytical requirements.

Adsorption of metallic ions. The adsorption of copper, zinc, and magnesium on red cells and stroma are shown in Figure 1. Copper is much more effectively adsorbed on both substances than zinc, while for magnesium little was observed, the data being within experimental error. In the event that magnesium is unusual, other alkaline earths should be tried since for algae the adsorption of alkaline earths was quite strong being about a third that of copper. There the bonding was thought to be electrostatic because of the surface charge and, since red cells are also charged as shown by electrophoresis and as inferred by the pH titration reported here, a similar bonding to alkaline earth elements could be expected.

The behavior of copper appears to be unusual and could be related to some specific covalent bonding on proton sites. This was in fact found by Bradshaw et al[5] to be the case for the protein myoglobin and certain of its constituent peptides where copper was bonded to histidine. They further demonstrated that copper denatured the protein which was completely reversed on its removal by EDTA. A similar action could occur with proteins in the red cell membrane.

Proton displacement. Figure 2 shows the displacement of protons in relation to the sample weight of stroma. The linear relation indicates there are no complications with stroma density over the range. The ratio of protons displaced per copper atom adsorbed, H/Cu, was found to be 0.48 and 0.45 for stroma and RBC's respectively. Thus it seems probable that the difference between the two substances is not large. This could mean that there is not much contribution by the inner cell surface. For this several explanations may be offered: (1) The proton activity sites could be on the glycoproteins and glypolipids which populate the outer

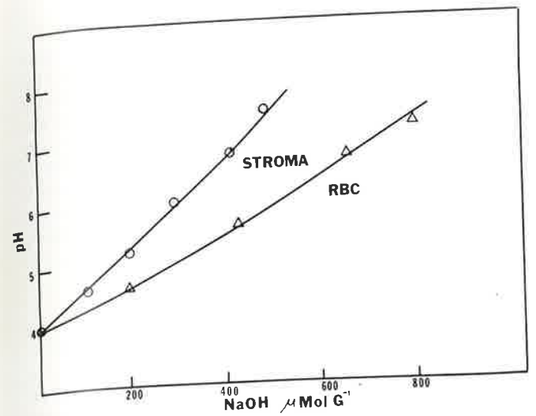


FIGURE 3. pH titration of stroma and RBC. A 0.01 to 0.05 g sample was put in 20 ml of water and brought to pH 4.5. NaOH 0.10M was then added to give the results indicated. The hydroxyl used is taken as a measure of the surface charge.

surface so that exposed inner surfaces would make little contribution. (2) Proteins or protein active proton sites could be destroyed by protease liberated on the cell bursting. (3) Ions could move rather freely through RBC membranes to populate both surfaces.

In the experiments coagulation of RBC's was effected by copper. This could conceivably be due to copper bonding between polysaccharides of adjacent RBC's. Since the clumping characteristic of isoantibody-isoantigen reactions is believed to involve polysaccharides on blood cell surfaces, it is not unreasonable to postualte a similar site for the clumping of cells observed with copper.

pH titrations. These are shown in Figure 3 for RBC's and stroma. Throughout the stroma titration the system was quite stable. With RBC's, on the other hand, there was considerable drift, the pH increasing at low pH and decreasing at high pH which indicates a proton equilibration process between the solution and the cell contents. After some 10-20 minutes the system was sufficiently stable to obtain fairly reproducible results. From the curves of Figure 3 one obtains the OH required to change pH from 4 to 7, namely, 400 and 750 μMol G^{-1} for stroma and RBC's, respectively. Because of the apparent mobility of protons through the RBC membrane, the hemoglobin and other cell components must be considered along with the membrane surface as proton exchange sources. Though the difference between stroma and RBC's is considerable, speculation is hardly justified because of the uncertainties of obtaining the RBC data. In any case the discussion of inner and outer layer components as affecting proton displacement could apply here, e.g., the higher population of polysacharides providing proton exchange sites on the outer surface of the RBC's.

Hemolysis of RBC's in the presence of 0.002 and 0.0002M Cu^{2+} is shown in Figure 4. Since the data for the normal and that in the presence of copper fall close together it can be taken that the adsorbed metal ions do not affect the elastic character of the membranes. This is somewhat surprising in that copper appears to have

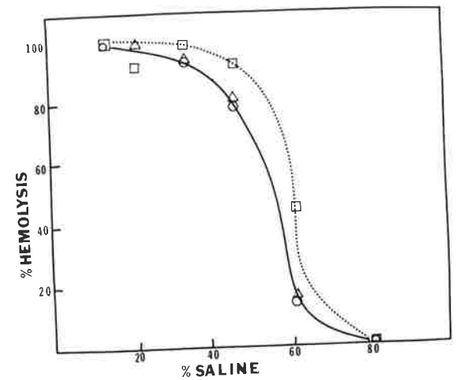


FIGURE 4. Effect of metalic ions on hemolysis of RBC. 0.15 ml of Fresh RBC were added to 15 ml of a mixture of distilled water and 0.15M $NaNO_3$ as "saline." The mixtures are expressed as % "salines." Curves are as follows: ⊙ normal, △ 0.002 M copper, ⊡ 0.0002 M copper.

a strong coagulating effect, and, also, from the work of Bradshaw et al[5] with the protein myoglobin to cause complete denaturization. However, here again the copper may not be affecting proteins essential to the integrity of the membrane, but, rather may be entangled with polysaccharides from adjacent cells which would not necessarily affect membrane fragility.

ACKNOWLEDGEMENTS

Early work on adsorption of metallic ions was done by Kent Tyson, William Bear, Beth Baxter and Mark Dilliplane while that on pH titrations was done by Beth Latshaw and Keith Rice. Their interest and effort on the project is gratefully acknowledged.

REFERENCES

1. Goodman, Louis S. and Alfred Gilman. 1967. *The Pharmacological Basis of Therapeutics.* The Macmillan Company. N.Y., 943.
2. Sillen, L. B.; Martel, A. E. *Spec. Publ. Chem. Soc.* 1971, No. 25, Supplement No. 1.
3. Frey, R. A., R.H. Crist, and K. Oberholser. 1978. Copper-algae equilibria in complexing solutions. *Proc. Pa. Acad. Sci.* 52:179-182.
   Salier, D., R. H. Crist et al. 1980. Ineractions of protons and metallic ions with algae. 1981. *Proc. Pa. Acad. Sci.* 54:85-88.
   Crist, R. H. et al. 1981. Nature of bonding between metallic ions and algal cell walls. *Environ. Sci. Technol.* 15:1212-1217.
4. Davis, J. A., et al. 1978. Surface Ionization and Complexation at the Oxide/Water Interface. *J. Colloid and Interface Science.* 63:480-499.
5. Bradshaw, R. A., et al. 1968. Sites of bonding of copper (II) by peptide (1-24) of bovine serum albumin. *J. Biolog. Chem.* 243:3817-3825.

Proceedings of the Pennsylvania Academy of Science 58: 92-98. 1984

PRELIMINARY STUDY OF THE ECTOMYCORRHIZAL DISTRIBUTION OF WHITE OAKS IN EASTERN PENNSYLVANIA FORESTS[1]

L. MINEO, S. K. MAJUMDAR, G. RALL, J. FRANCIS, A. SEGAL and A. MROWCA

Department of Biology
Lafayette College
Easton, Pennsylvania 18042

ABSTRACT

A comparative study of white oak *(Quercus alba)* ectomycorrhizae in the mor forest soils surrounding acidified lakes in the Poconos and in the mull forest soil of the limestone valley in Northampton County was initiated during the spring of 1984. Although general climatological features of the two areas were similar, several edaphic features differed. Ectomycorrhizal distributions were superficially similar in that more mycorrhizae were located in the uppermost humus layers than in the lower mineralized layers of each soil type and the percentages of active mycorrhizae increased through the growing season. This upward trend generally reflected increases in soil temperature. However, closer scrutiny demonstrated several dissimilarities in ectomycorrhizal distributions. Mycorrhizal cluster size was larger in the humus-mull. Active mycorrhizal frequencies (AMF) of the humus-mull were higher than the AMFs of the humus-mor by a factor of 4 in late summer. Composite AMFs for the soil profiles, which included values for the mineral horizons, showed that the mull forests contained more mycorrhizae than the mor forests by a factor of 2.5. The roots in the mineralized horizons of the mor forests had, then, a measureable portion of active mycorrhizae while roots in the mull forest did not. The significant differences of AMFs in the two forest types suggested a higher potential productivity for white oaks in the mull forest. Differences in AMFs corresponded to several differences in edaphic features between the two areas. The mor soils were acid (pH values ranged from 4.7-3.3), organic, shallow and stoney; the mull soil was slightly acid to neutral (pH values ranged from 6.5-7.1), mineralized, deep and relatively stone free. Mineral nutrients of the mor soil were low while nutrients of the mull soil were normal to high except for phosphorus which was low in both. The availability of heavy metals (Cu, Zn, Cd, Fe, Mn, Ni and Al) was high to excessive in the mor soils while it was normal to low in the mull soil. The use of mycorrhizae as indicators of adverse edaphic features, including changes caused by acid rain, is discussed.

[1] Received for publication September, 1984; revised.
[2]This study was made possible through a research contract grant provided by The Pennsylvania Power and Light Company, Allentown, Pennsylvania.

INTRODUCTION

Over the past decade, scientific evidence pointing up the acid rain phenomenon has accumulated with Pennsylvania centrally located in the deposition pattern (1). Concerns about possible destructive environmental effects of acid deposition which could be of a cumulative and irreversible nature (1, 2, 3), have prompted the investigation of Pennsylvania forests. The aspect of forest biosystems chosen for this preliminary study was ectomycorrhizae.

Ectomycorrhizae are symbiotic associations of certain fungal hyphae with plant roots. The symbiosis is recognized by differences in gross morphology from uninfected roots such as thicker root tips which are often both colored differently and clustered. Most trees of eastern forests are ectomycorrhizal including oaks, birches, beech and pines. Ectomycorrhizae provide several benefits to the host plant. The uptake of essential elements such as phosphorus, nitrogen and calcium is increased several times that of uninfected roots (4). Protection against certain pathogens is enhanced by the production of antimicrobial compounds and the formation of a structured rhizosphere containing other beneficial microbes. A hormonal balance is also created which offsets the aging of root tips (5). Ectomycorrhizae, then, are rather significant to the potential productivity of trees in eastern forests.

Edaphic conditions promoting mycorrhizal formation include favorable temperatures for both fungal and root growth, adequate soil oxygen levels, a slight deficiency of soil nitrogen and phosphorus (4), and moderate soil acidity (5). Other less defined edaphic conditions may also influence mycorrhizal formation and function. Non-edaphic factors affecting mycorrhizal numbers relate to photosynthetic sugar production by the host in that mycorrhizal fungi require adequate soluble carbohydrate (6). Factors that influence photosynthetic productivity are also likely to influence mycorrhizal distribution. By recognizing and monitoring the environmental factors which affect the symbiosis, it may be possible to establish the relationship between mycorrhizal quantitation and host productivity. This may be especially relevant in assessing the effects of acid rain on oak productivity, since dendrological techniques can be inconclusive (7). It also seems appropriate to consider other means of assessing the effect of acid rain on forest productivity because this topic remains controversial (8, 9). Only a few investigators (8, 10, 11) have begun exploring these possibilities. White oak, endemic to eastern United States and commonly found in Pennsylvania forests, has not been studied.

The purpose of this initial investigation was to compare the mycorrhizal distribution of white oak *(Quercus alba)* in forests with soils of different edaphic characteristics but with similar climatological characteristics, including the input of acid rain, and to point out the edaphic features that may relate to differences in mycorrhizal distribution. On this basis, parameters for future environmental studies can be recommended. Mycorrhizal quantitation may be another parameter for monitoring the potential environmental effects of acid precipitation and may provide additional insight into the assessment of host productivity.

METHODS AND MATERIALS

Root and soil samples were taken monthly using the methods of Harvey et al. (12). Ten centimeter sample cores were taken within the foliar canopies of large, apparently healthy trees (25 to 76 cm dbh) at distances 0.6 to 1.5 meters from the trunk at midday.

The term "mull" refers to forested soils with a humus rich layer consisting of mixed mineral and organic matter that blend without an abrupt change in soil characteristics; the term "humus-mull" refers to the AH horizon which is the upper horizon of mull soil. The term "mor" refers to forest soils with a distinct, unincorporated, humus layer of organic material that is often matted; "humus-mor" refers to the O_2 horizon which is the distinct, upper, dark mat (13, 14).

The mull forest, located in the central limestone valley of Northampton County (10 km. west of Easton), was composed of large, old oaks *(Quercus alba, Q. rubra* and *Q. velutina)* with *Acer rubrum* and *Carya species* as smaller associates and *Rhus radicans* covering the forest floor. The mineral soil type was an alfisol of the Washington series which have the following characteristics: soils are deep and well drained, formed in glacial till and weathered mostly from limestone. These soils have high available moisture capacity and moderate permeability (15). The general profile is: O_1 - litter, Ap (AH) - 0-25 cm., dark yellowish brown silt loam, friable, stone-free and neutral; B21t (M_1) - below 25 cm., brown silty clay loam, friable and neutral. The solum ranges from 1-2 m. depth with bedrock usually found below 2 meters (15). Soil cores were not retrieved below 36 centimeters.

The mor forests, located on the Pocono Plateau in Pike County and more specifically—the environs of two acidified lakes (Bruce Lake at Promised Land and White Deer Lake, 8 km northeast of the former), were similarly composed of oaks *(Quercus rubra, Q. prinus, Q. alba* and *Q. velutina)* with *Acer rubrum* as a common associate and *Betula lenta* as a less common but noticable species. The understory was composed of *Hamamelis virginiana, Rhododendron* sp., *Vaccinium* sp., *Gaylussacia* sp., *Gaultheria procumbens* and diverse mosses. The soil types were spodosols (16) which are often not well drained. The general profile of these acid soils consists of: O_1 (litter) of considerable thickness, O_2 (humus) - 5 to 10 cm black mat of tangled humus and roots, M_1 - 2 to 7 cm mineralized soil of ashen gray color, M_2 - > 15 cm layer of soil with medium yellow-brown or medium reddish-gray color. The solum, often wedged between boulders, is shallow.

Both forest types were located in a humid continental climate with a mean daily temperatures of 29°C (max.) and 16°C (min) from June through August and an average summer rainfall of 10.6 cm per month (15). Temperatures were cooler and rainfall higher than average (June - Aug., 1984); more than 22 cm of rainfall occurred in July alone. The precipitation pH (weighted mean) range was reported as 3.9 to 4.7 for three successive years, 1981-1983 (17). Both the precipitation, pH and the impact from auto exhaust were similar for all locations; major interstate highways were less than 3.2 km from each forest.

Root samples were prepared for counting by presoaking (1-3 hr) in tap water and gently rubbing soil particles from the feeder roots (18). Root segments averaging 7 cm in length were cut from the intact root system. Random segments with diameters from 0.5 to 1.5 mm were chosen for counting. These root segments comprised the fine branch roots on which the smaller feeder roots,

TABLE 1

Mycorrhizal Distribution of the White Oaks in the Mull Forest during 1984.

				Feeder Root Counts[1]								Root Tip Counts[3]						
Date	Soil Horizon	Temp °C	pH	Total[1] Root Length, cm.	Total number, Feeders	% Feeders Mycorrhizal	% Active	I[2]	II[2]	III[2]	IV[2]	Total Root Length, cm.	Total[3] Root Tips	RTF[4]	% Mycorrhizal	MF[5]	% Active	AMF[6]
May 7	AH	(<12)	6.5	150	281	80	12	11	1	0	0	54	485	8.9	95	8.5	15	1.3
June 22	AH	16.6	6.6	188	271	95	60	42	8	1	9	71	546	7.7	93	7.1	47	3.6
	M_1	14.4	6.9	130	80	90	10	7	2	1	0	53	35	0.7	71	0.5	11	0.1
Aug. 16	AH	19.3	6.8	536	642	86	56	27	14	8	7	134	5329	40.0	84	34.0	40	15.0
	M_1	17.7	7.2	99	76	56	12	8	4	0	0	75	591	8.0	50	3.5	6	0.5
Sept. 4	AH	14.4	7.1	320	384	69	53	23	11	10	9	68	2362	35.0	80	27.5	48	16.7

Average depth of soil horizons: AH, 19cm; M_1, more than 20cm (all available roots of this horizon were counted). [Litter was shallow, 2.0cm].
[1]In the uppermost soil horizon, 50 root pieces of a randomized sample were counted according to the USDA Forestry Bulletin (19).
[2]Notation for amount of activity: I, 1-3 roots actively mycorrhizal; II, 4-8 roots actively mycorrhizal; III, 9-15, IV, 16 & more.
[3]Root tip counts were made according to Grand & Harvey (18).
[4]The frequency of all root tips, both mycorrhizal and non-mycorrhizal, per unit length of fine root segment (RTF) is a representative basis for expressing the extent of root tip distribution and can be used as an index for comparing the absorptive area for trees of different areas.
[5]The frequency of all mycorrhizal root tips, both active and inactive, per unit length of fine root segment (MF), a representative basis for expressing the extent of mycorrhizal distribution, can be used comparatively for trees from different areas.
[6]The frequency of active mycorrhizal root tips per unit length of fine root segment (AMF), is a representative basis for expressing the extent of active mycorrhizal distribution and can be used to compare active mycorrhizal frequencies of trees from different areas.

TABLE 2

Mycorrhizal Distribution of the White Oaks in the Mor Forests for 1984.

				Feeder Root Counts[1]								Root Tip Counts[3]						
Date	Soil Horizon	Temp °C	pH	Total[1] Root Length, cm.	Total number, Feeders	% Feeders Mycorrhizal	% Active	I[2]	II[2]	III[2]	IV[2]	Total Root Length, cm.	Total[3] Root Tips	RTF[4]	% Mycorrhizal	MF[5]	% Active	AMF[6]
May & June	O_2	14.8	4.7	535	959	20	16	15	1	0	0	166	502	3.9	28	0.9	12	0.4
	M_1	13.8	4.0	290	624	28	25	24	1	0	0	-	-	-	-	-	-	-
	M_2	12.5	5.0	99	182	23	20	18	2	0	0	-	-	-	-	-	-	-
July	O_2	16.0	4.0	1135	1888	82	57	47	8	2	0	165	1232	7.5	70	5.2	26	2.3
	M_1	13.4	4.1	1049	1547	70	53	46	6	1	0	254	1532	6.0	49	3.0	33	1.9
	M_2	12.3	4.5	167	206	74	53	49	2	1	0	94	367	3.9	57	2.2	53	1.9
Aug.	O_2	17.6	3.4	513	715	64	43	26	12	4	1	223	2426	10.8	64	6.9	38	4.1
	M_1	16.6	3.3	254	346	61	38	23	9	3	3	167	777	4.6	72	3.3	49	2.2
	M_2	15.6	3.7	178	163	33	20	17	2	1	0	145	343	2.3	41	1.0	19	0.4

Average depth of soil horizons: O_2 horizon, 7cm; M_1, 4 cm; M_2, 14 cm (Litter, O_1, is thicker, 3.5 cm).

[1]In the uppermost soil horizon, 50 root pieces of a randomized sample were counted according to the USDA Forestry Bulletin (19).

[2]Notation for amount of activity: I, 1-3 roots actively mycorrhizal; II, 4-8 roots actively mycorrhizal; III, 9-15, IV, 16 & more.

[3]Root tip counts were made according to Grand & Harvey (18).

[4]The frequency of all root tips, both mycorrhizal and non-mycorrhizal, per unit length of fine root segment (RTF) is a representative basis for expressing the extent of root tip distribution and can be used as an index for comparing the absorptive area for trees of different areas.

[5]The frequency of all mycorrhizal root tips, both active and inactive, per unit length of fine root segment (MF), a representative basis for expressing the extent of mycorrhizal distribution, can be used comparatively for trees from different areas.

[6]The frequency of active mycorrhizal root tips per unit length of fine root segment (AMF), is a representative basis for expressing the extent of active mycorrhizal distribution and can be used to compare active mycorrhizal frequencies of trees from different areas.

—Not available at this time.

containing the root tips, were the final distal extremities. Root segments were measured before mycorrhizal counts were made; total segment length served as the basis for calculating mycorrhizal frequencies.

Enumeration of mycorrhizae was accomplished in two ways. In the first method, feeder roots on fifty or more of the random segments were evaluated (19). Three sets of data were recorded: the number of feeder roots, the number of feeder roots possessing mycorrhizae (both active and inactive) and the number of feeders possessing only active mycorrhizae. Corresponding percentages of the totals appear in Tables 1 and 2. The approximate numbers of active mycorrhizae per feeder were also scored from I to IV with I indicating 1-3 active mycorrhizal tips, II (4-8), III (9-15), and IV (16 and more), and displayed as a portion of the total active mycorrhizal percentages (Tables 1, 2). Active mycorrhizae were scored when root tips were decidedly swollen, light-colored and turgid-looking. Mycorrhizae were considered inactive when swollen root tips were wrinkled, unraveling, or rather dark when compared to the active ones. In the second method of evaluation, each root tip was tallied into the proper activity column, that is active, inactive or non-mycorrhizal (18, 20). These totals, when compared to the total length of segments evaluated, provided ratios called frequencies (21). The ratio of all root tips, or the sum of mycorrhizal and non-mycorrhizal tips, per centimeter of root segment (Tables 1, 2) indicated the frequency of root tips (RTF). Likewise, the ratio of all mycorrhizal root tips per centimeter of root segment indicated the frequency of combined mycorrhizae, both active and inactive (MF); and the ratio of active mycorrhizae per centimeter of root segment indicated active mycorrhizal frequency (AMF). Both methods (feeder and tip-frequency) provided similar information; the former was faster but the latter, which approached volumetric quantitation, was more representative of fine root status and proliferation. Frequency data served as indices and provided a basis for comparisons between seasonal changes, soil horizons and different locations.

Roots of each soil horizon were enumerated separately. Field recorded data for each horizon included: depth in centimeters, description, temperature in degrees Celsius, and pH. Soil pH was determined by mixing soil with deionized water (1:1 by volume) and recording the stabilized pH of soil-water with a field pH meter. Soil fractionation was accomplished in the field (20).

Soil data (Merkle and Baker tests) were supplied by The Pennsylvania State University. Merkle testing involved the use of ammonium acetate extractions to obtain plant available Mg, Ca and K; ammonium fluoride extractions were used to obtain P values. Total nitrogen values were obtained by the Kjedahl method. Standard methods for the above analyses are found in Black (22). Other soil testing procedures included the Walkley-Black titration method to determine soil organic matter (23) and testing procedures for heavy metals (Table 4) as carried out in the Soil and Environmental Chemistry Laboratories.

RESULTS

Ectomycorrhizae of the two locations were similar in distribution. The upper soil horizons, humus-mull and humus-mor, generally contained higher percentages for both mycorrhizal feeders and mycorrhizal root tips than the lower, M_1 layer, as shown in Tables 1 and 2. These results concurred with the findings of others (12, 16). As summer progressed, fungal hyphae penetrated the uppermost portion of the humus and the lower portions of

the litter. This fungal activity could be seen in the field with the naked eye and often seemed to be associated with mycorrhizae. Active mycorrhizae (%) increased similarly through the growing season in both kinds of soil. Spring samples of the humus-mull displayed 15% active mycorrhizal root tips (Table 1); this increased to 47% by mid-June and remained high through the summer (40%, August; 48%, September). The corresponding data for humus-mor changed from 12% in spring to 26% in July and 38% in August (Table 2). The percentage of feeder roots that contained active mycorrhizae reflected similar results (Tables 1 and 2). This trend generally corresponded to increases in soil temperatures.

Several differences between the mycorrhizae of the two locations were demonstrated by other parameters including changes in the number of active mycorrhizae on feeder roots and the frequency data (MF, AMF and RTF).

The extent of active mycorrhizae on feeder roots, scored as categories I-IV, increased the most in humus-mull with a shift to higher percentages in categories III and IV through the growing season (Table 1). Mor soils supported lower numbers, mostly category I, although slightly higher pecentages were recorded in other categories as summer progressed (Table 2). These observations were consistent with the size of mycorrhizal clusters which were scant in mor soils but readily apparent in the mull soil. The more compact, spheroidal clusters in humus-mull increased in size through the summer with some as large as 1 centimeter by early September.

Although MF increased in both kinds of soil through the season, the mull soil contained the greater numbers of mycorrhizae per centimeter of root segment. The MFs (humus-mull, AH horizon) increased from 8.5 in early May to 34.0 and 27.5 in August and September, respectively (Table 1). The mor soils contained relatively low numbers of mycorrhizae by comparison; the humus-mor (O_2 horizon) changed from 0.9 in spring to 5.2 in July and 6.9 in August (Table 2). Even though MFs' increased in each location, the spring numbers in humus-mull (8.5, Table 1) were higher than those from the humus-mor after summer growth (6.9, August, Table 2) and were nearly the same as the total MFs of all horizons (O_2, M_1, and M_2) in summer Pocono soils (10, July or 11, August; Table 2). The August values of the mull were generally higher than that of the mor by a factor of 4 (34, humus-mull versus 6.9, humus mor; 37, humus-mull plus M_1 versus 11, added horizons of mor; Tables 1, 2).

The index most indicative of absorptive surface area, AMF, showed the same developmental pattern in both soils; AMF values were very low in spring and increased significantly by late summer. AMF values of humus-mull changed from 1.3 in May to 16.7 by early September (Table 1) while the humus-mor ranged from 0.4 to 4.1 during a similar time period. The late summer values demonstrated more active mycorrhizae in the humus-mull by a factor of 4. Although the humus horizons of both soils had higher AMF values than each of the mineralized layers, the lower layers in the mor soil contributed to active mycorrhizal surface area. This was demonstrated by a comparison of composite AMFs of all horizons in each type of forest. Late summer composite AMFs in the mull forest (AMF = 16.7, Table 1) were higher than the mor forest (AMF = 6.7, Table 2) by a factor of 2.5. Although this comparison showed a decreased differential between the two forests, the overall difference in numbers of active mycorrhizae was significant enough to indicate a greater capacity for mineral ion absorption and potential productivity for trees of the mull forest. This difference was generalized and essentially repeated with the index showing very fine root proliferation, root tip frequency (RTF). The composite RTFs in the horizons of the mull forest was 48 by August as compared with 17.7 in the mor forests (Tables 1, 2); that is, total root tips were more abundant in the mull soil than in the mor soil by a factor of 2.7 at a comparable time.

There was a contrast of inactive mycorrhizae between the two locations in early spring. This was shown by the large discrepancy between MF and AMF (8.5 – 1.3 = 7.2) in the May samples of the humus-mull and the small discrepancy in the humus-mor (0.9 – 0.4 = 0.5) and corresponded to microscopic observations as well as counts. Inactive mycorrhizae did not seem to withstand winter conditions in the mor soil. During the remainder of the study period, inactive mycorrhizae constituted about half of the mycorrhizae in both locations. Inactive mycorrhizae of the humus-mor were light-colored, wrinkled and unraveling while those of the humus-mull were smooth-surfaced and darkened. Other than the differences in appearance and winter carry over, inactive mycorrhizae did not provide a diagnostic basis for comparison.

Similar edaphic features of both forests included soil temperature ranges and comparable soil moisture levels. There was a general increase of soil temperature for each layer of the soil profile during the period of study with the uppermost horizon

TABLE 3

*The results of Merkle assays for soil samples taken during July, 1984**

Area	Soil Horizon	Soil pH	pH Buffer	p lb/acre	K Meq/100gm	K % sat.	Mg (meq/100gm)	Mg % sat.	Ca meq/100gm	Ca % sat.	CEC
Mull Forest	AH	7.1	7.0	14.0 V*	0.70H*	3.7	1.2 N*	6.8	16.7 H*	89.3	18.7
	M_1	7.2	7.0	14.0 V	0.49 H	6.6	0.5 N	7.1	6.5 H	86.2	7.5
	M_2	M_2 Layer not sampled for reasons of depth.									
Mor Forest, Bruce Lake	O_2	3.6	4.5	18 V*	0.90 N*	2.5	1.0 L*	2.8	4.0 V*	11.2	35.6
	M_1	3.6	4.8	6 V	0.28 L	1.0	0.3 L	1.2	1.2 V	4.4	27.9
	M_2	4.2	4.8	2 V	0.15 L	0.5	0.2 L	0.8	0.5 V	1.8	26.9
Mor Forest, W. Deer L.	O_2	3.9	4.9	76 N*	0.93 N*	2.4	1.4 L*	3.9	10.2 L*	27.3	37.4
	M_1	3.8	4.9	18 V	0.35 L	1.2	0.5 L	2.1	2.2 V	8.0	28.0
	M_2	4.3	5.6	100.N	0.25 L	1.4	0.2 L	1.3	0.5 V	2.9	17.2

*Although numbers record absolute values, the pH of the soil influences the availability as indicated below:

V = very low
L = low
N = normal
H = high
E = excessive

*Merkle assays for composite soil samples taken during August are similar to those taken during July.

warming the most. The values reported in Tables 1 and 2 were consistent with the horizon temperatures reported by Johnson (16) for this latitude and time of day. Neither soil moisture levels nor soil O_2 levels were recorded but samples were generally aerobic. Monthly samples from each forest had similar moisture content.

Dissimilar edaphic features between the two forests included horizon depth and stoniness. The litter of the mull forest, composed of bark and leaves, was shallow (2.0 cm) while the litter of the mor forest, composed primarily of leaves, was deeper (3.5 cm). The depth of the humus-mull (AH horizon) averaged 19 centimeters while the humus-mor (O_2 horizon) was shallower and averaged 7 centimeters. The uppermost mineralized layer of each forest type differed in average depth also with the alfisol M_1 below 20 centimeters and the spodosol M_1 much shallower (4 cm). The alfisol was relatively stone free while the spodosol was very stoney (class 4) according to Johnson (16).

Other dissimilar edaphic features were delineated by soil chemistry analysis. The July samples of humus-mull reflected values typical of an alfisol, as described in Methods, with a low amount of organic matter (12%, Table 4), neutral pH (7.1, Tables 3, 4), moderate to high natural fertility with adequate amounts of potassium, magnesium and calcium (Table 3), normal cation balance of these elements (Table 4) and indications of adequate total nitrogen (0.27 %, Table 4), but with very low available phosphorus (Table 3). The cation exchange capacity of the AH horizon (CEC, 18.7 meq per 100 gm., Table 3) represented 99.5% base saturation as calculated according to Bohn (24). The black, mat-like mor horizon of the Pocono forests contrasted with the humus-mull and had high amounts of organic matter (51% - 41%, Table 4), acid pHs, 3.3-3.9 (Tables 3, 4), low natural fertility with small amounts of magnesium, calcium and phosphorus but adequate amounts of potassium (Table 3) and high levels of total nitrogen (0.76 to 0.88%, Table 4). The CEC (Bruce Lake Forest, 35.6 meq per 100 gm., Table 3) corresponded to 46% base saturation; similar values were recorded for August soil samples. Elevated levels of heavy metals (manganese, iron, copper, zinc, aluminum, nickel and cadmium) were recorded for the O_2 and M_1 horizons of the Pocono soils but normal or low levels were recorded for the AH horizon and the mull forest (Table 4).

DISCUSSION

The general increase of active mycorrhizal numbers corresponded to increases in soil temperatures. The highest mean temperatures were recorded for soil during August as were the highest AMFs (Tables 1 and 2). This concurred with the information in Powell (4) which states that the temperature optima for most ectomycorrhizal fungi lie within the range of 18 to 27°C. August temperatures for both forest types were both at the low end of this optimal range.

Although the occurrence of active mycorrhizae in the mor forests increased through the summer, the pattern was generally depressed when compared to the mull forest. Only one fourth as many active mycorrhizae were present in the upper horizon of the mor forest as in the mull forest by late summer. When the numbers of active mycorrhizae representing the entire soil profiles were compared, less than half as many were present in the mor soil than in the mull soil. Even though other procedures such as volumetric enumeration and estimates of mineral ion incorporation need to be carried out and related to the AMF index before this simpler procedure can be considered for diagnostic use, the differences in AMFs were sufficient to suggest impaired productivity for the white oaks of the mor forest.

The dissimilar edaphic features of the two locations most likely influenced the difference in AMFs. As mean temperatures and aeration for both locations were similar, other edaphic features must be considered. Features of the uppermost soil horizon were emphasized as most of the fine root structure occurred there.

Mycorrhizal formation is enhanced when soil nitrogen and phosphorus levels are low (4). Phosphorus levels were low in both locations, but the percent total nitrogen for the humus-mor was 2.5-3.0 times higher than that of the humus-mull (Table 4). Elevated nitrogen levels of the humus-mor may interfere with the production of fungal auxin, preventing mycorrhizal formation

TABLE 4

The results of Baker assays taken for soil samples during July, 1984.

			Cation Balance[x]														
	Soil Horizon	pH[+]	Ca&Mg H	Mg K	Ca Mg	Mn	Fe	Cu	Zn	Na	Al	Pb	Ni	Cd	% Organic Matter	% Total Nitrogen
Mull Forest	AH	7.1	5.8N*	1.8N*	0.8N*	8.2L*	20.2N*	15.0L*	10.6N*	58.4L*	12.7L*	12.0N	14.4L	13.2N	12.1	.277
	M_1	7.1	5.8N	1.9N	0.76N	8.4L	20.6N	15.4V	11.7L	60.7L	13.0L	12.6L	14.4L	14.0L	4.2	.049
	M_2	M_2 Layer was below the sampling depth.														
Mor Forest, Bruce L.	O_2	3.3	2.0V	1.7L	0.7N†	4.2E	4.7E	5.6E	4.4E	56.1L	4.4E	5.7N	5.8E	6.9E	41.2	.756
	M_1	3.4	2.1V	1.9N	0.6N	4.7E	14.7E	11.7N	8.1E	59.8L	7.2E	9.3L	11.3H	9.6E	11.6	.347
	M_2	4.0	2.7V	2.0N	0.6N	5.6H	15.9E	13.0N	9.6H	56.7L	8.1E	11.0L	13.0N	10.9E	9.9	.094
Mor Forest, W. Deer L.	O_2	3.8	2.5V	1.7L	0.6N†	3.8E	11.2E	7.8E	4.8E	57.5L	4.5E	5.3N	7.7E	7.0E	50.8	.884
	M_1	3.7	2.5V	1.8N	0.6N	4.7E	12.4E	9.7E	6.1E	66.2L	4.8E	7.4L	9.3E	7.6E	14.5	.210
	M_2	4.4	3.1V	2.0N	0.6N	6.7N	17.1H	13.7N	11.0N	64.0L	9.2H	12.0L	13.9H	12.0H	9.5	.116

[+]These pH values were determined by the Baker method.
*The availability of minerals follows the notation:
V = very low
L = Low
N = Normal
H = High
E = Excessive
[x]Other cation data is given in Table 4.
†Although the some ratios appear normal for Pocono soils, the amounts available are low (Table 3).

(5). Even though acid rain provides a source of nitrogen sufficient to increase nitrogen availability in ecosystems (25), the acid deposition is more similar than dissimilar in the two locations and the difference in % total nitrogen is more likely explained by the differences in soil organic matter. The organic content of Pocono soils was greater by a factor of four (Table 4). Accumulations of humic and tannic acids that occur under the acid conditions of mor soils, also inhibiting mycorrhizal formation (5).

Most of the soil pH values in the mor forests (4.7-3.3), fell below 4.6. Acidity greater than 4.6 is associated with harmful or potentially harmful effects on biota and ecosystems (1). Meyer (5) and others reported that contrary to former belief, many mycorrhizal fungi grow best at weakly acidic pHs in pure culture; however, acid soil (pH 3.0) was found to have a negative effect on growth of both mycorrhizal and non-mycorrhizal red pine seedlings (11). Meyer (5) indicated that mycorrhizal associations may become parasitic when host plants are under stress; the wrinkled, unraveling appearance of inactive mycorrhizae in the mor soils should be studied for evidence of this. Schutt (10) indicated that outright pathogenicity increases when soil acidity promotes the availability of toxic elements (Al + Mn), upsetting the balance of mycorrhizal and other microbial associations and giving way to wetwood symptoms. Indications in these and other reports point up the complexity of the soil matrix and its interacting factors.

According to Aber et al. (9), potential effects of acid precipitation on forest soils include decreased base saturation, reduced availability of cations and increased solubility of heavy metals. All of these conditions seem to prevail in the Pocono forest soils, but not in the mull soil. High CEC values, as occurred in all the soils studied, indicated high nutrient storage capacity; however, in mor soils the low percent base saturation indicated that much of that storage capacity was occupied by hydrogen ions rather than other cations (26). The availability of nutrient cations, especially calcium and magnesium, was low in mor soils but not in mull soil. The levels of available heavy metals in the Pocono forest soils were high. The values for copper and zinc were several times higher than those reported by Siccama (14) for humus-mor soils in Massachusetts forests in 1978. Elevated levels of heavy metals interfere with many biological processes. Copper, for example, is used as a general fungicide; more specifically, copper inhibits amylase activity (27) which relates to decreased mycorrhizal formation in that high sugar levels are required to sustain the mycorrhizal association. Several other toxic elements in the mor soils were readily available, such as manganese, iron, aluminum, nickel and cadmium. Availability of heavy metals increases with increasing soil acidity. The overall impact is recognized as a negative one for biological activity generally, including the development of roots and mycorrhizal fungi. Although the mor forests are naturally acid, continual input of acid rain may produce incremental edaphic effects which, in turn, would have an impact on the biota. Sequential yearly studies are necessary to establish judgemental baselines.

Bjorkman (6) demonstrated the positive correlation between enhanced photosynthetic rates and enhanced mycorrhizal frequency. The partial shading of plants produced lower mycorrhizal frequency. He attributed this finding to lowered carbohydrate produced by the host plants. A general relationship should exist then, between photosynthetic efficiency of the host and mycorrhizal frequency. Circumstances that curb photosynthetic rate, such as the photochemical oxidants of air pollution (28) and predation such as gypsy moth defoliation have a probable negative impact on mycorrhizal frequency and long term potential forest productivity. Although climatological features were generally the same for both study areas, including the input of acid rain and photochemical oxidants, the extent of predation may have differed between the two locations constituting an overall environmental difference that should be recognized.

The present investigation of the factors influencing mycorrhizal frequency in this preliminary study suggests that mycorrhizae are a potential parameter for gaining insight into the interacting complexities of forest biosystems and for monitoring the effects of acid deposition.

ACKNOWLEDGEMENTS

We wish to acknowledge Dr. P. Bradt and Ms. J. Dudley of Lehigh University and Prof. D. Baker, Ms. M. Long, and Mr. B. Moser of the Pennsylvania State University for consultations. We wish to thank the Bureau of Forestry, Department of Environmental Resources for cooperation with site selection, especially Mr. S. Shelton, Park Superintendent of Promised Land State Park and Dr. I. Mineo, Superintendent of Parks, Northampton County for access to the remote areas of these respective forests. We are indebted to the following members of the Biology Department, Lafayette College: Ms. J. Clymer for manuscript preparation, Mr. P. Auerbach for technical assistance and, especially, Prof. L. T. Stableford, Emeritus, for reviewing this manuscript.

REFERENCES CITED

1. Likens, G. E., R. F. Wright, J. N. Galloway and T. J. Butler. 1979. Acid Rain, Sci. Amer., 241: No. 4, 43-51.
2. Acid Rain Research, A Special Report, EPRI Journal, Vol. 8, No. 9, Nov., 1983, p. 64.
3. Hornbeck, J. W. 1981. Acid Rain: Facts and Fallacies, Jour. of Forestry, 79: No. 7, 438-443.
4. Powell, C. 1982. Chapter 26, Mycorrhiza in *Experimental Microbial Ecology;* Barns, R. and J. H. Slater (eds.), Blackwell Scientific Publications, Boston.
5. Meyer, F. H. 1974. Physiology of Mycorrhizae. Annual Review of Plant Physiology, 25: 567-586.
6. Bjorkman, E. 1970. Forest Tree Mycorrhiza-The Conditions for its Formation and Significance for Tree Growth Afforestation. Plant and Soil 32: 589-610.
7. McLaughlin, S. B., T. J. Blasing, I. K. Mann, and D. N. Duvick. 1983. Effects of Acid Rain and Gaseous Pollutants on Forest Productivity: A Regional Scale Approach. JAPCA, 33: 1042-1049.
8. Tamm, C. 1976. Acid Precipitation: Biological Effects on Soil and on Forest Vegetation. (Stockholm) Royal Swedish Academy of Sciences, 5: 235-238.
9. Aber, J. D., G. R. Hendrey, D. B. Botkin, A. J. Francis and J. M. Melillo. 1982. Potential Effects of Acid Precipitation on Soil Nitrogen and Productivity of Forest Ecosystems. Water, Air, and Soil Pollution, 18: 405-412.
10. Schutt, P. 1981. Towards an Explanation of Silver-fir Dieback. Schweizerische Zeitschrift fur Forstwesen, 132, 6: 443-452.
11. Wang, C. 1983. Effects of Acid Precipitation on Ectendomycorrhizal Associations in Red Pine. Progress Report CRIS USDA, (data base information).
12. Harvey, A. E., M. J. Larsen and M. F. Jurgensen. 1979. Comparative Distribution of Ectomycorrhizae in Soils of three

Western Montana Forest Habitat Types. Forest Sci., 25: 350-358.
13. Armson, K. A. 1977. *Forest Soils, Properties and Processes.* University of Toronto Press, Toronto, pp. 79-85.
14. Siccama, T. G., W. H. Smith and D. L. Mader. 1980. Changes in Lead, Zinc and Copper, Dry Weight and Organic Matter Content of the Forest Floor of White Pine Stands in Central Massachusetts Over 16 Years. Environmental Sci and Technol., 14: 54-56.
15. Soil Survey of Northampton County, Pennsylvania (Gov't. Document). 1974. USDA Soil Conservation Service and Pennsylvania State Univ., pp 103-104 and pp 116-117.
16. Johnson, W. M. 1975. *Soil Taxonomy.* Agricultural Handbook #436. USDA Soil Conservation Service, p 754.
17. Bradt, P. T., M. Berg, D. Barasso and J. Dudley. 1984. The Biological and Chemical Impact of Acid Precipitation on Pocono Mountain Lakes. Pennsylvania Power and Light Company, Allentown, Pa. p. 25.
18. Grand, L. F. and A. E. Harvey. 1982. Quantitative Measurement of Mycorrhizae in Plant Roots, pp 157-164, in *Methods and Principles of Mycorrhizal Research.* N.C. Schenck (ed.). American Phytopathological Society, St. Paul, Minnesota, p 237.
19. USDA Forest Service. 1979 (revised 1980 pamphlet). How to Recognize and Quantify Ectomycorrhizae on Conifers. Forestry Bulletin, SA-FB/PB, 1720 Peachtree St. N.W., Atlanta, GA.
20. Harvey, A.E. M. J. Larsen and M. F. Jurgensen. 1976. Distribution of Ectomycorrhizae in a Mature Douglas-fir/Larch Forest Soil in Western Montana, Forest Sci., 22: 393-398.
21. Slankis, V. 1974. Soil Factors Influencing Formation of mycorrhizae. Annual Review of Phytopathology, 12: 437-457.
22. Black, C. (ed.). 1965. *Methods of Soil Analysis, Part 2, Chemical and Microbiological Properties.* American Society of Agronomy, Inc., Madison, Wisconsin, p. 1572.
23. Noonan, L. and E. Holcombe. 1975. Procedures for Chemical Analysis of Plant and Soil Samples of Oregon State University. U.S./IBP Conference for Biome. Int Rep 160. Coll. For. Res., Univ. Washington, Seattle.
24. Bohn, H. L., B. L. McNeal and G. H. Connor. 1979. *Soil Chemistry.* John Wiley and Sons, New York. pp. 206-207.
25. Gorham, E. F., B. Martin and J. T. Litzau. 1984. Acid Rain: Ionic Correlations in the Eastern United States, 1980-81. Science 225: 407-409.
26. McFee, W. W., J. M. Kelly and R. H. Beck. 1977. Acid Precipitation Effects on Soil pH and Base Saturation of Exchange Sites. Water, Air and Soil Pollution, 7: 401-408.
27. Lepp, N.W. 1981. Copper, pp 111-144. In: *Effect of Heavy Metal Pollution on Plants,* Vol. I, Lepp, N. W. (ed.).
28. Aber, J. D. 1984. Acid Deposition and Heavy Metal Effects in Forest Ecosystems: A Review. Wisconsin Power and Light Co. and the College of Agriculture and Life Sciences, Univ. of Wisconsin, Madison, Wisconsin, p. 23.

Proceedings of the Pennsylvania Academy of Science 58: 99-100. 1984

RESEARCH NOTE:

OREOCHROMIS AUREUS (STEINDACHNER: CICHLIDAE), AN EXOTIC FISH SPECIES, ACCIDENTALLY INTRODUCED TO THE LOWER SUSQUEHANNA RIVER, PENNSYLVANIA[1]

WILLIAM F. SKINNER

Pennsylvania Power & Light Co.
Ecological Studies Laboratory
4417 Hamilton Blvd.
Allentown, Pennsylvania 18101

Oreochromis aureus (Steindachner; renamed from *Tilapia aurea;* Trewavas 1983), commonly known as blue tilapia, is a member of the fish family Cichlidae and non-native to North America. Cichlids were imported into the southern United States beginning in the 1960's for research, aquaculture, recreational and aquatic weed control purposes (Shafland 1979; Robins *et al.* 1980; Courtenay and Stauffer 1984). The potential of *O. aureus* is now being investigated in Pennsylvania for commercial production as table fare (T. Beck, Brunner Island Aquaculture Facility, York Haven, PA, pers. comm.).

Cichlids are native to tropical and warm sub-tropical areas of Africa and Central and South America. They consequently prefer higher ambient temperatures for reproduction, juvenile growth and adult maintenance than do most of our native fishes (McBay 1961). Therefore, escape of cichlids, particularly *Oreochromis, Sarotherodon* and *Tilapia* spp., into waters of the United States would not, *a priori,* be cause for concern. However, accidental and intentional introductions of cichlids to waters of the southeastern United States have had major impacts on resident fish communities (Shafland 1979).

Blue tilapia convert food efficiently, grow rapidly, reach sexual maturity in 4-6 months (Tave and Smitherman 1980) and reproduce as frequently as every 4-6 weeks. They have an exceptional ability to adapt to new and adverse environmental conditions, and are resistant to disease and parasites (Pinto 1982; Shafland 1979). These characteristics contribute to blue tilapia's attractiveness as aquaculture species. Ironically, these same characteristics also make blue tilapia a threat to native fish species in the Susquehanna River. Evidence is presented here that indicates *O. aureus* has been introduced to the Susquehanna River and that conditions do exist, primarily in artificially heated industrial cooling waters, which may offer winter-time refugia and may enable this exotic species to become established.

Thirty-one specimens of *O. aureus* were collected on 18 September 1984 from two locations in the lower Susquehanna River by biologists from Pennsylvania Power & Light Company's Ecological Studies Laboratory (Fig. 1 & Table 1.). Shorezone fish collections with a backpack electroshocker yielded 18 individuals (76-141 mm TL) from shallow (75-100 cm deep) backwater areas near the mouth of PP&L's Brunner Island Steam Electric Station cooling water discharge canal (lat 40° 5' 30", long 76° 41' 15").

Thirteen individuals (26-70 mm TL) also were collected in shallow (10-50 cm deep) pool/backwater areas approximately 1.7 km downriver from Brunner Island SES and some 200-300 m out from the west river bank. Water temperatures in these two areas

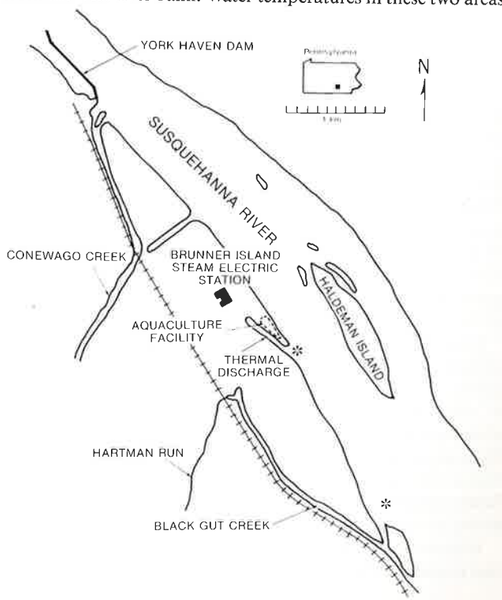


FIGURE 1. Susquehanna River locations (*) where *Oreochromis aureus,* blue tilapia, was collected on 18 September 1984.

[1]Revised; accepted October 22, 1984.

TABLE 1

Total length (20 mm group), mean weight ($\bar{x}$, Grams) and sex of Oreochromis aureus *collected from two locations in the Susquehanna River on 18 September 1984.*

	Length Group													
Location	21-40	$\bar{X}$ Wt.	41-60	$\bar{X}$ Wt.	61-80	$\bar{X}$ Wt.	81-100	$\bar{X}$ Wt.	101-120	$\bar{X}$ Wt.	121-140	$\bar{X}$ Wt.	141-160	$\bar{X}$ Wt.
Mouth of Brunner Island SES cooling water discharge canal														
male					1	10.5	1	17.1	6	25.2	2	55.4	1	64.5
female									2	34.3				
1.7 km downriver from Brunner Island SES														
female					1	6.3								
not sexed	4	1.8	4	2.2										
not sexed or weighed					9									

were 31.0 C and 28.5 C, respectively. Additional specimens of *O. aureus* also were collected in August and September 1984 from the Susquehanna River near Wrightsville and from the river below Conowingo Dam, approximately 19.6 and 78 air km, respectively, downriver from Brunner Island SES (D. Mathur, Muddy Run Ecological Laboratory, pers. comm.).

Although temperatures were suitable at the time of collection for reproduction and spawning of this maternal mouthbreeding species, examination of females indicated no juveniles being held in mouths or incidentally swallowed into stomachs. Two specimens were sent to Dr. Jay R. Stauffer, Jr., The Pennsylvania State University, University Park, PA for positive identification and cataloging in the University's voucher collection (The Pennsylvania State University Fish Museum, Nos. 1512 and 1513). A third specimen was sent to the Mr. Delano Graff, Pennsylvania Fish Commission, Fisheries Division, Bellefonte, PA.

The local source of *O. aureus* is believed to be PP&L's Brunner Island Aquaculture Facility, a research facility currently licensed by the Pennsylvania Fish Commission to propagate and sell this and other fishes. Originally stocked in raceways at the Facility on 13 October 1982, 100—200 blue tilapia of numerous size classes were collected on 23 & 24 August 1983 by ESL biologists in the Facility's oxidation pond and from the Susquehanna River in the immediate vicinity of the oxidation pond discharge, approximately 0.3 km upriver from the mouth of the cooling water discharge canal. Anglers have also reported catching blue tilapia (900-1200 gm) from the Brunner Island SES cooling water discharge canal during the winter of 1983-84 (T. Beck pers. comm.).

The introduction of blue tilapia to the north temperate Susquehanna River would not normally be of concern because this species probably cannot survive prolonged temperatures below 9 C (Shafland and Pestrak 1982). However, winter-time survival of this species may be possible in PP&L's Brunner Island SES and Philadelphia Electric Company's Peach Bottom Atomic Power Station (downriver) thermal discharges which may provide artificially heated areas of water favoring the survival of the species during this period.

Whether or not *O. aureus* will develop an established population in the lower Susquehanna River remains to be documented. However, periodic sampling by PP&L and Pennsylvania Fish Commission biologists will attempt to track its success. Particular emphasis will be placed on sample areas within artificially heated areas during winter months. It is requested that other biologists and anglers report confirmed or suspected specimens, along with location, weight, length, and sex (if available) to the author, or to personnel at the Brunner Island Aquaculture Facility, York Haven, PA.

ESL biologists Robert B. Domermuth and John M. Burke assisted in collections. Acknowledgement is given Dr. Robert F. Denoncourt, Dr. Dilip Mathur and Dr. Jay R. Stauffer, Jr. for reviewing the manuscript. Special acknowledgement is given to Dr. Denoncourt for his untiring encouragement and enlightenment of this author in the pursuit of aquatic sciences.

LITERATURE CITED

Courtenay, W.R., Jr. and J.R. Stauffer, Jr. 1984. Distribution, Biology and Management of Exotic Fishes. The Johns Hopkins Univ. Press. Baltimore. 430pp.

McBay, L.G. 1961. The biology of *Tilapia nilotica* Linneaus. Proc. 15th Ann. Conf., Southeastern Assoc. of Game and Fish Commissioners, 22-25 October 1961.

Pinto, L.G. 1982. Hybridization between species of *Tilapia*. Trans. Amer. Fish. Soc. 111(4): 481-484.

Robins, C.R., *et al.* 1980. A list of common and scientific names of fishes from the United States and Canada. Spec. Publ. No. 12. Amer. Fish. Soc., Bethesda, MD. 174p.

Shafland, P.L. 1979. Non-native fish introductions with special reference to Florida. Fisheries. 4(3): 18-24.

_____ and J.M. Pestrak. 1982. Lower lethal temperatures from fourteen non-native fishes in Florida. Env. Biol. Fish. 7(2):149-156.

Tave, D. and R.O. Smitherman. 1980. Trans. Amer. Fish Soc. 109-(4): 439-445.

Trewavas, E. 1983. Tilapiine Fishes of the Genera *Sarotherodon, Oreochromis* and *Danakilia.* Brit. Mus. Nat. Hist. London. 583pp.

Proceedings of the Pennsylvania Academy of Science 58: 101-102. 1984

RESEARCH NOTE

SEX, AGE, AND DRESSED WEIGHTS OF HUNTER-KILLED SIKA AND WHITE-TAILED DEER FROM ASSATEAGUE ISLAND, MARYLAND[1]

RONALD R. KEIPER, JOEL STEPHENS, and DAVID BALDWIN

[2]*Department of Biology*
The Pennsylvania State University
Mont Alto, Pennsylvania 17237

Sika deer (*Cervus nippon*), native to Japan, Formosa, and the East-Asian mainland, were released on James Island in the Chesapeake Bay in 1916 (Flyger and Warren 1958). Since their introduction, the sika deer have had an average dispersal rate through Dorchester County of about 0.08 km per year (Feldhamer and Chapman 1978). Almost 50 years after their initial introduction, only a few sika deer were shot during the hunting season, compared to an annual harvest of 200-300 white-tailed deer (Flyger and Davis 1964). Since that time, however, the total number of deer harvested in Dorchester County has averaged over 1400 deer, and the proportion of the sika deer in the total harvest has steadily increased from 16.3% in 1973 to 41.1% in 1977 (Feldhamer and Chapman 1978).

Sika deer were introduced onto Assateague Island along the Atlantic Coast of the eastern shore of Maryland in 1923 (Presnall 1958), and by 1935 the herd was estimated at between 100-125 animals (Anonymous 1935). Because much of the island was privately owned, no information was gathered on the size and species composition of the annual harvest for over 50 years after the sika introduction.

Beginning in 1978, however, the National Park Service began to record the number of deer of each species killed by hunters on the Maryland portion of Assateague Island.

In many areas following introduction, sika deer have out competed sympatric species of deer. This has been noted for populations of red deer (*Cervus elaphus*) in New Zealand (Kiddie 1962) and this may be occurring for sika and white-tailed deer in Dorchester County, Maryland (Feldhamer and Chapman 1978). To determine if sika deer were replacing white-tailed deer on Assateague Island, data on the annual deer harvest was examined for 1978-1980. In 1981 and 1982 a deer check station was operated on Assateague during the one week deer seasons, and the species, sex, and dressed weights of harvested deer was recorded. The age of harvested deer, based on tooth replacement and wear, was estimated for deer killed in 1981.

For the years 1978-1982, 260 deer were harvested on the Maryland portion of the Assateague Island National Seashore. Of this total, 200 deer (76.9%) were sika (table 1), of which 42.8% were male, 41.8% were female, and 15.4% were fawns whose sex was not determined. Likewise, of 21 white-tailed deer harvested in 1981 and 1982, 11 (52.4%) were male, 8 were female (38.1%), and 2 were fawns. For both deer species, the male:female sex ratio approached 1.0 (1.03 for sika, 1.37 for white-tailed deer). Since the number of males and females are about equal at birth (Schemnitz 1980), these data suggest that mortality was not sex specific: hunters do not apparently selectively harvest male deer of either species. The relative percentage of sika deer in the total harvest has increased from 72% to 82% in the last five years.

The ages of 44 sika deer killed in 1981 were determined and of these twenty-seven (61.4%) were fawns and yearlings. The average age of the sika deer tallied was 2.02 years (SE;0.20 years). Females were more prevalent in the older age classes, but their average age (x = 2.75 years, SE; .37 years) did not differ significantly ($P > .05$) from that of males (x = 2.22 years, SE; 0.21 years). The fawn:adult female ratio, an indicator of reproductive success, was 62.5%. These results suggest that the sika deer harvest was fairly heavy, with younger animals making up the principal kill. The harvest, in turn, appeared to be balanced by good reproductive success and rate of increase.

The age structure of white-tailed deer harvested was similar to that of sika deer with five (45%) being fawns or yearlings. The small sample size precluded a more detailed analysis.

The dressed weights of 45 sika deer killed in 1981 were obtained. The mean weight of 10 sika fawns was 23.90 pounds. Eighteen adult male deer averaged 48.94 pounds, while 17 adult female sika deer averaged 42.65 pounds. Two white-tailed deer fawns averaged

TABLE 1

Species composition of deer harvested in Assateague Island National Seashore, 1978-1982.

Year	Sika Deer	White-Tailed Deer	Total Deer	% Sika Deer
1978	26	10	36	72.2
1979	38	13	51	74.5
1980	37	16	53	69.8
1981	52	11	63	82.5
1982	47	10	57	82.5
Total	200	60	260	76.9

[1]Received for publication November 11, 1983; reviewed; accepted January 9, 1984.

32.5 pounds. Three male white-tailed deer averaged 86.3 pounds (the fourth male was not field dressed) while 5 female white-tails averaged 54.4 pounds. The small sample size prevented any additional analysis. Sexual dimorphism in weight is characteristic of members of the deer family.

The results suggest that sika deer have been increasing in abundance on Assateague at the expense of the white-tailed deer. The success of the sika deer may be attributed to their more diverse and adjustable feeding habits as opposed to any overtly aggressive behavioral traits (Feldhamer and Chapman 1978).

It may also be possible that white-tails are affected by differential hunting pressure, either because they are more easily seen or simply preferred by hunters. Management practices such as increasing the allowable bag limit of sika deer may be needed to diminish or reverse this differential pressure in the future.

ACKNOWLEDGEMENTS

We thank Nick Hunter, Todd Stephens, Bob Schooley, Karen Pitelli, Barry Hemler, Ann Basehore, and John Coxey for their assistance in the field. The research was supported by funding from the National Park Service (contract USDI PX40000-2-0430).

LITERATURE CITED

Anonymous. 1935. Deer killed in Dorchester County. Maryland Conserv. 12(1):28.

Feldhamer, G. and J. Chapman. 1978. Sika deer and white-tailed deer on Maryland's Eastern Shore. Wildl. Soc. Bull. 6:155-157.

Flyger, V. and N.W. Davis. 1964. Distribution of sika deer (*Cervus nippon*) in Maryland and Virginia in 1962. Ches. Sci. 5:212-213.

Flyger, V. and J. Warren. 1958. Sika deer in Maryland—an additional big game animal or a possible pest. Proc. 12th Annu. Conf. Southeast. Assoc. Game Fish Comm. 12:209-211.

Kiddie, D.G. 1962. The sika deer in New Zealand. N.Z. For. Serv. Inf. Ser. No. 44.35pp.

Presnall, C.C. 1958. The present status of exotic mammals in the United States. J. Wildl. Mgt. 22:45-50.

Schemnitz, S.D. 1980. Wildlife Management Techniques Manual. The Wildl. Soc., Washington, D.C. 686 pp.

Proceedings of the Pennsylvania Academy of Science 58: 103-105. 1984

RESEARCH NOTE:

LONG TERM PROFITS: A DIFFERENCE EQUATION MODEL[1]

R. F. MELKA

Mathematics Department
Division of Natural Science
University of Pittsburgh at Bradford
Bradford, PA 16701

ABSTRACT

Difference equation models are developed for the growth of enterprise. Since the main purpose of an enterprise is to generate profit the question of how to maximize profit over a long term period is investigated. The solution for the linear case involves polynomials whose degree depend upon the time period. A BASIC program is included for the linear and nonlinear cases.

Long Term Profits: A Difference Equation Model

A maximization of profits example is discussed in [1] (p. 20) for an enterprise whose growth rate is assumed continuous. The differential equations of the model are:

$$\frac{du}{dt} = a(1-k)u \qquad \frac{dp}{dt} = ku$$

$$u(0) = u_o \qquad p(0) = 0.$$

Here u(t) represents the total dollar value of an enterprise at time t while p(t) is the accumulated profit and the parameter k a fraction between zero and one.

In contrast to this model, we consider the case of discrete time periods and we designate u(t) by U_t and p(t) by P_t.

Linear Discrete Model

Consider now two extreme cases; the first where all profits are returned for reinvestment and the second where all are paid out. In each case we assume that the growth rate of U_t over one time period is proportional to its total dollar value during that period.

Case (i) All profits are reinvested for enterprise growth: (In this case P_t remains zero for all time)

$$U_{t+1} - U_t = RU_t \qquad U_o > 0$$

$$P_{t+1} - P_t = 0 \qquad P_o = 0.$$

Case (ii) All profits generated are paid as dividends to the owners of the enterprise. (In this case U_t remains at U_o for all time):

$$U_{t+1} - U_t = 0 \qquad U_o > 0$$

$$P_{t+1} - P_t = RU_t \qquad P_o = 0.$$

Consideration of these two cases leads us to the following model:

$$U_{t+1} - U_t = R(1-k)U_t \qquad U_o > 0 \tag{1}$$

$$P_{t+1} - P_t = RkU_t \qquad P_o = 0. \tag{2}$$

We consider the parameter R to be $0 < R < 1$ and the growth rates will always be less than the enterprise value. The parameter k will satisfy $0 \le k \le 1$ and will indicate that fraction of the growth rate to be utilized as profits. We also note that our enterprise model describes moneys invested in an account at R interest rate and k is the fraction of interest withdrawn as "profits." We now consider the problem of choosing k so that the profit is maximized over long time periods.

The solution to (1) is

$$U_t = [1 + R(1-k)]^t U_o \tag{3}$$

so that (2) becomes

$$P_{t+1} - P_t = RkU_o[1 + R(1-k)]^t \qquad P_o = 0 \tag{4}$$

with solution

$$P_t = \frac{kU_o}{1-k}([1 + R(1-k)]^t - 1) \tag{5}$$

Now consider t to be fixed at some value T (T = 1,2,...) so that P_T represents the accumulated profit at the time period's end. Further, let us note P_T to be a function of k:

$$P_T = P_T(k). \tag{6}$$

[1]Received for publication May 17, 1982; reviewed; accepted June 2, 1983.

Note that $P_T(0) = 0$, and

$$P_T(1) = \lim_{k\to 1} kU_o \left\{ \frac{[1 + R(1-k)]^T - 1}{1-k} \right\} \tag{7}$$

$$= U_o \lim_{k\to 1} \frac{T[1 + R(1-k)]^{T-1}(-R)}{(-1)} \quad \text{(by L'Hopital's Rule)}$$

$$= R\,U_o\,T. \tag{8}$$

We now consider maxima of (5), differentiate with respect to k and set

$$P'_T(k) = 0. \tag{9}$$

This results in

$$[1+R(1-k)]^T + R(1-k)^2T[1+R(1-k)]^{T-1} - R(1-k)T[1+R(1-k)]^{T-1} = 1. \tag{10}$$

Note that $P'_T(1) = 0$ can be readily verified by setting $k = 1$ in (10). The question, however, concerns the existence of extrema for $0 < k < 1$. Equation (10) is a polynomial of degree $T+1$ in $1-k$. Using the binomial expansion we have

$$\left[\frac{T}{R} - \frac{T(T-1)}{2}\right] R^2(1-k)^2 + T(T-1)\left[\frac{1}{R} - \frac{(T-2)}{3}\right] R^3(1-k)^3 + \ldots + \frac{T}{R} R^{T+1}(1-k)^{T+1} = 0. \tag{11}$$

We see that $k = 1$ is always a root, then we can divide equation (11) by $R^2(1-k)^2$ to obtain a polynomial of degree $T-1$ in $(k-1)$. After this division set $T = 1$ to note that no other roots for k exist. If $T = 2$, however, $k = (2+R)/2R$, and the restriction $0 < R < 1$ indicated $k > 1$, so that this extrema lies outside the k range. We now consider the question of whether or not extrema move into the allowable k range as T increases. Let $1 - k \cong 0$ and positive.

We again consider the factored version of (11), but consider only the first two terms as an approximation which disregards $0(1-k)^2$ terms. Solving for $1-k$,

$$1-k = \frac{\frac{T-1}{2} - \frac{1}{R}}{R(T-1)\left[\frac{1}{R} - \frac{(T-2)}{R}\right]} > 0.$$

A positive numerator and denominator yield the approximate T range

$$\frac{2+R}{R} < T < \frac{2R+3}{R}.$$

If we choose $R = .1$, then $21 < T < 32$ should yield a maximum for k close to 1 and $k < 1$. Table 1 and Figure 1 result from numerical computation on (1) and (2). The BASIC program is also listed.

TABLE 1

Time Period	k value	Maximum profit	K = 1 value
20	95	$P_{20}(.95) = 2.003$	$P_{20}(1) = 2$
30	.55	$P_{30}(.55) = 3.51$	$P_{30}(1) = 3$
50	.30	$P_{50}(.3) = 13.05$	$P_{50}(1) = 5$

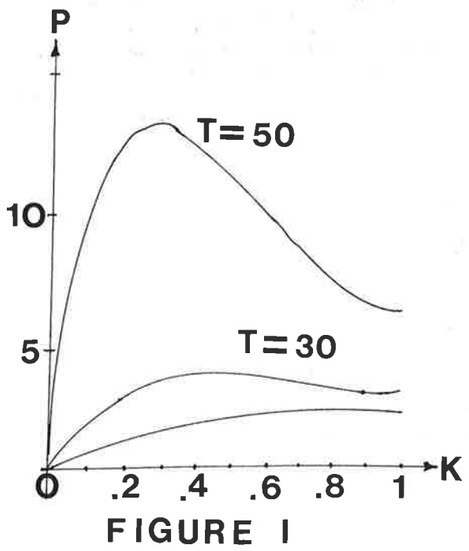


FIGURE 1

Nonlinear Model

Another possibility is the nonlinear model

$$U_{t+1} - U_t = (1-k)[R - BU_t]U_t, \tag{12}$$

$$P_{t+1} - P_t = R\,K\,U_t, \tag{13}$$

Equation (12) is similar to population models discussed in [2], [3], and [4]. An important reason for considering such a case is that enterprises in general will have upper bounds on possible growth. Equation (12) admits stable solutions approaching $U_t = R/B$ as an equilibrium value. Some mumerical cases are given in Tables 2 and 3.

TABLE 2

B = .001, R = .1, U_o = 1

Time Period	Profit Factor k	U Value	Profit
30	0	15.2	0
30	.6	3.2	3.5
30	1.0	1.0	3.0

TABLE 3

B = .001, R = .1, U_o = 25

Time Period	Profit Factor k	U Value	Profit
40	0.	95.1	0
40	0.55	66.8	100.7
40	0.75	47.4	107.9
40	1.	25.	100.

Note that the equilibrium values $R/B = 100$ in both cases and Table 3 indicates another type of maximization is possible, namely MAX[P+U], which occurs at approximately $k = .55$. The following BASIC program iterates on equations (1) and (2) or (12) and (13). After selecting the parameter values for R and B, a time period T, and initial enterprise value U_o, the program will

print out the profit and enterprise value at the termination of the time period for values of $k = 0$ *to* $k = 1$ in intervals of .05.

```
10  REM NUMERICAL EVALUATION OVER GIVEN
    TIME PERIODS
20  PRINT
30  K=0
40  REM I AND B ARE PARAMETER VALUES; B=0 IS
    THE LINEAR CASE
50  PRINT "INPUT THE VALUES OF THE
    PARAMETERS I AND B"
60  INPUT I,B
70  PRINT "INPUT THE TIME PERIOD OF THE
    INVESTMENT"
89  INPUT J
90  PRINT "INPUT THE INITIAL ENTERPRISE
    VALUE"
100 INPUT U
110 Z=U
120 PRINT "TIME", "K VALUE", "U VALUE",
    "PROFIT"
130 PRINT
140 P=0
150 U=Z
160 T=1
170 U=U+(1-k)*(I-B*U)*U
180 P=P+I*K*U
190 T=T+1
200 IF T<=J GOTO 170
210 PRINT T-1, K, U, P
220 PRINT
230 K=K+.05
240 IF K<=1 GOTO 140
250 END
```

REFERENCES

[1] Bellman, R. and Cooke, K.L. Modern Elementary Differential Equations (1971) Addison-Wesley.

[2] Lancaster, P. Mathematical Models of the Real World (1976) Prentice-Hall, Inc.

[3] Kapur, J. N. and Khan, Q. J. A. Difference Equation Models in Ecology and Epidemiology. International Journal of Mathematical Education in Science and Technology. Vol. 12, No. 1, Jan-Feb, 1981.

[4] May, Robert, M. Biological Populations Obeying Difference Equation: Stable Points, Stable Cycles, and Chaos. J. Theor. Biol. (1975) 51, 511-524.

Proceedings of the Pennsylvania Academy of Science 58: 107-120. 1984

ABSTRACTS*

JAMES P. ULERY (U.S. Bureau of Mines). VITRINITE REFLECTANCE AND ITS IMPLICATIONS REGARDING THE GAS CONTENT, MAXIMUM DEPTH OF BURIAL, AND PALEOGEOTHERMAL GRADIENT FOR PENNSYLVANIAN COALBEDS, WESTMORELAND CO., PENNSYLVANIA.—Local and regional coalification studies may provide information useful in interpreting the paleogeothermal history as well as the relative ages of the burial, folding and faulting in a sedimentary rock sequence. Coalification of organic matter (peat) occurs contemporaneously with burial, through the interaction of temperature and pressure through geologic time. For any given rock sequence then, if one assumes a constant geothermal gradient during the coalification period, rank will be dependent on maximum depth of burial. Currently, a commonly used indicator of coal rank is vitrinite reflectance. This value was used by the Bureau of Mines to determine the rank of Pennsylvanian coalbeds from a borehole drilled along the axis of the Greensburg Syncline, Westmoreland County, PA. Thermal maturity of the coalbeds, as indicated by vitrinite reflectance, was found to relate directly to by-product gas content. The reflectance gradient of the borehole is .10%/100m, which corresponds to gradients measured by Hacquebard and Donaldson (1975) for the Rocky Mountain Foothills of Canada. An estimate of the paleogeothermal gradient based on the Karweil nomogram for coalification, using 50 m.y. as the effective heating time, indicates a significantly higher paleogeothermal gradient than proposed by Hower and Davis (1981). The estimated paleogeothermal gradient indicates a maximum depth of burial for the Allegheny?als of only 1.6 to 1.7 km. This depth corresponds well with estimates made by McKee et al. (1967) and Farrington (1954) but is significantly lower than the estimate of Hower and Davis (1981).

ROBERT B. DOMERMUTH and WILLIAM F. SKINNER (Pa. Power & Light Co., Ecological Studies Lab, Allentown, PA). MOUNTOUR BENTHIC STUDY—AN INDEPTH INVESTIGATION OF MACROINVERTEBRATES ABOVE AND BELOW AN INDUSTRIAL EFFLUENT: SAMPLE METHODS.—Things are not always what they appear to be. This is true in environmental impact studies. While historical data portrayed the benthic macroinvertebrate community to be negatively affected by the discharge from the Montour Steam Electric Station, results of ichthyofaunal studies indicated no impact. Upon closer inspection of specific sampling locations, substantial macroinvertebrate habitat differences were discovered between Reference and Impact stations. These differences are hypothesized to be of greater influence in determining benthic communities than power plant impacts alone. A comprehensive study, employing several site-specific and novel investigatory techniques, was undertaken in 1983 to address benthic habitat differences, among other objectives. Presented here is the methodology used in one phase of the Mountour Benthic Study, and a brief discussion of some preliminary indications from the data.

DANIEL T. STRICKLER (York College of Pennsylvania), ROBERT F. DENONCOURT (York College of Pennsylvania) and TODD BECK (Pennsylvania Power and Light Company). LARVAL DEVELOPMENT AND AQUACULTURE OF THE MARGINED MADTOM, *NOTURUS INSIGHTS*.—Some 14 freshly spawned egg masses (X = 100 per mass) were collected 12 June 1983 and transferred to special incubation/culture troughs at Brunners Island Steam Electric Station, Aquaculture Research Station, York Haven, Pa. Development of eggs, larvae and growth were monitored every 24 to 48 hours until 2 July and then monthly through December. Photographs, diagrams and descriptions of larval growth of young from the source stream, tributary of Bermudian Creek, demonstrated that aquaculture could produce growth within five months that compared with adult sizes in the field, suggesting aquaculture possibilities as a bait fish.

JOHN J. DROPP (Mount Saint Mary's College). RESULTS OF A QUESTIONNAIRE GIVEN TO COLLEGE STUDENTS CONCERNING CONTRACEPTION AND ABORTION.—A questionnaire concerning contraception and abortion and consisting of 65 questions was given to 125 Mount Saint Mary's College students and 182 Shippensburg University students during the Fall semester, 1982. The responses of the students, which were analyzed (e.g., cross-tabs) using a PRIME computer, will be presented.

DEBORAH LYNN HALL and WILLIAM E. DIETRICH JR. (Biology Dept., Indiana University of Pennsylvania). THE EF-

*The abstracts published herein have not been subjected to editorial scrutiny.

FECTS OF ACID RAIN AND DEICING SALTS ON PLANT PRODUCTIVITY.—A greenhouse simulation of the effects of acid rain, road salt runoff and a combination (acid rain/road salt) were performed using Rugter's tomatoes. All treatments decreased total biomass when compared with control plants. Acid alone caused *no* decrease in the number of leaves, nor height; although an*increase* in number of nodes was observed. Salt alone caused a decrease in height, number of leaves and number of nodes. The combination of acid rain and salt treated plants which were somewhat intermediate between those treated with acid rain and salt solution alone.

RENÉ KOCHENBERGER (Millersville University/New Jersey Audubon Society) and DR. SAMUEL J. HA (Millersville University). INDIVIDUAL RECOGNITION IN THE MOCKINGBIRD (*Mimus polyglottus)*.—Mockingbirds on territory were recorded during spring months of 1981 in Lancaster County, Pennsylvania and Cape May County, New Jersey. A list was made for each bird of the imitated calls identified in its repertoire. Species imitated most often included the Carolina Wren, American Robin, Common Flicker, Blue Jay and Wood Thrush. Mockingbirds recorded in Cape May County, NJ also frequently used calls from Gulls and Terns, Greater Yellowlegs and Red-winged Blackbird in their repertoires. Recordings were then made of each of these imitated species in both study areas. Sonograms were made from representative portions of each mockingbird's repertoire, and from representative calls of each of the imitated species. These sets of sonograms were then compared to determine if individual mockingbirds identified themselves through their repertoire by adding a "signature" to each of the calls they used in their repertoire. Results did not show any significant differences between the two sets of sonograms. No such signatures were found in any of the mockingbirds studied, although one of the mockingbirds could be identified as a young bird who had not yet perfected his repertoire.

TEMPERATURE-SENSITIVE DICTYOSTELIUM MUTANTS JC5 AND JC36, DEFECTIVE IN LATE-STAGE CELL COHESION.— Dictyostelium discoideum is a valuable experimental system with which to study the molecular basis of development and morphogenesis. Mutants JC5 and JC36 of D. discoideum have been studied. Both have a temperature-sensitive mutation in late stage cohesion. JC5 also carries a temporal alteration in development, but JC36 has a wild-type background. JC5 completes sporeformation successfully, and after 12th of development at 27°C the non-cohesive cells form a flat lawn. By contrast, at this elevated temperature JC36 does not develop past the 16h stage and no spores are formed. JC36 cells also partly lose cohesivity and are sloughed-off the moving slug (16h) stage of development. Hence, the late-stage cohesive system is involved both in cohesion and development, but its function is more easily studied against the wild type background (JC36). Both mutants may prove to be useful in studying cell-contact mediated gene-expression.

T.S. VATES, SUE NATOLI and S.K. MAJUMDAR (Lafayette College, Easton, PA). TUNICAMYCIN-INDUCED SHAPE TRANSFORMATION OF MURINE ERYTHROLEUKEMIA CELLS AND NUCLEATED AND ANUCLEATED ERYTHROCYTES.—The effect of tunicamycin (TM), an antibiotic and strong inhibitor of protein glycosylation, was studied on the surface morphology of Friend virus induced murine erythroleukemia cells and anucleated and nucleated erythrocytes. Tunicamycin treatment resulted in the reduction in the size and number of cytopodial structures in MEL cells. The most smoothening of the cell surface was observed when TM was used in conjunction with DMSO. The application of TM on anucleated erythrocytes (Mouse and Rabbit) changed the normal biconcave discs to spherical cells with several cytoplasmic protrusions from the surface. Nucleated red blood cells (Frog and Chicken) did not form protrusions on the surface; rather, they become spindle-shaped in low concentrations and then lysed in higher concentrations. Nucleated erythrocytes were more sensitive to the TM treatment than were the anucleated red blood cells.

A.G. AULETTA, K.E. BOYLE, C. KEIMEG, R.J. CARR, J.H. DREISBACH (University of Scranton). GROWTH STUDIES OF A FACULTATIVE THERMOPHILIC BACTERIA.—A gram-positive bacterial isolate from a soil sample obtained near a city steam duct, was identified as a strain of *Bacillus brevis* on the basis of morphological and metabolic characteristics. The organism demonstrates growth patterns of a classic facultative thermophile. Growth rates are maximum at 40°C and 55°C with significantly lower rates of growth at temperatures between these optima. Analysis of the activity and temperature optima of selected metabolic enzymes obtained from the organism cultured at the two temperatures reveal significant differences.

RAYMOND W. EYERLY, ROGER H. DOWNING and RICHARD D. TWARK (Institute for Research on Land and Water Resources, The Pennsylvania State University). RESURGENCE OF THE BITUMINOUS COAL INDUSTRY: EFFECTS ON PER CAPITA INCOME IN PENNSYLVANIA.—Energy is vital to the growth and development of the U.S. During the 1970's, there were dramatic increases in energy prices and coal was no exception. Extraction of bituminous coal is a major industry in 26 Pennsylvania counties. Because of the structure of the coal mining industry, which consisted of many small to medium-sized companies during the seventies, local economies benefited from these price increases. Regression analyses were used to examine the factors influencing income changes in Pennsylvania counties during the seventies. Data from several sources were used. It was found that bituminous coal producing counties had significant percentage increases in per capita income versus non-coal producing counties.

LYDLE F. BRINKLE (Gannon University). GEOGRAPHY AND GENETICS.—The incidence of genetically caused malformations varies widely by geographical area, and in different racial and ethnic groups. Some racial and ethnic groups show a higher birth frequency of disorders than those of their neighbors, and populations descended from those with high frequencies of certain disorders may inherit and transmit a mutant gene(s) which may be passed down and affect future generations. The transmission of genetic defects from one generation to the next may also vary in the degree of severity. The data and evidence for genetic predisposition by geographical area and racial groups is at best sketchy on a global scale, nevertheless for some countries and races the frequencies of the main forms of some genetic diseases are essentially known and are discussed in this context.

MARK STEPHEN MONMONIER (Syracuse University). MAPS IN *THE NEW YORK TIMES,* 1860-1980: A STUDY IN THE HISTORY OF JOURNALISTIC CARTOGRAPHY.—As photoengraving replaced woodcut engraving in the late nineteenth century *The New York Times* increased its use of maps to illustrate news stories and feature articles. Map use increased substantially from an average of less than one map-illustrated article per issue in 1930 to over three mapped articles per issue in 1940, principally due to the addition of a daily weather map in 1934 and increased coverage of events leading to American involvement in the Second World War. Another increase, to an average of nearly five map-illustrated articles per issue, occurred in 1960 and reflected an increased investment in science reporting, recreation and travel features, and articles on neighborhoods and the environment. The Sunday edition carries about three times as many maps as the average weekday edition. Most maps are a single column wide, and less than one map in seven now appears on the front page or the first page of an interior section. In recent years maps in *The Times* have addressed national and local themes more frequently than global or foreign themes, and large—and intermediate—scale maps have become proportionately more common.

GEORGE A. SCHNELL (The College at New Paltz, SUNY). TRENDS IN THE DISTRIBUTION OF THE BLACK AND WHITE POPULATIONS OF THE UNITED STATES DURING THE SEVENTIES.—Black and white population trends in the United States from 1970 to 1980 are described and discussed at several levels—nation, region, state, county, metropolitan area, and city. Findings suggest that, although distributions show signs of some convergence in behavior between the white majority and our most numerous minority, blacks remain not only an urban population but mainly metropolitan in residence. Among other objectives, the study reveals places at a variety of political levels (that is, particular states, counties, metropolitan areas, and cities) in which the black-white trends in distribution are distinctive and, thus, warrant further, in-depth study.

ROBERT R. WARREN (The Pennsylvania State University). FIGURING ENERGY BY THE "DOT".—The "Dot Product" model can serve the Engineer in several capacities, but the most advantageous function would be in the computing of energy, either that being applied or that which already exists in the system. A concern of the Engineer when working with the various vectors in a system, either constant or variable, is to know if that vector is applicable to the energy criteria. Once the vectors have been defined and placed in the "Dot Product" model, it is then virtually impossible to err in either theory or mechanical operation to determine the amount of energy in the system. The "Dot Product" model can be associated to either a static or a motion situation, in a liquid or solid state, linear or curvilinear displacement, and either a coplanar or spatial diagram. This paper will first derive the "Dot Product" model; secondly, demonstrate the important advantage of the "Dot Product" in determining of energy; and thirdly, demonstrate the ease of understanding the language when used in the approach of the problem. As Issac Newton stated, "energy can neither be created nor destroyed", but the Engineer knows that energy must be transferred. The Engineer therefore, must be capable of transferring energy in a system by the most suitable and convenient method, and that is the "Dot Product" model.

ANASTAS LAZARIDIS (Widener University). ADVANCES IN SOLAR THERMAL POWER GENERATION WITH CENTRAL RECEIVER SYSTEMS.—The central receiver concept for power generation by solar energy is receiving attention since it is expected to increase the overall efficiency of a solar based power plant. Research during the past decade led to the construction of a 10 MWe pilot plant in Barstow, California. The receiver system of that plant consists of 24 panels of 45 ft. height and 35 in. width composed of ½ in. diameter tubes of Incoloy 800. Water moving upward through the panels is converted to steam by sunlight reflected from the mirrors of a heliostat field. The expansion of steam in a turbine provides the kinetic energy to an electric generator. A major disadvantage of this central receiver is the need to transfer heat to the fluid through the walls of the tubes of the panels, which results in loss of energy and reduced overall efficiency. An improvement results when the fluid is heated directly without the interference of a tube wall. Thus, a cavity receiver is provided with a sloping surface over which an absorbing liquid flows by gravity and is heated with the sunlight reflected from the heliostats. It is estimated that temperatures of over 1000°C are achievable. This paper summarizes current research activity in the area.

WILLIAM E. GESSNER (East Stroudsburg University). PRELIMINARY INVESTIGATION OF THE USE OF LIGHT-EMITTING DIODES TO VERIFY PLANCK'S CONSTANT.—The purpose of this investigation was development of a simple method, using light-emitting diodes, to verify Planck's Constant. Early in the course of the work, the discovery of an invalid assumption in the researcher's plan led to a concomitant investigation. An equation was derived to determine the number of photons produced per electron in the current through the diode. Taking this into consideration, the method was devised to verify Planck's Constant.

PAUL H. DEHOFF (Univ. of North Carolina—Charlotte) and JACK E. HARCLERODE (Bucknell Univ.). EFFECT OF METAL DESIGN ON RESIDUAL STRESS IN PFM CROWNS.—The residual stress which develops in porcelain-fused-to metal (PFM) crowns depends on specimen geometry, porcelain viscoelastic behavior, metal and porcelain thermal expansion and contraction differential, and thermal history. In several previous studies, marginal or generalized distortion has been attributed to developing residual stress. The objective of this study is to evaluate the effect of metal coping design on the distribution of residual stress and metal displacement in PFM crowns. Using dilatometric data, finite element stress analyses were performed on chamfer, chamfer-bevel, shoulder-collar and shoulder-bevel configurations. Calculations were made using combinations of a base metal alloy and an Au-Pd alloy with three porcelain products. Residual tensile stresses in the base metal shoulder-design coping varied from 1 MPa at the gingival margin to 165 MPa at the internal surface of the occulsofacial aspect of the crown. Maximum tensile stress in the Au-Pd coping was 76 MPa. For the shoulder-bevel design, the maximum tensile stresses in the base metal and Au-Pd copings were 172 MPa and 76 MPa, respectively. *Based on these calculations, the metal displacements appear to be insufficient to cause significant distortion of porcelain-metal crowns with shoulder-collar and shoulder-bevel geometries.*

BRUCE B. SMITH (York College of Pennsylvania) and SCOTT NEELY (York College of Pennsylvania). EARLY OVULE DEVELOPMENT, MEGASPORGENESIS AND MEGASPOROGENESIS, AND MEGAGAMETROGENESIS IN MCKANA'S HYBRID COLUMBINE, *AQUILEGIA* SP. (RANUNCULACEAE).—Flowers at various stages of development were collected during the spring of 1983. They were fixed in FPA_{50} (formula) and stored in 70% ethanol. Various pretreatments were tried before immersing the ovules in Herr's clearing fluid. Starch grains in the nucellar region presented the greatest impediment to clearing. Results will be given on the attemps to pretreat with various concentrations of amylase. The ovules are anatropous, pleurotropous, ventrally located in a double marginal placentation. The megaspore mother cell is three cells down from the nucellar apex. The chalazal spore is functional. Megagametogenic stages will be presented.

JAMES C. PARKS (Millersville University). THE DISTRIBUTION OF THE FERN GENERA VITTARIA AND TRICHOMANES IN PENNSYLVANIA: A PROGRESS REPORT.—Expanding on the state records for the gametophytes of these genera, reported by Farrar, Parks and McAlpin (RHODORA 85:83, 1983) progress on a county by county mapping of their distribution is presented. Sixteen county records for *Trichomanes*, including the first in western New York, are mentioned. *Vittaria* new to four Pennsylvania counties and two New York counties, *the latter constituting a New York State Record*, are presented. Gametophytes of these genera are known from Pennsylvania, but the nearest known *Trichomanes* sporophyte is in West Virginia and the sporophyte of this *Vittaria* may be extinct. Ecological and biogeographic peculiarities of their distribution in Pennsylvania and adjacent New York are discussed.

JAN MIKESELL (Gettysburg College). TEMPORAL AND SPATIAL DEVELOPMENT OF THE REPRODUCTIVE SPIKES OF PLANTAGO MAJOR L. (PLANTAIN).—Common plantain is a frequent weed of lawns and waste places, and a successful competitor throughout much of the eastern U.S. Reproductive spikes were collected weekly throughout the growing season for the purposes of determining reproductive development from the base to the terminus of the spike, as well as ascertaining differences and similarities in sexual reproduction from the beginning to the end of the growing season. Numerous flowers and fruits differentiate spirally about the spike axis in an acropetal direction. Each flower develops a calyx and corolla composed of 4 sepals and 4 united petals respectively. Flowers are bisporangiate with the androecium comprised of a whorl of 4 stamens, and the gynoecium having 2 carpels. Within the bilocular ovary are a variable number of ovules initiated from an axile placenta. Seeds are disseminated from the capsule (a pyxis) as a result of dehiscence of the upper half of the fruit. Ovules are tenuinucellar in that the archesporial cell forms close to the nucellar epidermis, and gives rise directly to the megasporocyte. The micropyle results from pore formation in the single integumentary layer. Embryo sac formation occurs by the *Polygonum*-type of embryo sac development. The embryo sac is enclosed by an endothelium. Haustorial cells develop from the embryo sac at opposite ends. A large unicellular haustorium grows at the chalazal end, while 4 smaller juxtapositioned haustoria form at the micropylar end. Haustoria presumably function in absorbing nutrients, which most likely explains tissue degradation in older ovules. The space resulting from tissue loss is ultimately filled by endosperm proliferation. Spikes have considerable photosynthetic tissue, as well as both internal and external phloem strands. However, determinations of resource allocation reveals that the 7-8 spikes per plant receive no more biomass than vegetative organs.

KENNETH M. KLEMOW (Wilkes College). WATER RELATIONS OF LIMESTONE-QUARRY AND OLD-FIELD HERBACEOUS PLANT SPECIES.—Herbaceous plants colonizing the Jamesville Limestone Quarry near Syracuse, New York are subjected to periodic drought due to shallow soil with a low water-holding capacity. To determine whether quarry-inhabiting plants differed from plants growing naturally in other habitats due to their water
relations, stomatal resistance was examined in relation to soil-water depletion. Quarry species studied were *Hieracium florentinum* and *Picris hieracioides.* Non-quarry species were *Plantago major* and *Dipsacus sylvestris.* Quarry plants tended to deplete soil water more slowly than non-quarry plants. *Picris* stomata failed to close until the soil was very dry, suggesting that it is a drought-tolerating species. Stomata of *Hieracium* closed when the soil was still comparatively moist, suggesting that it is a drought-evading, moisture-conserving species. *Dipsacus* was also a drought-tolerating species, and it seems unlikely that it is excluded from the quarry due to water relations. *Plantago* individuals were neither drought-tolerators nor drought-evaders and this species is probably excluded from the quarry due to the lack of appropriate adaptations to periodic severe drought. The findings of this study emphasize that complex and contrasting adaptations allow plants to exploit a stressful habitat. Evolution of *Picris* and *Hieracium* has led to two different solutions to the problem of successfully colonizing shallow, drought-prone soils, such as those in the quarry.

CARL R. PRATT, JR. (Pennsylvania State University, Wilkes-Barre Campus). EXAMINATION OF A GRAY BIRCH (*Betula populifolia)* FROM THREE CONTRASTING HABITATS IN NORTHEASTERN PENNSYLVANIA.—Overall growth and physiological status of gray birch trees growing on anthracite coal mine spoil banks in Northeastern Pennsylvania was evaluated by comparison of chlorophyll and nutrient content of leaf and twig samples collected from trees in each of three habitats. The sampling sites were chosen to represent a range of environmental conditions typically encountered by gray birch in the area. The sites used were: (1) an abandoned mine spoil bank supporting only gray birch and no significant amounts of other vegetation, (2) an older spoil bank which supported a variety of herbaceous plant species in addition to gray birch and (3) birch trees on the lawn of the Penn State Wilkes-Barre Campus. To characterize the environmental conditions of each habitat, soil samples were collected and analyzed for moisture content, nitrate nitrogen, potassium, phosphorus, magnesium, pH, cation exchange capacity and total dissolved salts. Each tree sampled was cored at breast height and age determined by counting the number of annual growth rings. Chlorophyll content was determined by spectrophoto-metric measurement of chlorophyll acetone-extracted from discs of leaf material. Differences among the trees at the various sites are explained in terms of the environmental conditions of each habitat type.

KEITH WITHERUP (Slippery Rock University) and RICHARD J. MEDVE (Slippery Rock University). THE FLORA OF WOLF CREEK VALLEY, BUTLER COUNTY, PA.—Wolf Creek valley is considered by some ecologists to be the northernmost extension of the mixed mesophytic forest and exemplifies many of the botanical features that characterize this biome to the south. Because of the spectacular variety of flora indigenous to this type of forest, the area was purchased for preservation by the Western Pennsylvania Conservancy. The study involved the identification of vascular plants for a 1 yr period and the preparation of distribution maps for each species located within the study area.

ROBERT P. ZIMMERER and ALLISON HILDEBRANDT (Juniata College). UNUSUAL CONIFER NICHES IN A PENNSYLVANIA FOREST.—Conifers located in a state forest in Huntingdon County were found to survive unusual germination sites by two different means. In one case, a white pine (*Pinus strobus* L.) survived germination in a deep rock depression by severe growth limitation (natural bonsai). In a second case, eastern hemlocks (*Tsuga canadensis (L.) carr.*) survived germination on broad, flat rock surfaces by growing roots in forest debris and moss cover on the rock surfaces until their roots could reach the soil. In both cases ecological conditions at the site enabled the trees to survive early growth periods.

JUDITH L. DUDLEY (Pymatuning Laboratory of Ecology, University of Pittsburgh). IDENTIFICATION AND QUANTIFICATION OF MICROFLORAL COMMUNITIES IN THE LEAF LIQUID OF THE PITCHER PLANT, *SARRACENIA PURPUREA* L.—Field collections of liquid from the leaves of *Sarracenia purpurea* L. (Sarraceniaceae) were made during the summer of 1983 from natural populations in northwestern Pennsylvania and southwestern New York. The temperature, pH, and volume of the liquid were measured in the field for each leaf sampled, and the leaves were aged according to their order of attachment on the stem of the plant. Twenty three different genera of algae, representing four taxonomic divisions were identified from the filtered leaf liquid. Algae were not observed in nearly one third of the pitchers.

SCOTT FLINN and CHRISTINE NEBIOLO (Allegheny College, Meadville, PA 16335). THE EVOLUTION OF PROTAMINE IN ANADROMOUS FISHES.—Fish of the salmonid family, including trout, undergo physiological changes due to their anadromous nature. One of these changes may be the replacement of histones in the sperm DNA by the salmon type protamine. If this protamine type is found in anadromous fishes, it implies that the protamine may have evolved from an earlier protamine type in order to maintain the DNA structure in the sperm of the anadromous fishes. Protamine has previously been found in rainbow trout and herring, both of which have anadromous populations. Using polyacrylamide gel electrophoresis, it was found that protamine is present in brown and brook trout testis. Comparison of the protamine bands suggests that this protamine is the salmon type. Both species also have anadromous populations. The amount of protamine increases as the testis of the brown trout matures, analogous to the progression of protein types in rainbow trout.

DANIEL T. STRICKLER (York College of Pennsylvania), ROBERT F. DENONCOURT (York College of Pennsylvania) and TODD BECK (Pennsylvania Power and Light Company). CONTRIBUTION TO THE LIFE HISTORY OF THE MARGINED MADTOM *NOTURUS INSIGNIS* OF BERMUDIAN AND KREUTZ CREEK, YORK COUNTRY, PENNSYLVANIA.—Field observations and collections of *Noturus insignis* were made February through November 1983. Data from 764 specimens indicated a 1:1 sex ratio, the largest female 153 mm and male 144 mm total length. Two size groups were obvious in February-March, three with young of year in July and then two again in September when the young of the year overlapped smaller adults and the largest specimens of the summer were absent. Gonosomatic indices, mean ova diameter and mean number of ova per female reached maximum in June when freshly spawned eggs were first observed and collected. Some 100 percent of specimens over 69 mm could be sexed by external observation of urinary papillae, described herein.

MARK A. ORLIC and WM. R. KODRICH (Clarion State College). AN EVALUATION OF THE POTENTIAL FOR COLD WATER FISHERY MANAGEMENT OF BIG COON CREEK, FOREST COUNTY PENNSYLVANIA.—Biological, physical, and chemical characteristics of Big Coon Creek were examined from April 1 to December 4, 1982 in an effort to establish a database on the quality of its fishery resource.

Water quality analysis showed that the stream is receiving pollution in the form of acid mine drainage, SO_4 (140mg/l), Fe (0.5mg/1), and Mn (l.8mg/1), by way of tributaries originating in Clarion County. Quantitative analysis of stomach contents of stocked and wild brook trout indicates that during the study, food items consumed by the wild trout population did not change, but did for the stocked trout population. Catch per unit effort showed that the existing wild trout population, though small in size, remained stable throughout the study. The population of stocked trout declined immediately after stocking. Isometric Condition Factor K showed that the condition of wild trout remained stable from April 16 to May 19, 1982, but the condition of stocked trout declined 14.5% during that period. By examination of the age and growth characteristics of wild trout, it was determined that the power of predictability of the linear regressions, the total length as a function of age, and the total length as a function of scale radius, are the same. The stream shows a good diversity of forage fish, but because of the small size of the brook trout, they probably cannot exploit this food resource. Macroinvertebrates sampled did not show a great diversity of organisms. However, the stream is capable of producing sufficient natural trout food to sustain a small wild trout population.

T.H. CERVONE[1], R.M. LANGIANESE[2], and S.M. STAYER[3], (1, Dept. of Biol., St. Bonaventure Univ. St. Bonaventure, NY, 2, Bradford, PA and 3, Olean, NY.) THE FISHES OF TUNUNGWANT CREEK DRAINAGE, MCKEAN CO., PA AND CATTARAUGUS CO., NY.—Tunungwant Creek drainage is a brackish stream bordered by many oil and brine fields. Fish kills are numerous; yet, information on fishes is lacking. This, along with its feeder effect on the Allegheny River and indirectly, the Kinzua Reservoir, justified studying the type, distribution, relative abundance, and community structure of fishes therein. A secon-

dary objective was to investigate its water quality. Sixty stations, sampled from the Fall of 1977 to Fall of 1978, revealed 44 species of fish. The most common fish @seined was the blacknose dace. It constituted 31% of the total catch. Moreover, the white sucker, creek chub, common shiner, northern mimic shiner, bluntnose minnow, and central stoneroller were moderately abundant. These 7 species comprised 72% of the total catch and were widely distributed; whereas, the other 37 species constituted only 28% and were unevenly distributed. The preponderance of these few species indicated semi-enriched waters in Tunungwant Creek drainage and consequently, a depressed fish fauna. Species diversity of fishes in Tunungwant Creek showed the majority of stations moderately polluted. The lowest diversity indexes in Tunungwant Creek were observed below the Kendall Oil Refinery in Bradford, PA and the town of Limestone, NY. Two stations, Kennedy Springs and Droney Run, supported neither fish nor insect life. Of the 4 major tributaries entering Tunungwant Creek, Foster Brook and Kendall Creek displayed the highest pH, temperatures, and salt concentrations. Furthermore, neither brook trout, brown trout, nor mottled sculpin were found here. In addition, the West Branch demonstrated higher temperatures than the East Branch, thus more contrarchids and percids but fewer brook trout, brown trout, and mottled sculpin. Higher temperatures were attributed to headwater impoundments.

FRED J. BRENNER and DAN IRBY (Grove City College). USE OF EYE LENS PROTEINS TO DISTINGUISH BLUEGILL POPULATIONS WITHIN THE SAME GEOGRAPHIC AREA.—Variation in eye lens proteins, as determined by electrophoretic analysis, was investigated in 8 populations of the bluegill sunfish (*Lepomis macrochirus*). Samples were obtained from five flood control reservoirs located on two different watersheds near Greenville, PA and from three surface mine lakes near Grove City, PA. Individuals from these populations could be distinguished on the basis of their eye lens proteins. Eye lens protein, therefore, may possibly be used as a genetic mark to identify individual populations in the same geographical area or within the same watershed.

MELVIN C. ZIMMERMAN and MICHAEL ENGEL (Lycoming College). USE OF THE HILSENHOFF BIOTIC INDEX TO DETERMINE THE WATER QUALITY OF LOYALSOCK CREEK.—The Biotic Index (BI), a numerical index that combines the pollution tolerance of benthic insects with estimates of community structure, effectively discriminated among difference in the macroinvertebrate assemblages of 13 sites differing in water quality (BI classification ranged from excellent/no disturbance to poor/significant disturbance) along Loyalsock Creek (Sullivan/Lycoming Co., PA). The BI at a given site is affected by spatial and temporal differences in the benthic community but not by species that occur only in small numbers. Two Surber samples collected at each site during Oct. (1982), May, July, Oct. (1983) provided sufficient data for estimating average BI values. Differences in BI among sampling sites are examined along with changes in taxonomic composition, species diversity indices, and monthly chemical/physical parameters. Analysis of water samples for 12 heavy metals was also made. Furthermore, the main tributaries of the watershed were examined to determine their input to the main stream.

JEFFREY A. HOLBROOK and VINNEDGE M. LAWRENCE (Washington and Jefferson College). RIFFLE BEETLES (ELMIDAE) OF WASHINGTON COUNTY, PENNSYLVANIA.—Riffle beetles (Elmidae) were collected from the watersheds of Buffalo Creek, Chartiers Creek, Cross Creek, Mingo Creek, and Ten-Mile Creek in Washington County in an effort to extend recorded distributions of Pennsylvania elmids into the southwestern part of the state. Finni, Hasse, and Masteller's 1978 survey of the riffle beetles of Pennsylvania includes no records for this area.

A COMPARATIVE STUDY OF PARENTAL CARE IN CICHLID FISHES (Pices: Cichlidae).—The division of parental care between several species of substrate brooding and a species of mouth brooding cichlid was studied to determine if an equal division of labor exists between species, between sexes and between the developmental stages of the brood. Fish were obtained from tropical fish stores and kept on a 14L:100 regime. Observations were made in sets of four 10 mintue observation periods. Two of these observation periods were to time behaviors and two were to record frequencies. Behavior patterns studied were: fanning, hovering, mouthing, spitting, digging, chasing, threatening and pumping. Brood stages were classified as egg, wriggler and fry.

FRED J. BRENNER and DONALD L. SAWYER III. (Grove City College). EFFECT OF CHANGING COAT COLORATION ON AGGRESSIVE BEHAVIOR IN HAMSTERS.—Changing the coat color of male hamsters increased aggressive activity within previously stable populations. Aggressive behavior in control populations declined over the same period. Individual recognition is apparently an important factor in reducing aggressive activity, thereby stabilizing populations.

NEIL A. MERCANDO and CHRISTOFER DONAGHY (The Pennsylvania State University, Ogontz Campus). MODIFICATION OF THE SHELL-ENTRY BEHAVIOR OF THE HERMIT CRAB *PAGURUS LONGICARPUS* BY THE SYMBIOTIC POLYCHAETE *LEPIDONOTUS SUBLEVIS*.—Numerous factors (e.g., shell size, shell condition, and symbionts present) influence the shell-selection behavior exhibited by hermit crabs. The symbiotic polynoid scale worm, *Lepidonotus sublevis*, has been found frequently inhabiting the inner whorls of various species of gastropod shells collected from Townsends Inlet, N.J. The effects of the presence of *L. sublevis* in gastropod shells on the shell selection behavior of the common, intertidal hermit crab, *Pagurus longicarpus*, were investigated in laboratory studies. The behavioral patterns exhibited by *P. longicarpus* when exploring and entering empty gastropod shells are described and compared with that exhibited when entering a shell occupied by *L. sublevis*. These studies indicate that the normal shell-entry behavior exhibited by *P. longicarpus* is modified by the presence of the scale worm. The rapid "adjustment thrust" or "snap withdrawal" behavior normally exhibited by hermit crabs following the insertion of their abdomen into an empty shell becomes slow, gradual, and prolonged when a scale worm is detected within the shell. In addition, shell preference studies were conducted in the laboratory using pairs of size-matched *Ilyanassa obsoleta* shells, one with and one without a *L. sublevis* inhabitant. *P. longicarpus* selected empty *I. obsoleta* shells significantly more often ($X^2 = 7.12$, $P = 0.008$) than shells occupied by *L. sublevis*.

H.G. MASTERS, S. GRANGE, J. BARNDOLLAR, and J. MURRAY (Juniata College, Huntingdon, Pennsylvania 16652). DISCRIMINATED PASSIVE AVOIDANCE AS A FUNCTION OF AGE AND BILATERAL OCCIPITAL ABLATION IN WHITE RATS.—The main purpose of this study was to investigate reacquisition of a discriminated passive avoidance response to a light CS following simultaneous bilateral occipital ablations in 36, 90, and 220 day old white rats. Acquisition of this same passive avoidance response by occipitally ablated neonatal rats (9-11 days old) was also compared to the postoperative performance of the other three groups. The neonatal group began passive avoidance response acquisition at 28 days of age. The data indicated: 1) all animals in all the postoperative groups performed the passive avoidance task to preoperative criterion levels, 2) the young group (90 day old) took as many sessions to criterion to relearn the original task. The adolescent (36 day old) and the old (220 day old) groups took significantly fewer sessions to criterion to relearn the original task, and 3) simultaneous bilateral occipital ablations performed at 9-11 days postnatally resulted in poorer original passive avoidance acquisition when this performance was compared to normal rats of the same age. These data also suggested the possibility that the performance of these neonatally ablated rats was poorer than the postoperative reacquisition performance of the other three groups. These results were discussed within a neuroanatomical and a biochemical framework.

HERBERT E. HAYS (Shippensburg University). PREDATOR-PREY INTERACTION: GARDEN SPIDERS AND HOUSE FLIES.—When house flies, *Musca domestica* Linnaeus are ensnared in the web of the orb weavers, *Argiope aurantia* Lucas or *A. trifasciata* Forskal, they usually cease all movement. The duration of cessation is highly variable but is prolonged if the spider shifts position at the hub or plucks the radial web filaments. Fly behavior under a variety of conditions was examined to determine the stimulus eliciting immobility. Comparisons of fly behavior in webs with and without a spider in residence revealed significant differences in the flies' activity. Experimental reduction of the tension of web elements resulted in increased fly activity and they appeared unable to detect the web vibrations as the spider moved. Initial immobility by the fly results from the abrupt termination of flight. Eventual struggling attracts the spider, which in turn results in immediate immobility by the fly. This response appears to be another example of the immobility by many animals under attack by a predator.

GREGORY WULCZYN (Bucknell University). ARE THE TRIGONOMETRIC FUNCTIONS WELL DEFINED?

1. Right triangle definition.

$$\sin x = \frac{y}{r}, \cos x = \frac{x}{r}, \tan x = \frac{\sin x}{\cos x}, \ldots .$$

x and y are the legs of a right triangle and r is the hypotenuse.

2. Exponential definition.

$$\sin x = 1/2i\,(e^{ix} - e^{-ix}), \cos x = \tfrac{1}{2}\,(e^{ix} + e^{-ix}),$$

$$\tan x = \frac{\sin x}{\cos x}, \tan x \cot x = 1, \sec x \cos x = 1,$$

$$\csc x \sin x = 1, \sin^2 x + \cos^2 x = 1.$$

The author prefers the exponential definitions using the finite difference approach $\cos ox = 1$, $\cos x = \cos x$, $\cos 2x = 2\cos^2 x - 1$, $\cos 3x = 4\cos^3 x - 3\cos x$, ..., $\cos(n+2)x = 2\cos x \cos(n+1)x - \cos nx$. They are still not well defined. But it is now possible to establish an isomorphism between the trigonometric functions and the hyperbolic functions, the hyperbolic functions and Type IV real quadratic number fields.

R. KIT KITTAPPA (Millersville University). DUAL REPRESENTATION OF LINES IN A PLANE BY A COMPLEX VARIABLE.—Instead of the usual representation of points by a complex variable, this paper shows how to represent effectively lines by a complex variable. This leads to reinterpretation of expressions involving a complex variable and theorems in Complex Variables of a geometrical nature. It also leads to new results.

BONITA ADLESTEIN KINCADE (Milton S. Hershey Medical Center of Pennsylvania State University). A DE-OBFUSCATION OF PIAGET IN MATHEMATICS.—In order to analyze the development of logical mathematic thinking in children, Piaget focused his cognitive research on atypical classroom situations. His findings were then presented in logic equations. In the teaching of mathematics, it is argued that a mathematical model could better depict the gradual changes from a concrete operational mode of thinking to a formal operational mode. By describing this transitional phase in mathematical structures, the utilization of Piaget would depict the "natural" development of logical thinking in children.

LEWIS MIFSUD, Ph. D., (The Pennsylvania State University). A MINATURIZED GAS/VAPOR CHROMATOGRAPH AND HYDROCARBON DETECTOR FOR USE IN ADVANCED UNDERGRADUATE EXPERIMENTS.—Most undergraduate students, even after taking all their required chemistry courses, may not have been exposed to the principles of column chromatography and even less likely that they have ever handled such equipment. The usual significant expense and elaborateness of marketed laboratory chromatographs fully explains their absence in most of our colleges. The federal government's alertness to the nation's increase of fire disasters has encouraged many a college to incorporate Fire Science and Management curricula, incorporating aspects of fire investigation, protection and safety. Crucial to these students education is a practical knowledge of gas/vapor leak detection and analytical screening of fire accelerants. The minaturized gas/vapor chromatograph and hydrocarbon detector offers an affordable and simplified teaching-lab equipment toward the training of Fire Science and Management students.

JOHN A. CROSS (Indiana University of Pennsylvania). COMPUTER WORKSHOP FOR UNIVERSITY FACULTY.—Four one-week workshops were conducted in the first two weeks of January, 1983, for teaching faculty at Indiana University of Pennsylvania (IUP). Participants attempted to define their knowledge

and skill needs and those of their students in the context of a series of meetings and structured computing experiences on the IUP mainframe computer. Particular activities in the "literacy" workshops included the use of computer graphics, word processing, a simulation game, an electronic grade book and a CAI tutorial. Two of the four workshops emphasized BASIC programming. Results included an enthusiastic reception, development of campus computing facilities and a general awareness of the potential for faculty development activities during the January part of the semester break. Plans for January, 1984 are focused on the particular needs of the College of Natural Sciences and Mathematics. This program was initiated and managed by the Computer Science Department.

BETSY B. SMITH (Wilkes College) and CHARLES B. REIF (Wilkes College). MICROSCOPIC BIOTA OF HARVEYS LAKE, 1982-1983.—Continuing interest in the water quality of Harveys Lake, Luzerne County, prompted this study of Pennsylvania's largest natural lake during 1982-1983. This survey found more kinds of algae than did Casterlin & Reynolds in 1976 (81 genera vs. 40 genera) or than did the EPA Eutrophication Study of 1977 (170 species vs. 37 species). Also found were 31 species of zooplankton. Palmer indices are given for algae eutrophication indicators, and a change in cladoceran population (daphnias replaced by bosminas) is noted. Current physical and chemical data are presented. Possible external factors (aerial spraying, sewerage, acid deposition) influencing the lake's condition are discussed.

RUSSELL W. DAVIS and CHENG-YIN CHENG (East Stroudsburg University). A CHEMICAL STUDY OF THE SHOHOLA CREEK HEADWATERS, PIKE COUNTY, PENNSYLVANIA.—A chemical study was performed on the headwaters of the Shohola Creek in Pike County, PA from June 8, 1983 to August 31, 1983. Weekly samples were taken from six sites along the creek, and a total of 156 samples were analyzed for temperature, pH, alkalinity, hardness, nitrate-nitrogen, phosphate-phosphorous, specific conductance, Fe, Mn, and Pb by EPA approved methods. The pH over the test period decreased from a high of 7.41 to a low of 6.76 while the alkalinity showed a gradual increase over the same test period. Hardness, phosphate-phosphorous, and nitrate-nitrogen showed similar increases. Manganese and iron concentrations were very low and the lead concentrations were almost all negligibly low. During the testing period the overall inorganic water quality seemed not to be affected by the heavy traffic on Interstate 84, which lies nearby.

MATTHEW L. ROMBERGER and TIMOTHY C. THOMAS (Bucknell University). DISCHARGE RATE AND ITS EFFECT ON NUTRIENT ELEMENT CONCENTRATIONS IN A NUTRIENT RICH 1st ORDER STREAM. —In flowing water systems it is clear that the rate of discharge accounts for much of the variation in the concentration of most common nutrients. By plotting the concentrations of one element versus stream discharge in time sequence, a nutrient trajectory is obtained which may be characteristic for that element in a particular system. The patterns of nutrient trajectories are presumably controlled by the contributions of groundwater flow and surface runoff as well as the magnitude of stream discharge. This study attempts to determine concentration-discharge patterns for three ions: (NH_3-N); (NO_3, NO_2-N); and (PO_4-P). Nutrient trajectories are constructed for the various nutrients on seasonal data as well as data obtained from short term hydrological events.

ROBERT E. HUNT (Science Teacher, Warren County Technical School, Washington, N.J.) and C. Y. CHENG (Professor of Chemistry, East Stroudsburg University, East Stroudsburg, Pa.). A CHEMICAL ANALYSIS OF THE PEQUEST RIVER.—A slide/lecture presentation will be made of a chemical analysis of the Pequest River which is located in Northwest New Jersey, near the Poconos. Samples were taken weekly at four locations along this thirty mile river and also at five tributaries on a monthly basis. Tests were then run at East Stroudsburg University for pH, phosphates, nitrates, phenolphthalein acidity, methyl orange alkalinity, and EDTA hardness. The study encompasses the entire year of 1983. The tests will be explained as well as some interesting findings about changes in the river's chemical analysis as it travels downstream.

DAVID D. PEARSON and MAHSHEED JAMNEJAD (Bucknell University). CARBOHYDRATE INVOLVEMENT IN THE INTERACTION OF RHEUMATOID FACTOR WITH ANTIGEN-BOUND IgG.—Immune complexes are the cause of several autoimmune diseases. In rheumatoid arthritis, the immune system reacts with normal immunoblogulin and thus produces a group of antiantibodies. The normal immunoglobulin is usually of the IgG class and the antibody made in response is usually of the IgM class. Our hypothesis is that the site of interaction between these two molecules is the oligosaccharide moiety present on the F_c portion of the IgG. We propose that an alteration in the mechanism of attachment of these sugars results in an obligosaccharide sequence foreign enough to provoke an immune response. We have tested this hypothesis by developing an ELISA test for rheumatoid factor and pretreating the rheumatoid factor with various concentrations of mono, di, and trisaccharides structurally related to those normally found on the IgG molecule. This is a blocking-type test which should prevent the rheumatoid factor from subsequently reacting with the IgG. Most of the carbohydrates tested did not block the interaction.

ROBERT H. DAVIS, PATRICK S. AGNEW and EUGENE SHAPIRO (Pennsylvania College of Podiatric Medicine). EFFECT OF ALOE, VITAMIN C AND RMA ON ADJUVANT ARTHRITIS.—Adult male rats (200 gm; 10-12/group) were injected on the plantar aspect of the hind paw with 0.1 ml heat killed Mycobacterium butyricum in mineral oil at 5mg/ml. Animals were given daily subcutaneous 150mg/kg aloe, vitamin C and DMA from day 0 to day 12 (13 days). Other rats were given tonical 5% combined aloe, vitamin C and RNA in hydrophillic cream (Prevention aspect). This study contained oil, adjuvant and cream controls. The regression study allowed the symptoms to develop over 21 days. Then rats were treated for 13 days from day 21 to 33. Hind paw volumes were measured at various times from day 0 through day 21 (prevention) or day 38 (regression). A significant 55% regression of arthritis was recorded with systemic administered vitamin C. The topical 5% combination of aloe, vitamin C and RNA in cream exhibited a 25% prevention and a 45% regression of the disease.

JOANNE E. NATALE (Allentown College) and STEVEN J. KENNEL (Oak Ridge National Laboratory). QUANTITATION OF TOTAL PROTEIN IN BRONCHIOPULMONARY LAVACE FLUID IN MICE INTRODUCED WITH INTERPERITONEAL BHT.—This study was undertaken to assay bronchiopulmonary lavage fluid (BPLF) from mice treated with a single intraperitoneal injection of 400 mg/kg butylated hydroxytoluene (BHT) in order to correlate the concentration of protein in BPLF, over a 7-day period, with the extent of lung injury. BPLF of treated mice contained two times the amount of protein as in the BPLF of control mice 24 hours after injection. The BPLF of treated animals contained the greatest concentration of protein after 48 hours, indicating maximum damage to alveolar and pulmonary capillary endothelial tissue. After seven days the total concentration of protein in BPLF of treated animals returned to control levels, indicating complete tissue repair. Thus the total protein concentration of BPLF can be correlated to known histological changes occurring in the seven-day period following intraperitoneal BHT injection.

HOWARD S. PITKOW (Pa. College of Podiatric Medicine, Phila., PA. 19107). DIMETHYLBENZANTHRACENE (DMBA) SUPPRESSION OF ADRENAL STEROID SECRETION AND ITS EFFECT ON LACTATIONAL PHYSIOLOGY IN THE RAT.—We have reported that DMBA administered to pregnant rats caused a significant decrease in mammary gland nucleic acid contents on day 1 postpartum. No significant differences were found on days 6 and 11. The retarded litter weight on day 6 was normal by day 11. In order to determine the effects of DMBA on hormones essential for lactation, female adult virgin Long Evans rats (12 animals/group) were intraperitoneally injected daily with 1 mg DMBA in 0.2cc sesame oil on days 8 through 12 of pregnancy. On days 1, 3, and 8 postpartum, prolactin or corticosterone serum levels were determined by radioimmunoassay. On day 1 of lactation we observed a significant decrease in corticosterone levels (32.8 ± 2.7 μg/100ml) in DMBA rats when compared to controls (55.9 ± 5.2 μg/100ml). No significant differences were found in corticosterone levels on day 8 nor prolactin levels on day 3. Our data suggests that DMBA in pregnancy suppresses the normal increase in corticosterone levels in early lactation thereby depressing mammary gland growth (i.e., DNA) and secretion (i.e., RNA). We believe the normalization of corticosterone levels by day 8 between control and DMBA groups account for the mammary gland rebound phenomenon.

KATHLEEN K. STRYKER and EDWARD G. GABRIEL (Lycoming College). THE INFLUENCE OF HYDERGINE ON HEMOPOIESIS IN THE MOUSE.—Hydergine (ergoloid mesylates) is often used to ameliorate confusion, unsociability, and depression in elderly patients. In this study, the influence of hydergine on hemopoiesis in two groups of laboratory mice was monitored. The experimental mice received hydergine dosages equivalent to normal and three times the human amounts. These two groups and the control were injected daily for a month with the appropriate amounts of hydergine or with saline in the case of the controls. At the end of this time, the Schmid Mouse Micronucleus test was used to screen for the mutagenicity of hydergine. Hydergine was not found to induce a dose dependent increase in the number of micronuclei nor was the drug found to significantly increase micronuclei formation. It was noted, however, that the dose of hydergine was negatively correlated with the number of erythrocytes. Analysis of this observation will be expanded and possible explanations for this observation will be suggested.

RICHARD J. CLARK (York College of Pennsylvania). QUAKER RUN REVISITED: A NEW LOOK AT SOME OLD DATA.—Saunders (1936) censused the breeding birds of the Quaker Run Valley, Allegheny State Park, Cattaraugus County, New York, using a fixed width transect belt. He reported the ecological density by habitats after determining the area of each avian habitat by mapping it and plotting the area with a polar planimeter. This study was criticized as using too wide a transect belt (152m) (Kendeigh, 1944) and being conducted after the height of the breeding season (Kendeigh, 1946). Comparing the data from Saunder's (1936) study with his 1938 study which utilized territory mapping revealed the following: average numbers of pairs (2 years, 1936 study) per 40 ha for Maple-Beech 38.7, for Maple-Beech-Hemlock modified by camping 71.9, Cherry-Aspen 127.7 and Maple-Beech-Hemlock 128.5. Data from the 1938 study yielded 27.8, 77.2, 122.9, and 132.7 pairs for the respective habitats. Odum's (1950) percentage differences were 23.6, 33.7, 24.7 and 11 for between study comparisons. Using Kendeigh's (1946) data for comparing the similar Maple-Beech-Hemlock habitats in the Helderberg Plateau (N.Y.), showed percentage differences of 42.4 and 44.4 with the Saunder's 1936 and 1938 studies respectively. Avian species diversity is then examined using Saunder's (1936) data.

FRANCIS A. VELAZQUEZ and RICHARD J. CLARK (York College of Pennsylvania). COMPARISON OF AVIFAUNAL POPULATIONS SURROUNDING SCIENCE LAKE, ALLEGHENY STATE PARK, CATTARAUGAS COUNTY, NEW YORK.—A comparison of breeding avifaunal populations of Saunders (1938) 225 acre Science Lake study area in Allegheny State Park is made with a similarly conducted study 42 years later. Vegitational succession has been allowed to proceed naturally. Variations between study methods are discussed as are qualitative and quantitative results of avifaunal populations. Local extinctions include: Black-billed Cuckoo, Yellow-billed Cuckoo, Ruby throated Hummingbird, Hermit Thrush, Black-throated Blue Warbler, Canada Warbler, Indigo Bunting, Goldfinch and Field Sparrow, while local colonizations include Wild Turkey, Ruffed Grouse, Barred Owl, Chimney Swift, Yellow-bellied Sapsucker, Great Crested Flycatcher, Eastern Wood Peewee, Brown Creeper, Veery, Yellow Warbler, Louisiana Waterthrush, Evening Grosbeak, Redwinged Blackbird, Common Grackle, Northern Oriole and Purple Finch.

TERRY L. MASTER (Biometric Services, Inc.) and CARL S. OPLINGER (Muhlenberg College). NESTING AND BROOD REARING ECOLOGY OF AN URBAN WATERFOWL POPULATION. ALLENTOWN, PENNSYLVANIA.—The effects of crowding on nesting and brood rearing behavior in an urban waterfowl population were observed during an investigation of the population's breeding behavior. This study was conducted in and around the Allentown city park system from 1 January 1977 through 14 August 1977. The waterfowl population consisted of Mallards and Canada Geese. Nesting success and brood sur-

vivability were density dependent with low success and survivability corresponding to the most dense nesting conditions. The effects of crowding on the mallard population were evident in the lack of pair bond formation, occurrence of numerous multiple male attacks on females, increased incidence of egg dropping and choosing of unusual nesting sites. Canada Geese, although exhibiting some of these tendencies to a lesser degree, were able to adapt to the crowded conditions and enjoyed relatively high nesting success and brood survivability.

DANIEL KLEM, JR., MELANIE A. PARKER, WILLIAM L. SPRAGUE, SCOTT A. TAFURI, CARL J. VELTRI and MICHAEL J. WALKER (Department of Biology, Muhlenberg College, Allentown, PA). GROSS MORPHOLOGY AND GENERAL HISTOLOGY OF THE ALIMENTARY TRACT OF THE AMERICAN ROBIN (*Turdus migratorius).*—The alimentary tract of the American Robin was prepared for gross and microscopic examination. From anterior to posterior the tract proper consists of the *esophagus, ingluvies* or crop,*proventriculus* or glandular stomach, *ventriculus* or muscular stomach (gizzard), small and large intestines, *cecum* and*cloaca.* Macroscopically, except for the *ventriculus* and*cecum,* the gross morphology of the tract is generally tubular. The *ventriculus* is oval-shaped; the *ceca* are bud-like projections that arise from the junction of the small and large intestines. Histologically, each section of the tract consists of four primary tissue layers and their subdivisions. The layers are the mucosa *(tunica mucosa)*, submucosa (*tela submucosa),* muscularis externa (*tunica muscularis)* and adventitia (*tunica adventitia).* The primary tissue layers are differentially represented throughout the tract. Generally, the alimentary tract of the American Robin exhibits morphological adaptations similar to other euryphagous species of passerine birds.

KIMBERLY L. MAY and VINNEDGE M. LAWRENCE (Washington and Jefferson College). HENSLOW'S SPARROW IN CROSS CREEK COUNTY PARK, WASHINGTON COUNTY, PENNSYLVANIA: BREEDING BIRD CENSUS.—A breeding bird census was conducted to determine the status of Henslow's sparrow (*Ammodramus henslowii)* in Cross Creek County Park, Washington County, Pennsylvania. Sixteen surveys were made in a 15.75 acre field of meadow fescue from 14 May to 3 August, 1983. Nine Henslow's sparrow breeding territories were recorded among a total of 34 territories for six avian species. Adult and immature birds were netted and color banded. Adults were observed carrying fecal pellets on four occasions. This was the second consecutive breeding season in which Henslow's sparrow has been found at this site.

T. H. CERVONE and R. C. BOTHNER (St. Bonaventure University, St. Bonaventure, NY 14778.) THE HABITAT OF *VIRGINIA VALERIAE PULCHRA* (SERPENTES; COLUBRIDAE) IN NORTHWESTERN PENNSYLVANIA.—*V.* v. *pulchra*, commonly known as the Mountain Smooth Earth Snake, is confined to the unglaciated Allegheny Plateau or western Pennsylvania, eastern West Virginia, and western Maryland and shows a disjunct distribution within its range. It typically inhabits short herbaceous, leaf-littered clearings with flat-fine sandstone rocks at altitudes from 274 to 1183 meters above sea level. The relief ranged from 0 to 34 meters above valley floor. These clearings are bordered by a mixed mesophytic, deciduous forest and have gentle to moderate slopes which tend to be located near water on well-drained, sandy soils facing any direction except north. Ant mounds are very abundant in this type of habitat. The most common snakes found sharing this habitat with *V. v. pulchar* were *Diadophis punctatus edwardsi* (Northern Ringneck Snake) and *Storeria occipitomaculata occipitomaculata (*Northern Red-bellied Snake).

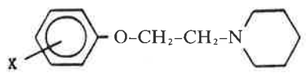
T. H. CERVONE, S. L. KELLOGG, and R. C. BOTHNER, (St. Bonaventure University, St. Bonaventure, NY 14778). HIBERNATION OF *VIRGINIA VALERIAE PULCHRA* AND OTHER SMALL SNAKES IN AN ANT MOUND IN NORTHWESTERN PENNSYLVANIA.—Ant colonies are very common throughout the range and habitat of*V. v. pulchra* (Mountain Smooth Earth Snake). Their galleries interlace the habitat and open beneath the many strewn flat-fine sandstone rocks which shelter *V. v. pulchra.* On a number of occasions, this snake has been observed to use these tunnels as avenues for escape. Furthermore, immature *V. v. pulchra* have been found in early spring near the perimeter of and found retreating into *Formica sp.* mounds. This ant-snake association is unique and prompted us to excavate three ant mounds in northwestern Pennsylvania in April of 1982, while snow was still on the ground. This was done to determine if this snake used these mounds as hibernacula. From one *F exsectoides* (Hymenoptera; Formicidae) mound that was unoccupied, four brumating *V. v. pulchra* were unearthed. Two were immature males and one was an immature female. The last snake was an adult male. They were all torpid and coiled within ant tunnels at depths from 40 to 60cm from the surface. In addition, one adult *Thamrophis brachystoma* (Short-headed Garter Snake) and 3 young *Diadophis punctatus edwardsi* (Northern Ringneck Snake) were uncovered from this mound. In contrast, the other two mounds revealed no snakes. One of these mounds was occupied by many *F. exsectoides,* while the other mound was unoccupied. To our knowledge, this is the first record of any *Virginia* using*Formica sp.* mounds as hibernacula.

JEFF DUNLOP and BARRY B. HUNTER (California University of Pennsylvania). MICROSCLEROTIAL GERMINATION OF*CYLINDROCLADIUM SCOPARIUM* (IMPERFECT FUNGUS) IN STERILE AND NATURAL SOILS.—The microsclerotia (MS) of *Cylindrocladium scoparium (*Morgan) were investigated to ascertain their capacity to germinate, form secondary MS and to sustain viable germtubes in sterile and natural soils. Nursery, agricultural, and woodland soils were amended/treated with, either, a bacterial antibiotic, sawdust-manure mixture, freezing, dried leaves or a geranium leaf extract. The test fungi were grown on a tyrosine agar medium (conducive for MS development). The MS were separated from the medium and were placed on agar covered microscope slides. Coverslips were added and the slides (agar side down) were then placed on saturated soil within petri dishes. Twenty MS were observed daily for each amendment/treatment with a compound microscope. Microsclerotia germinated in 24 hours in every soil, except that amended with dried leaves. Secondary MS developed after 96 hours in sterile soil or soil treated with antibiotics. Fewer secondary MS developed in sterile woodland soils than on sterile agricultural and nursery soils. Germtubes were usually devoid of cytoplasm after 96 hours in most soils. Germtube viability was prolonged to 144 hours with geranium leaf extract and 216 hours when the antibiotic was added to the soils. Germtubes remained viable indefinitely when all soils were sterilized.

ROBERT E. OGREN (Wilkes College, Wilkes-Barre, PA). EXOTIC LAND PLANARIANS OF THE GENUS *BIPALIUM* PLATYHELMINTHES:TURBELLARIA) FROM PENNSYLVANIA AND THE ACADEMY OF NATURAL SCIENCES, PHILADELPHIA.—Members of the genus *Bipalium* are endemic in Japan, India, Ceylon, & Indo-China. However, certain species have been introduced into the United States by man with exotic plants and distributed by horticultural practices. Specimens of one of these, *Bipalium kawanse,* are described from the museum of the Acad. Nat. Sciences, Phila. The recent discovery of the species *B. adventitium* and a variety of *B. trilipeatum* from Collegeville, PA., Ursirus College campus, shows that three species are established in Pennsylvania.

MARTIN L. CIPOLLINI and JERRY L. PICKERING (Indiana University of Pa.). SIGNIFICANCE OF Ba AS A COMPONENT OF BRINES IN THE YIELD AND ELEMENTAL COMPOSITION OF PLANTS.—This study was conducted to determine the significance of barium, as a component of brines released into leach fields at natural gas wells, on the yield and elemental composition of plants. Ba was isolated for study due to its known phytotoxicity, its unusual elevation in local (Indiana Co., Pa.) brines and its possible accumulation in plant tissue. A greenhouse experiment was conducted on bean and barley plants using brines of average elemental composition and containing high (2000 ppm) and low (trace) levels of Ba. Also, sampling of soils at two high-Ba gas well sites was undertaken. Soil extracts and plant digests wwere analyzed for Ca, Mg, Ma and K by flame atomic absorption and emission and for Ba by atomic absorption using heated graphite atomization. pH of soil extracts was also taken. The results of this research show that, at the levels seen in local brines, Ba has no detectable effect upon yield and produces no induced elemental imbalances in plants and, instead, sodium is probably the major, if not sole, contributor to phytotoxicity evident at well sites where brine is released.

POTHEN VARUGHESE and JON KIRSCH (Indiana University of Pennsylvania). SYNTHESIS OF MONOAMINE OXIDASE INHIBITORS BY PHASE TRANSFER CATALYSIS.—Monoamine oxidases are enzymes responsible for the biochemical oxidation of biogenic monoamines in many organs and internal body tissues. But most of the enzyme activity occurs in the brain. A series of potential monoamine oxidase inhibitors of the general structure



are synthesized by the phase-transfer catalyzed nucleophilic displacement reaction between N-(2-chloroethyl) piperidine and various substituted phenoxide ions in dichloromethane/water two-phase solvent system. The products are isolated, purified, and characterized by IR and NMR spectrometry. The products are obtained in good yield. The synthetic process and analytical data will be presented and discussed.

DEBRA A. HORSTMAN and WILLIAM E. DIETRICH JR. (Biology Dept., Indiana University of Pennsylvania, Indiana, PA 15705). EVALUATION OF THE PHENOL/TANNIC ACID TURBIDOMETRIC PROTEIN ASSAY.—A turbidometric protein assay using phenol/tannic acid reagent (P/T) as a precipitant was evaluated for routine lab use. (*Clinica Chimica Acta 4* (1959).515) Standard curves of high reproducibility over the 10-100ug range are produced in 15 minutes using two reagents. Several common biochemical buffers, protein reducing agents, and glycerol give negligible interference. Sensitivity was decreased one-third by 1% SDS and 8M urea. The level of interference by DNA and RNA is about the same as for the Lowry and Bio-Rad protein assays. The P/T assay was shown to be a superior predictor of protein content using several purified enzymes.

M. CHAMBERLAIN and G. HESS (Messiah College). PROTON TRANSPORT THROUGH RED BLOOD CELL MEMBRANES.—When the pH of human or rat blood cells (RBC's) is decreased it tends to drift toward the normal of 7.4. This is interpreted as a transport of protons through the cell membrane to the hemoglobin system giving $Hb + H^+ \rightarrow HHb$, a process which is reversed on raising the pH above the normal. On attainment of equilibrium in the range of pH 4.5-10 it was found that the moles of protons transferred per mole of contained Hb was about 40 which would indicate involvement of constituent amino acids. The rate of proton transport for human and rat RBC's as measured by the HCl (or NaOH) required to hold the pH, for example, at 6 (or 10) appears to be first order with k's of 0.0110 and 0.0186 sec^{-1}, respectively. These are considerably reduced on the addition of Cu^{2+}. Whether the rate as measured is one of proton transport through the membrane or of a rearrangement of the Hb molecule cannot yet be decided.

STEPHEN E. D'ORAZIO and CHARLES W. HOLLIDAY (Lafayette College, Easton, PA, 18042). SALINITY-INDUCED CHANGES IN GILL Na^+, K^+-ATPase IN THE FIDDLER CRAB, *Uca pugilator*.—The enzyme, Na^+, K^+-ATPase, has been implicated in adaptive increases in gill ion transport in osmoregulating crustaceans. Ionic requirements of gill Na^+, K^+-ATPase specific activity (ESA) were characterized and ESA was measured in crude homogenates of individual gill pairs of crabs acclimated 21d to 10, 50, 100, 150, and 200% sea water (SW) under two conditions: continuous immersion or a "natural" environment with dry sand and SW. In immersed crabs gills 5 and 6 contained approximately 75% of total gill ESA and most of the gills significantly increased ESA in 10% SW relative to 100% SW controls. Crabs in 50% SW had significantly higher ESA in gill 6. Acclimation to 150 or 200% SW did not significantly change gill ESA. Crabs in the "natural" environment had essentially the same gill ESA response but were able to hyper and hyporegulate much better than immersed crabs. Thus, gill Na^+, K^+-ATPase appears to be important in adaptation to dilute media only. Supported by a grant from Research Corporation and by Lafayette College.

HAROLD J. WEBSTER (DuBois Campus, Pennsylvania State University) and DAVID KAIRYS (DuBois Campus, Pennsylvania State University). AN IMPROVED TECHNIQUE FOR COLLECTION OF HUMAN TEARS.—While pursuing a study of

lysozyme levels in human tears, the authors were dissatisfied with collection systems previously used. We therefore constructed a new, improved apparatus for tear collection using a thin, flexible polyethylene tube attached to a standard 25-gauge 1.0 cc tuberculin syringe. This system is superior to previously designed apparati in that it permits the collection of a relatively large volume of tears in a short time without risking damage to delicate ocular structures. This promises to enhance the reliability of tear chemistry research without significantly adulterating the chemical composition of the samples. Typical results for total protein, levels of IgA and lysozyme, and Minimum-Inhibitory-Concentration bioassay of tears are presented to support the authors' position that standard chemical assays are not altered. An additional bonus inherent in this technique is the potential for obtaining larger populations of experimental subjects due to the low level of irritation that subjects experience when tears are sampled. This apparatus is easily ammendable to clinical and medical diagnostic studies of tear chemistry in patients suffering from various eye diseases.

P. J. PADGETT (Wilkes College) and N.R. KRIEG (Virginia Tech.). EFFECTS OF VARIOUS WAVELENGTHS OF LIGHT ON THE GROWTH OF *SPIRILLUM VOLUTANS*.—*Spirillum volutans*, a microaerobic organism, grows aerobically in casein hydrolysate succinate salts (CHSS) medium and microaerobically on CHSS medium solidified with 1.5% agar and supplemented with 0.002% potassium meta bisulfite. Growth, either aerobic or microaerobic, was inhibited in both liquid and solid media when the media was exposed to 10,760 lx of white fluorescent light for 1 hour. It has been demonstrated that hydrogen peroxide is generated in CHSS broth when it is exposed to light and that *S. volutans* is very sensitive to this compound. Colored filters representing the spectrum of visible light (400-760 nm) were used to expose CHSS plates to these wavelengths. The wavelengths responsible for the hydrogen peroxide generation and subsequent inhibition were thus determined. Light intensity remained the same at all of the wavelengths to which the plates were exposed.

JANIS E. FEGLEY and LESTER J. TUROCZI (Wilkes College). STUDIES IN MUTAGENESIS AND ANTI-MUTAGENESIS, III. A MODIFIED MICRONUCLEUS TEST AS A GENOTOXIC SCREEN USING VITAMIN A.—The Mouse Micronucleus Test for mutagenicity was employed as a genotoxic screen for vitamin A (retinol). In this *in vivo* mammalian system, vitamin A was screened for its mutagenic potential by injecting the substance i.p. and reading the effects directly from bone marrow smears of the femur. In this investigation, vitamin A demonstrated very little change in the number of micronuclei produced as compared with the controls, and was classified as a nonmutagen at dosage levels tested. A modification of the test was then employed to screen the vitamin A for possible antimutagenic potential. The protocol was followed using a known mutagen, quinacrine, as the insult agent against which the test compound could be measured for anti-mutagenic (protective) effects when vitamin A was injected concurrently with the quinacrine. The results demonstrated a significant reduction in the number of micronuclei produced, and therefore was considered to confer antimutagenic properties.

CELESTE M. BARKER and DENNIS M. McNAIR (Department of Biology, University of Pittsburgh at Johnstown). HELMINTHS AND ECTOPARASITES OF THE SHORT-TAILED SHREW, *Blarina brevicauda,* IN CAMBRIA COUNTY, PENNSYLVANIA.—Short-tailed shrews, *Blarina brevicauda,* were examined for parasites during Spring, 1982 and Fall, 1982 and 1983. Parasites recovered include: cestodes -*Hymenolepis acanthocephalus* and *Pseudodiorchis reynoldsi;* trematodes—*Brachylaima rhomboideus, Entosiphonus thompsoni* and *Panopistus pricei;* nematodes—*Porrocaecum ensicaudatum* (3rd stage larva),*Porrocaecum* sp. and two unidentified species; flea—*Doratopsylla blarinae.* Species of parasites recovered are the same as those found in Ohio, North Carolina, Connecticut, Indiana and Iowa. Seasonal changes in parasite loads has been noticed.

LUCINDA UNDERWOOD and ALLAN MILLER (California University of Pennsylvania). MICROHABITAT UTILIZATION AND DISPERSAL OF *PEROMYSCUS LEUCOPUS*.—The study area is a privately owned woodlot located approximately 2.75 km. south of California, Pennsylvania along Route 88. The main objectives of the research were: to determine if differential microhabitat utilization was operative among the age classes and sexes; to determine the effect adult males and females have on the dispersal of juveniles and subadults; to determine what effect pulsating removal had on dispersal and dispersion. Live trapping utilizing the mark-recapture technique was conducted on a 2.484 ha grid consisting of 15 rows of 45 traps on a 6 meter grid. Home ranges were calculated using a modified elliptical technique of Jennrich and Turner (1969). Data were collected from three trapping periods between 1 May and 29 October 1982. The woody vegetation was sampled at four strata: overstory (dbh $\geq$7.5 cm); understory (dbh $\leq$7.5 cm); sapling and shrub (2.0 m. ht. $\leq$ 7.5 cm); ground litter. The vegetation data was analyzed by discriminant analysis.

MICHAEL J. FERRIS and CARL R. PRATT (The Pennsylvania State University, Wilkes-Barre Campus). ECOLOGICAL CHARACTERISTICS OF A GRAY SQUIRREL (*Sciurus carolinesis)* POPULATION IN NORTHEAST PENNSYLVANIA.—A population of gray squirrels (*Sciurus carolinesis)* was monitored for a period of approximately 15 months. During this time the identity of members of the population was established through the use of ear tags and color-coded collars. The colored collars allowed easy identification of individual squirrels in the field. Characteristics such as weight, body length, tail length, chest girth and neck girth were recorded for each individual as it was repeatedly live-trapped. Collared squirrels were observed during feeding periods at a feeder constructed to increase and concentrate activity in an easily observed area. Social interactions were observed as members of the population approached the feeding station which was designed to permit only one squirrel to feed at a time. Feeding rates of individual squirrels at the feeding station were examined to determine the rate at which a squirrel can ingest food in order to understand the cyclic increase in weight typically observed during the fall season. Productivity data for this population has been difficult to obtain and nest boxes were installed this fall to aid in determining the reproductive success of the population. Although on progeny were observed during the early spring season, 4 immatures were live-trapped and collared during the fall of 1983.

RONALD R. KEIPER (The Pennsylvania State University). LATE AUTUM FOOD HABITS OF WHITE-TAILED DEER *(Odocoileus virginianus)* AND SIKA DEER (*Cervus nippon)* ON ASSATEAGUE ISLAND, MARYLAND.—The late fall food habits of deer on Assateague Island, Maryland were determined by microscopically examining 50 pellet samples collected from 18 deer (5 white-tailed and 18 sika deer) at a deer check station between November 27, and December 1, 1982. The procedure consisted of preparing 20 microscope slides from each pellet sample and comparing the plant materials on the slides with known plant reference slides. Thirty-five different plants were identified in the sika deer fecal samples, although only 4 species made up over 90% of the relative density of plant fragments in the pellets. These plants, and their relative densities, were *Solidago* (34.04%),*Myrica* (27.12%), *Spartina* (17.17%), and *Rhus* (13.19%). Twenty-three different plants were identified in the pellets of white-tailed deer, and only three of these were not found in the sika pellets. *Myrica* (17.79%), *Rhus* (16.42%), *Solidago* (14.80%), and *Lechea* (34.73%) were the most important plants in the diet of white-tailed deer. These data suggests there is a broad overlap in the diets, and competition between, the two deer species in late fall.

RENÉ KOCHENBERGER (Millersville University) and DR. DAVID ZEGERS (Millersville University). FEEDING HABITS OF SIKA DEER *(Cervus nippon)* ON CHINCOTEAGUE NATIONAL WILDLIFE REFUGE.—Field observations were conducted from October, 1980 to May, 1981 at major feeding grounds, to determine major dietary components for fall, winter and spring. Resulting data were used to produce a summary of seasonal change in major dietary components of sika. Plants of major importance were *Myrica, Spartina patens, Smilax, Baccharis halimifolia, Rhus, Prunus serotina,* and *Distichlis spicata.* Sika were classified as grazers during spring and fall. In winter months they were browsers, with grazing still important. Sika preferred feeding along wood edges and in fresh and salt marshes. They were most active during the hours just after dawn and just before dusk in spring and fall, with high midday activity during the winter. Night spotlighting patrols showed deer to be most active during moonlit nights. Behavioral observations showed that sika fed regularly in fresh and salt marshes, thus decreasing competition with native white-tailed deer on Chincoteague National Wildlife Refuge. The study concluded the sika deer as being a highly adaptable species with a diverse diet.

RICHARD D. L. FULTON (Trenton, N.J. , State College) and JON D. INNERS (Pennsylvania Geological Survey). CRINOIDS FROM THE MAHANTANGO FORMATION (MIDDLE DEVONIAN), CARBON COUNTY, PENNSYLVANIA.—Four species of crinoids are described from the Mahantango Formation (Middle Devonian—Givetian) of Carbon County, Pennsylvania. Three of the species—*Gennaeocrinus kentuckiensis* (Shumard), *Megistocrinus ontario* Hall, and *Dolatocrinus liratus* (Hall)—are camerates belonging to the suborder Monobathrida. They are known from numerous relatively complete crowns. The fourth species—*Ancyrocrinus bulbosus* Hall—is diagnosed solely on the basis of its distinctive holdfast and is of uncertain taxonomic affinity. The genera *Megistocrinus* and *Ancyrocrinus* are recognized for the first time in Pennsylvania. In Carbon County each species appears to characterize definite stratigraphic levels within the Mahantango Formation. In ascending order, the species occur as follows: *M. ontario* in the Little Gap fossil zone, *G. kentuckiensis* and *A. bulbosus* in the Centerfield fossil zone, and *D. liratus* in the Tully fossil zone. The latter species has been previously reported from the Centerfield of Monroe County.

DAVID K. BREZINSKI (University of Pittsburgh). EPIZOAN-HOST RELATIONSHIPS IN THE WYMPS GAP LIMESTONE (CHESTERIAN) OF PENNSYLVANIA.—Epizoans in the Wymps Gap Limestone in southwestern Pennsylvania are represented by commensal and parasitic habits. Brachiopods, such as *Anthracospirifer, Composita,* and *Diaphragmus,* commonly serve as hosts for commensal relations with *Cornulites, Spirobis,* and *Stenopora.* These epibionts encrust both the brachial and pedicle valves and are often more numerous along the commissure. This positioning allowed utilization of feeding currents created by the host brachiopods. Colonization of dead hosts is indicated by the overgrowth of the commissure by @epibionts. Platycerid gastropods represent a second type of commensal epibiont. Restricted only to live crinoid hosts, these gastropods indulged in coprophagus feeding habits. Parasitic behavior is illustrated where *Stenopora* have overgrown zooecia of other fenestrate bryozoans, where *Cornulites* have grown to the commissure of brachiopods, and where barnacles have bored brachiopod valves. Understanding epizoan-host relationships aids greatly in the study of host functional morphology and ecology.

CARLA A. KERTIS (U.S. Bureau of Mines). DISCRIMINATING SYNDEPOSITIONAL VS. POST-DEPOSITIONAL COALBED DISCONTINUITIES.—Processes that are contemporaneous with peat deposition create coalbed discontinuities that are clearly distinguishable from discontinuities that form post-depositionally. Syndepositional discontinuities are most commonly the result of scouring by ancient distributary channels. These breaks in the coalbed are recognized by several criteria: 1) absence or thinning of the coalbed, 2) numerous partings or binders, 3) decreased coal quality, 4) anomalous coal thicknesses immediately adjacent to the channel, and 5) rolls in the coalbed. Syndepositional discontinuities may also result from channel-bank slumping, growth of structural folds, and topographic irregularities in the peat swamp. Discontinuities generated after peat deposition commonly occur in conjunction with syndepositional discontinuities and include channel scouring and associated slumping, tectonic faulting, and the formation of clay veins. Syndepositional discontinuities created by distributary channel activity produce numerous warning signs, as mentioned above, and can be predicted well in advance of mining. On the other hand, post-depositional discontinuities occur abruptly and give little advance notice of their presence. Although both types of coalbed discontinuities create severe safety and economic hazards in underground coal mines, the problems associated with syndepositional discontinuities are more numerous. Recognition of coalbed discontinuities may allow the mine operator to implement plans to avoid or accommodate the hazards.

ROBERT WEISS, (University of Pittsburgh, Geology and Planetary Science). CAUSES AND CHARACTERISTICS OF SLOPE FAILURES ALONG THOROUGHFARES IN THE PITTSBURGH AREA.—The alternation of resistant sandstone

and weaker claystone and shale units in the Pennsylvania Conemaugh group is the cause for many slope stability problems in the Pittsburgh region. The many highway cuts in the Pittsburgh area are often the site of slope stability problems. Slopes which have been cut at too steep of an angle into shale and claystone units have a high incidence of failure, slopes where sandstones overlie weaker shale and claystone units are prove to rock falls when support for the sandstone is removed by the weathering and erosion of the weaker units. Failure to take the local geology into consideration during the planning of highway construction can, and has had tragic results, such as the tragic rock fall which occurred along U.S. Route 51 earlier this year.

DEBORAH ANN WEIBLE (Thiel College) and DORIS T. HAARR (Thiel College). CONODONTS FROM THE PENNSYLVANIAN (DESMOINESIAN) VANPORT LIMESTONE.—The lithology of the Vanport limestone shows a progressive variation, as inferred from a 10 locality transect from Eastern Ohio into Elk County, Pennsylvania, from a relatively pure calcite to a very clay rich limestone reflecting a closer proximity to shoreline in the east than in the west. Conodonts recovered from the highly fossiliferous limestone show a variation in the color alteration index (CAI) from west to east indicating differing depths of burial. The specimens obtained from the nearly pure limestone to the west are of excellent preservation while those recovered from limestone with a higher percentage of clay material to the east are of moderate preservation.

**The abstracts published herein have not been subjected to editorial scrutiny.*

THE PENNSYLVANIA ACADEMY OF SCIENCE
CONSTITUTION
APPENDIX I
CONSTITUTION AS ADOPTED
APRIL 11, 1925

ARTICLE I

Section 1. This Association shall be called the Pennsylvania Academy of Science.

Section 2. The object of this Academy shall be scientific research and the diffusion of knowledge concerning the various departments of science: to promote intercourse between those engaged in scientific work, especially in Pennsylvania; to assist by investigation and discussion in developing and making known the material, educational, and other resources and riches of the Commonwealth; to arrange and prepare for publication such reports of investigation and discussion as may further the aims and objects of the Academy as set forth in these articles.

ARTICLE II

Section 1. Membership in this Academy shall be made up of the following classes: 1. active members; 2. associate members; 3. honorary members, and 4. non-resident members.

Section 2. Any person engaged in any department of scientific work, or in any original research in any department of science, shall be eligible to active membership. Active members shall pay an admission fee of two dollars, which shall also cover the first year's membership fee, and thereafter an annual fee of two dollars. Active members who have removed from the Commonwealth may continue as active members by the payment of annual dues.

Section 3. Any resident of Pennsylvania interested in science but who does not qualify for active membership may be elected to associate membership. Fees for associate members shall be the same as for active members.

Section 4. Honorary members may be elected to this class of membership in the Academy on account of special prominence in science or other branches of learning. They shall be exempt from the payment of dues.

Section 5. Any person not residing in Pennsylvania who is eligible to membership in the Academy may be elected to non-resident membership. Such members shall pay the regular admission fee and annual dues.

Section 6. Application for membership in any of the foregoing classes shall be referred to a Membership Committee, which shall consider such application and report to the Academy before the election. In any case a three-fourths vote of the active members present at any meeting shall elect to membership.

Section 7. The privilege of voting in this Academy shall be restricted to the class of active membership.

ARTICLE III

Section 1. The officers of this Academy shall be chosen by ballot at the annual meeting and shall hold office one year or until their successors may be chosen. They shall consist of a President, Vice President, Secretary, Assistant Secretary, Press Secretary, Editor, and Treasurer, who shall perform the duties usually pertaining to their respective offices and in addition, with the ex-Presidents of the Academy, shall constitute an Executive Committee. Additional members of the Executive Committee shall be elected annually, sufficient to bring the total number of such additional members to four, until such time as past-Presidents become available. The President shall, at each annual meeting, appoint a Program Committee and a Local Arrangements Committee, each of two or more members, which shall prepare the programs and have charge of the arrangements for all meetings for one year. There shall also be a Committee on Publications, consisting of the President, Secretary and Editor.

Section 2. The Academy may also elect an Advisory Council to consist of the Governor of the Commonwealth and an indefinite number of others as may be determined from year to year.

Section 3. The annual meeting of the Academy shall be held during the Easter vacation of each year and at such place as may be determined by the Executive Committee. Other meetings may be called at such time and place as may be decided upon by the Executive Committee. The Executive Committee shall transact any necessary business not especially provided for in this constitution, in the interim between general meetings.

Section 4. The regular publications of the Academy shall, include the transactions and all other papers deemed suitable by the Committee on Publication. All members shall receive gratis all current publications of the Academy.

Section 5. This constitution may be altered or amended at any annual meeting by a favorable vote of three-fourths of the members present, provided that a copy of the proposed amendment shall be sent to all members at least thirty days previous to the annual meeting.

APPENDIX II
ARTICLES OF INCORPORATION FOR PENNSYLVANIA ACADEMY OF SCIENCE AND CONSTITUTION AS ADOPTED MAY 2, 1975 AND *AS AMENDED APRIL 10, 1983

1. The name of this corporation shall be Pennsylvania Academy of Science which name has been registered with the Department of State of the Commonwealth of Pennsylvania within six (6) months prior to the date of application made to the Court of Common Pleas of Northampton County for approval of corporate charter.
2. The initial registered office of the corporation is in Easton, Pennsylvania with post office address as follows: Lafayette College, Easton, Pennsylvania.
3. This corporation is formed for the following purposes: To encourage scientific research; to promote interest in the teaching of science; to stimulate exchange of ideas among those engaged in scientific work especially in Pennsylvania; to assist in the development and distribution of information about the material, educational, and other resources and riches of the Commonwealth; and to arrange and prepare for publication such reports as may further these objectives, all of which purposes do not contemplate pecuniary gain or profit, incidental or otherwise, to the members of the corporation.
4. This corporation shall exist perpetually.
5. This corporation is organized upon a nonstock basis.

ARTICLE I INITIAL MEMBERSHIP

Section 1. The initial membership of the Academy shall consist of those members of the various classes of membership who have heretofore been members of the Pennsylvania Academy of Science as an unincorporated association.

ARTICLE II
MEMBERSHIP

Section 1. Memberships to the Academy shall be made up of the following classes: 1. active members; 2. student members; 3. life members; 4. honorary members; 5. emeritus members; *6. sustaining members; and 7. institutional members.

Section 2. Any person engaged or interested in scientific work shall be eligible to active membership.

Section 3. Honorary members may be elected by the Board of Directors to this class of membership in the Academy on account of special prominence in science or other branches of learning. They shall be exempt from the payment of dues.

Section 4. Active members who elect to pay an increased rate of annual dues specified in the appended bylaws shall be designated as sustaining members.

Section 5. Any business or professional organization, or educational institution, that is interested in science may be elected to institutional membership.

Section 6. The privilege of voting in the Academy shall be restricted to the classes of active, student, life, sustaining, and honorary membership, but the privilege of speaking from the floor at meetings of the Academy shall be available to all classes of membership.

Section 7. Applications for membership will be accepted by the Chairman of the Membership Committee. Election of honorary members shall be by a three-fourths vote of the active, student, life, sustaining, honorary and emeritus members, present at any meeting. No election is required to permit active members to advance to the sustaining or emeritus membership category.*

Section 8. Members of all categories shall pay at a rate set annually by the Board of Directors and subject to a three-fourths vote of the voting members present at the Annual Meeting. The rates set should reflect the programs and operating costs of the Academy as determined by the membership. Life membership is conferred upon active members upon payment of two hundred dollars ($200). Honorary members shall be exempt from the payment of dues.

**Section 9.* To qualify for emeritus status, a member must have been in good standing for a minimum of ten years, active in the Academy as judged by the Board of Directors and no longer gainfully employed either because of disability or retirement.*

ARTICLE III
DIRECTORS AND OFFICERS

Section 1. The Board of Directors shall be composed of the persons holding office as provided in this article.

Section 2. The officers of the Academy shall be and consist of a president, a president-elect, a recording secretary and a corresponding secretary, a treasurer, a historian, a director of the Junior Academy of Science, an editor of the Proceedings, and an editor of the Newsletter.*

Section 3. The offices shall be held initially by those persons who were elected to the comparable offices of the Academy prior to its incorporation, and they shall serve for the terms for which originally elected.

Section 4. Officers elected hereafter shall hold office for terms in accord with the following schedule.
President, President-Elect, Recording Secretary, Corresponding Secretary,* Treasurer, Assistant Treasurer—Two Years, Director of the Junior Academy—Three Years, Editor of the Proceedings, Editor of the Newsletter, and Historian—four Years.

Section 5. The duties of the officers shall be those that usually pertain to the respective offices. The Secretaries shall keep a record of all official business. The treasurer shall accept funds, deposit monies, issue membership cards, and keep a record of all members of the Academy. The assistant treasurer shall disburse funds and maintain investments and property of the Academy. The historian shall collect and preserve all information of interest to the Academy.*

Section 6. In case of the inability of the President to perform the functions of his office, the following succession shall assume the responsibility of the Office of the President: President-Elect, Recording Secretary, Corresponding Secretary, Treasurer, and Assistant Treasurer.*

Section 7. Interim vacancies on the Board of Directors may be filled by appointment by the President with approval by the majority of the Board of Directors. The office will be open for election at the next annual meeting.

ARTICLE IV
ELECTION OF OFFICERS AND DIRECTORS

Section 1. The officers and directors of the Academy shall be elected at the annual meeting of the Academy by majority vote of the membership entitled to vote by other provision of these bylaws.

ARTICLE V
MEETINGS

Section 1. The annual meeting of the membership of the Academy shall be held in the spring of each year at such time, date and place as may be determined by the Board of Directors, and need not be held at the registered office of the corporation.

Section 2. Other meetings of the membership, customarily held in the summer, shall be held at such time and place as may be determined by the Board of Directors from time to time.

ARTICLE VI
COUNCILS AND COMMITTEES

Section 1. The membership may elect an honorary council to consist of the Governor of the Commonwealth and others as may be determined from year to year.

Section 2. The President shall appoint an Advisory Council to be composed of eight to twelve members with not more than one person per discipline. The members shall be appointed for terms of no more than two years, the terms of which may overlap at the discretion of the President.

Section 3. All past presidents of the Academy, including those who held office of president prior to the incorporation hereof, shall constitute a committee representing the membership as delegates to any and all meetings of the Board of Directors.

Section 4. The following standing committee chairmen shall be appointed by the President: 1. membership; 2. editorial; 3. time and place of meetings; 4. local arrangements; 5. program; and 6. auditing. Special committees may be appointed by the President.

Section 5. The nominating committee shall consist of the immediate past president as chairman, the other two members being the second past president and the chairman of the advisory council.

ARTICLE VII
DUTIES OF COUNCILS AND COMMITTEES

Section 1. The Honorary Council shall assist the Academy in resource planning.

Section 2. The Advisory Council shall promote greater Academy interaction with the public, industry, and public and private educational institutions.

Section 3. The membership committee shall direct the maintenance and development of the membership of the Academy.

Section 4. The editorial committee shall study all contributions and papers submitted to determine their quality and suitability for publication in the Proceedings.

Section 5. The nominating committee shall prepare the slate of nominees for Academy offices, and shall present the slate at the annual meeting.

Section 6. The committee on time and place of meetings shall determine the dates and the locations of the annual spring and summer meetings subject to the final vote of the Board of Directors.

Section 7. The program committee shall develop a program suitable for the annual spring and summer meetings.

Section 8. The committee on local arrangements shall make all necessary arrangements for the spring and summer meetings.

Section 9. The auditing committee will audit the treasurer's books.

Section 10. Special committees shall function in accordance with the purpose for which they were appointed.

ARTICLE VIII
JUNIOR ACADEMY OF SCIENCE

Section 1. This Academy shall sponsor a "Junior Academy of Science" open to students in secondary schools and preparatory schools who have exhibited an interest in science.

Section 2. The officer of this Academy who serves as Director of the Junior Academy of Science shall attend the meetings of the Academy and report to this membership on the activities of the Junior Academy.

Section 3. The Junior Academy shall conduct its own meetings and elections in accordance with its own rulings.

ARTICLE IX
PUBLICATIONS

Section 1. The regular publication of the Academy shall be the annual Proceedings, which shall include the transactions and all papers deemed acceptable by the editorial committee.

Section 2. The Academy shall sponsor the Pennsylvania Academy of Science Newsletter which shall include notices pertinent to Academy business, and information about the activities of the Academy and its members.

Section 3. All current publications shall be distributed gratis to all Academy members in good standing.

ARTICLE X
ASSETS UPON DISSOLUTION OF ACADEMY

Section 1. In the event of the dissolution of the Academy, the monetary and other assets of the organization shall be transferred to the American Association for the Advancement of Science for its use and benefit.

ARTICLE XI
AMENDMENTS

Section 1. These bylaws may be amended at any annual meeting by a favorable vote of three-fourths of the members present and entitled to vote thereon, provided that a copy of the proposed amendment shall be sent to all members at least thirty (30) days prior to the annual meeting. For purposes of this section, publication of the proposed amendment in the Newsletter shall be sufficient notice, provided that copies thereof are mailed at least thirty (30) days prior to the annual meeting.

VOTED ON AND PASSED BY EXECUTIVE COMMITEE
AND GENERAL MEMBERSHIP
ON APRIL 10, 1983 AND
APRIL 11, 1983 RESPECTIVELY

CONSTITUTIONAL AMENDMENT

Just a reminder that several amendments to the Constitution will be voted upon at the Business meeting on Monday morning. The amendments were printed in the January 1983 issue of the NEWSLETTER and they are reprinted here for your information.

ARTICLE II
MEMBERSHIP

Section 1. Membership in the Academy shall be made up of the following classes: 1) active members; 2) student members; 3) life members; 4) honorary members; 5) *emeritus members;* 6) sustaining members; and 7) institutional members.

Section 7. Applications for membership will be accepted by the chairman of the membership committee. Election of honorary members shall be by a three-fourths vote of the active, student, life, sustaining, honoray and *emeritus members* present at any meeting. No election is required to permit active members to advance to the sustaining *or emeritus* membership category.

Section 9. To qualify for emeritus status, a member must have been in good standing for a minimum of ten years, active in the Academy as judged by the Board of Directors and no longer gainfully employed either because of disability or retirement.

Proposed Changes:

Article III—Directors and Officers
Section 2. Delete: a secretary Add: a recording secretary and a corresponding secretary
Section 4. Delete: Secretary
Add: Recording Secretary, Corresponding Secretary
Section 5. Delete: The Secretary
Add: The Secretaries
Section 6. Delete: Secretary
Add: Recording Secretary, Corresponding Secretary.
The amendment provides for the election of two secretaries, one corresponding and the other recording.

PENNSYLVANIA ACADEMY OF SCIENCE

SUGGESTIONS TO AUTHORS

Authors are requested to examine this copy of the Pennsylvania Academy of Science in order to bring their script into conformity with the general style of the *Proceedings*. All papers submitted for publication will normally have been presented at the spring meeting of the Academy and will be delivered in form for publication to the section chairman for transmittal to the Editor at the time of their presentation. Submission of the manuscript is a representation that it has not been published, copyrighted, or submitted for publication elsewhere. *Submit an original, 1 carbon copy, and 2 sets of illustrations.* At least one author of each paper must be a member of the Academy. Authors are billed for page charges. It is suggested that authors of papers keep in mind the following:

1. *General.* All papers should be typed, double spaced, and on "8½ X 11" paper, with adequate margins for editing. The organization of the manuscript according to the following sequences is recommended: title, authors and addresses, abstract, introduction, materials and methods (or other appropriate heading), results, discussion, acknowledgements, and references. Two copies (original and one carbon) of the manuscript are requested. *Do not use single spacing anywhere.*

2. *Headings.* All headings are in CAPITAL letters and centered. Follow exact form of this issue.

3. *Title.* Brief and to the point. It should inform the reader of the subject of the paper, and the organism to which it relates.

4. *Byline.* Include author's name, name of institution, department, address and zip code. Official title or academic degree is optional.

5. *Abstract.* A concise and lucid digest of the paper should be provided, preferably in one paragraph. This will eliminate the need for a summary.

6. *Introduction.* The introduction should be concise and offer only that information necessary to orient the reader to the purpose and scope of the paper. It should state the reasons for the work, with brief reference to previously published work (by the authors as well as other workers) on the subject.

7. *Materials and Methods.* Describe materials, methods, and equipment. Avoid repeating previously published details, unless modifications are extensive. The necessity for conciseness should not lead to omission of important experimental details necessary for others to repeat the work. Indicate specific experimental design and justify its use (unless obvious).

8. *Results and Discussion.* This section should be a clear, concise account of the findings and should explain, extend or contradict current publications. Data should be presented in the form that is briefest and clearest. Many times this is best done with tables, graphs, and charts. Limit discussion to subject; avoid unsupported theories and speculations.

9. *Acknowledgements.* These should be as brief as possible.

10. *References and Footnotes.* Number all references to the literature and footnotes in the order in which they are cited in the text. Footnotes should be avoided if possible. Each entry must be cited in the text by author and number or by number alone. For works by 1 or 2 authors, include names in each citation. For works by 3 or more authors use DOE *et al.* Give author(s) and initials of the author(s), year, title, abbreviation of the name of the journal according to *World List of Scientific Periodicals,* volume number and first and last page numbers. References to books should include author(s), year, title, publisher, place of publication, and inclusive pages. Use the following style:

Journal: Schnell, G. A. 1969. Title. *Proc. Pa. Acad. Sci.* 43:153-156.

Book: Snedecor, G.W. 1956. *Statistical Methods.* The Iowa State University Press, Ames, Iowa, 237-238.

11. *Tables and Illustrations.* Tables must be typed on separate sheets, numbered in Arabic numerals and must include a title. Check all calculations and formulae with special care. Drawings and graphs should be done in black India Ink on a white paper or on coordinated blue-lined paper. Photographs are to be presented as glossy prints with high contrast. Illustrations should be numbered and completely lettered (if applicable) using India Ink or "Tactype" typesetting. *Make lettering large enough to be legible if reduced.* Trim illustrations to show only important areas. Author's name and figure number must be written on the back of each illustration; use a soft pencil for identification. Legends for illustrations should be typed on a separate sheet in consecutive order. *Submit two sets* (original and one photographic copy) of each diagram, graph, map or photograph. Drawings, maps and graphs that are carelessly drawn will not be acceptable for publication. Each illustration and table must be cited in the text.

12. *Taxonomy.* The names of phyla are in (large) Boldface Capitals, those of classes in (light) Italic Capitals, those of orders in Boldface Capitals and Lower Case Letters, and those of families in Capitals and Small Capitals. Genera and species are always in *italics.*

13. *Technical Practices.* Draw one line under matter to be italicized; two lines under matter to be printed in small capitals (small caps); three lines under matter to be printed in Capitals (caps); and a wavy line under matter to be printed in bold-face. For italic capitals, draw three lines under the matter and write "italic caps" opposite it in the margin.

14. *Page Charges, Proofs and Reprints.* Publication space will be charged at cost to the author. *Galley proofs will be sent to authors which should be returned to the Editor within a week after receipt.* Page charges entitle the authors to 50 free reprints.

15. *Editorial Policy.* Every paper is reviewed by the Editor and his advisory board and may be returned or rejected if considered unsuitable for publication.

16. *Manuscripts and Correspondence.* All matters relating to publication in the *Proceedings* should be addressed to the Editor: Daniel Klem, Jr., Department of Biology, Muhlenberg College, Allentown, Pennsylvania 18104.

OFFICERS
1984-85

GEORGE C. SHOFFSTALL
President
Director of Education and Organizational Development
Western Pennsylvania Hospital
4800 Friendship Avenue
Pittsburgh, Pennsylvania 15224

SHYAMAL K. MAJUMDAR
President-Elect
Professor of Biology
Lafayette College
Easton, Pennsylvania 18042

STANLEY J. ZAGORSKI
Immediate Past-President
Associate Dean College of Science and Engineering
Gannon University, University Square
Erie, Pennsylvania 16541

ERNEST H. BRAU, JR.
Treasurer
Department of Chemistry
Pennsylvania State University
Mont Alto Campus
Mont Alto, Pennsylvania 17237

SHERMAN S. HENDRIX
Assistant Treasurer
Department of Biology
Gettysburg College
Gettysburg, Pennsylvania 17325

DANIEL KLEM, JR.
Editor of the Proceedings
Department of Biology
Muhlenberg College
Allentown, Pennsylvania 18104

HOWARD S. PITKOW
Corresponding Secretary
Professor of Physiology
Pennsylvania College of Podiatric Medicine
Eighth at Race Street
Philadelphia, Pennsylvania 19107

VIOLA YAKSTIS
Recording Secretary
131 S. 17th St.
Pittsburgh, Pennsylvania 16541

KURT C. SCHREIBER
Editor of the Newsletter & Director, Science Talent Search
Dean of Graduate School
Duquesne University
Pittsburgh, Pennsylvania 15219

J. ROBERT HALMA
Historian
Professor of Biology
Cedar Crest College
Allentown, Pennsylvania 18104

CLARENCE MYERS
Director of Junior Academy
Knoch High School
Saxonburg, Pennsylvania 16056

PAST PRESIDENTS OF THE ACADEMY

1925 O. E. Jennings
1926 B. L. Miller
1927 N. H. Stewart
1928 E. A. Ziegler
1929 F. D. Kern
1930 R. T. Hance
1931 D. S. Hartline
1932 E. M. Gress
1933 S. H. Williams
1934 J. C. Johnson
1935 S. H. Derickson
1936 E. T. Wherry
1937 T. D. Cope
1938 G. H. Ashley
1939 L. K. Darbaker
1940 R. W. Stone
1941 H. W. Thurston, Jr.
1942 E.A. Vuilleumier
1943 C.E. Mohr
1944 C.A. Horn
1945 H. C. Will
1946 B. Willard
1947 T. L. Guyton
1948 V. E. Light
1949 L. Whitcomb
1950 R. M. Foose
1951 T. H. Knepp
1952 W. S. Lapp
1953 E. P. Claus
1954 E. C. Herber
1955 C. E. Beekey
1956 H. K. Lane
1957 R. E. Myers
1958 R. B. Gordon
1959 A. W. Shively
1960 A. Martin, Jr.
1961 K.N. Dearolf
1962 J.L. Dyson
1963 G.F. Deasy
1964 P.C. Martin
1965 Kenneth B. Hoover
1966 Kenneth B. Hoover
1967 E. Willard Miller
1968 E. Willard Miller
1969 R. S. Chase, Jr.
1970 W. A. Uricchio
1971 W. A. Uricchio
1972 Bernard Fried
1973 Bernard Fried
1974 Charles W. Rutschky III
1975 Charles W. Rutschky III
1976 George C. Shoffstall, Jr.
1977 George C. Shoffstall, Jr.
1978 Sister M. Gabrielle Maze
1979 Sister M. Gabrielle Maze
1980 Bruce D. Martin
1981 Bruce D. Martin
1982 Stanley J. Zagorski
1983 Stanley J. Zagorski
1984 George C. Shoffstall, Jr.

PROCEEDINGS OF THE PENNSYLVANIA ACADEMY OF SCIENCE Vol. 58, Issue 1, 1984

ISSN: 0096-9222

CONTENTS

President of the Academy—Dr. George C. Shoffstall, Jr. 3
Program of the 60th Annual Meeting 4
The Honorable Governor Richard Thornburgh's Greetings 5
The Pennsylvania Academy of Science President's Address 6
Executive Committee Meeting 7
Academy Business 11
Executive Council Meeting 23
BIOLOGY: Lectin Interactions with Biomembranes: A Survey—*Darryl L. Landis and William J. Yurkiewicz* 29
BIOLOGY: An Aging Scheme for the Pine Vole, *Pitymys pinetorum scalopsoides*—*Tyrone R. Cornbower and Gordon L. Kirkland, Jr.* 37
BIOLOGY: A Survey of the Furbearers of the Codorus Drainage, York County, Pennsylvania—*Gordon L. Kirkland, Jr. and Edwin C. Gillman* 42
BIOLOGY: Correlation of Blood Glucose and Cholesterol with Social Rank and Testosterone Repalcement in Male Hamsters *(Mesocricetus auratus)*—*Fred J. Brenner and Sharon K. Bradley Wirtz* 47
BIOLOGY: A Survey of the Mammals of the Wattsburg Fen Natural Area—*Steven J. Ropski and Kenneth W. Andersen* 53
BOTANY: Vascular Riffle Flora of Appalachian Streams: The Ecology and Effects of Acid Mine Drainage on *Justicia americana* (L.) Vahl—*Michael Koryak and Rosemary J. Reilly* 55
BOTANY: Effects of Edge, Age, and Cover Type on Wildlife Microhabitats in Even-Aged Forest Stands in Central Pennsylvania—*Richard H. Yahner and Jeffrey W. Grimm* 61
BOTANY: Growth Rates of Norway Spruce *(Picea abies)* from 46 Diverse Seed Sources Studied in Maryland's Appalachian Region—*John B. Genys, Dan M. Harman and Kent B. Fuller* 67
ENTOMOLOGY: The Influence of Phorid and Sciarid Populations on Mushroom Yield at Commercial Mushroom Farms in Pennsylvania—*D. L.Rinker, R. J. Finley, P. J. Wuest, R. Snetsinger, R. Tetrault and D. J. Royse* 70
GEOGRAPHY: Trends in the Distribution of Black and White Populations During the Seventies—*George A. Schnell* 73
GEOGRAPHY: Maps in *The New York Times,* 1860-1980: A Study in the History of Journalistic Cartography—*Mark Stephen Monmonier* 79
GEOLOGY: Pressure Solution Shortening in the Martinsburg Slate, New Jersey—Eric Erslev and Carol Mann 84
PHYSIOLOGY: Interaction of Metallic Ions with Red Blood Cells and Stroma—*Robert Weisbrod, David Zercher, Gerald Hess and Ray H. Crist* 89
BIOLOGY: Preliminary Study of the Ectomycorrhizal Distribution of White Oaks in Eastern Pennsylvania Forests—*L. Mineo, S. K. Majumdar, G. Rall, J. Francis, A. Segal and A. Mrowca* 92
RESEARCH NOTE: *Oreochromis aureus* (Steindachner: Cichlidae), An Exotic Fish Species, Accidentally Introduced to the Lower Susquehanna River, Pennsylvania—*William F. Skinner* 99
RESEARCH NOTE: Sex, Age, and Dressed Weights of Hunter-Killed Sika and White-Tailed Deer from Assateague Island, Maryland—*Ronald R. Keiper, Joel Stephens and David Baldwin* 101
RESEARCH NOTE: Long Term Profits: A Difference Equation Model—*R. F. Melka* 103
Abstracts 107
Pennsylvania Academy of Science Constitution 121
Suggestions to Authors 125