PROCEEDINGS
of the
PENNSYLVANIA
ACADEMY OF SCIENCE

Founded on April 18, 1924

VOLUME 51
Issue No. 1
1977

SHYAMAL K. MAJUMDAR, EDITOR
LAFAYETTE COLLEGE
EASTON, PA. 18042

53rd Annual Meeting
Mt. Airy Lodge
East Stroudsburg, Pennsylvania

PROCEEDINGS OF THE PENNSYLVANIA ACADEMY OF SCIENCE Vol. 51, Issue 1, 1977

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. — The John Hopkins University, Baltimore, Maryland
Robert S. Chase, Ph.D. — Lafayette College, Easton, Pennsylvania
Louis J. Cizek, M.D. — Columbia University, New York, New York
Robert F. Denoncourt, Ph. D. — York College of Pennsylvania, York, Pennsylvania
Arthur Falek, Ph. D. — Emory University, Atlanta, Georgia
Henry N. Fremount, Dr. PH. — East Stroudsburg State College, East Stroudsburg, Pennsylvania
Bernard Fried, Ph. D. — Lafayette College, Easton, Pennsylvania
T. C. Hsu, Ph. D. — The University of Texas, Houston, Texas
Barry B. Hunter, Ph. D. — California State College, California, Pennsylvania
James H. Leathem, Ph. D. — Rutgers-The State University, New Brunswick, New Jersey
Robert J. Lowry, Ph. D. — The University of Michigan, Ann Arbor, Michigan
Kenneth E. Michel, Ph. D. — Slippery Rock State College, Slippery Rock, Pennsylvania
Richard P. Nickelsen, Ph. D. — Bucknell University, Lewisburg, Pennsylvania
Hayden N. Pritchard, Ph. D. — Lehigh University, Bethlehem, Pennsylvania
Herbert P. Riley, Ph. D. — University of Kentucky, Lexington, Kentucky
Leonard M. Rosenfeld, Ph. D. — Thomas Jefferson University, Philadelphia, Pennsylvania
George A. Schnell, Ph. D. — State University College, New Paltz, New York
E. J. L. Soulsby, Ph. D. — University of Pennsylvania, Philadelphia, Pennsylvania
Louis T. Stableford, Ph. D. — Lafayette College, Easton, Pennsylvania
Guy L. Steucek, Ph. D. — Millersville State College, Millersville, Pennsylvania
Henry H. Vallowe, Ph. D. — Indiana University of Pennsylvania, Indiana, Pennsylvania
William J. Yurkiewicz, Ph. D. — Millersville State College, Millersville, Pennsylvania

OFFICERS
1977-78

GEORGE C. SHOFFSTALL, JR.
President
214 Whitmore Laboratory
The Pennsylvania State University
University Park, Pennsylvania 16802

SISTER M. GABRIELLE MAZE
President-Elect
Grove and McRobert Road
Pittsburgh, Pennsylvania 15234

DAVID S. OSTROVSKY
Secretary
Department of Biology
Millersville State College
Millersville, Pennsylvania 17551

STANLEY J. ZAGORSKI
Treasurer
Department of Biology
Gannon College, Perry Square
Erie, Pennsylvania 16501

SHYAMAL K. MAJUMDAR
Editor of the Proceedings
Department of Biology
Lafayette College
Easton, Pennsylvania 18042

PAUL B. GRIESACKER
Assistant Treasurer
Department of Physics
Gannon College, Perry Square
Erie, Pennsylvania 16501

FREDERIC J. BRENNER
Editor of the Newsletter
Department of Biology
Grove City College
Grove City, Pennsylvania 16127

THOMAS H. KNEPP
Historian
706 Scott Street
Stroudsburg, Pennsylvania 18360

JOSEPH A. GENNAULA
Director of Junior Academy
5872 Kings School Road
Bethel Park, Pennsylvania 15102

SUBSCRIPTIONS. Correspondence concerning subscriptions, purchase of single copies and back issues and related business should be addressed to the Treasurer, Stanley Zagorski, Gannon College, Perry Square, Erie, Pa. 16501. Subscription price for non-members is $10.00 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, David S. Ostrovsky, Department of Biology, Millersville State College, Millersville, Pa. 17551, 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.
MEMBERSHIP. 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 member (scientist) — $10.00, (b) Associate member (non-scientist) — $10.00, (c) Student Member — $5.00, (d) Sustaining member — $15.00, (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, Shyamal K. Majumdar, Department of Biology, Lafayette College, Easton, Pennsylvania 18042.
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, F. J. Brenner, Grove City College, Grove City, Pennsylvania 16127.
Copyright 1977 by the Pennsylvania Academy of Science, Inc.

PROCEEDINGS of the PENNSYLVANIA ACADEMY OF SCIENCE

VOLUME 51
Issue No. 1
1977

SHYAMAL K. MAJUMDAR, EDITOR

Papers

Presented at the
53rd ANNUAL MEETING
PENNSYLVANIA ACADEMY OF SCIENCE
APRIL 17, 18, 19, 1977
MT. AIRY LODGE
EAST STROUDSBURG, PENNSYLVANIA

Sponsored by
EAST STROUDSBURG STATE COLLEGE

Printed by

Typehouse of Easton
167 Northampton Street
Easton, Pa. 18042

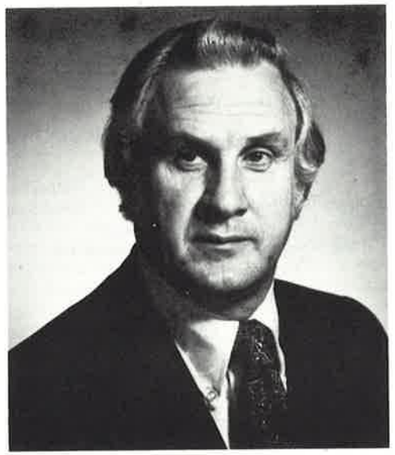
CONTENTS

President of the Academy and Academy Officers ... 3
Program of the 53rd Annual Meeting ... 4
Executive Council Meeting ... 5
Academy Business ... 7
THE DARBAKER PRIZE PAPER — BIOLOGY: Electron Microprobe Analysis of Colloidal Iodine in Thyroid Gland of White-Throated Sparrow, *Zonotrichia Albicollis* — *Jack Harclerode, David Zeigler, William Zeigler and Eugene W. White* ... 19
BIOLOGY: Spontaneous Activity of Pregnant and Nonpregnant Control CF-1C Mice — *Howard S. Pitkow, Ph.D., Mark Warnquist, Steven Phillips, and Robert H. Davis, Ph.D.* ... 23
BIOLOGY: Mercury in North Atlantic Lobster of the New York Bight — *Salvatore J. Ali, Jr. Mary Jane Bradford and G. Earl Peace* ... 26
BIOLOGY: A Simple Culture Technique for *Equisetum hyemale* Through the Entire Life Cycle — *Frank M. Hoffman* ... 29
BIOLOGY: Field Observations Including Acoustic Behavior of the Black-Digger Wasp, *Sphex pennsylvanicus* (Linn.) — *Louis Rigley and Herbert Hays* ... 32
BIOLOGY: A Histological Study of the Short Term Effects of Anthophyllite Fibers on Guinea Pig Lungs — *Stephan R. Sanko and Allan F. Wolfe* ... 35
BIOLOGY: A Seasonal Study of the Ectoparasites of *Sylvilagus transitionalis* — *Dan M. Harman and Joseph A. Chapman* ... 40
BIOLOGY: A Re-examination of the Subspecific Status of the Maryland Shrew, *Sorex cinereus fontinalis* Hollister — *Gordon L. Kirkland, Jr.* ... 43
BIOLOGY: A Study of the Realtionship Between Scarlet Oak (*Quercus coccinea* Muenchh.) and Hill Oak (*Quercus ellipsoidalis* E.J. Hill) in Michigan and Nearby States — *William Roy Overlease* ... 47
BIOLOGY: Effects of a Zinc Mine Ground Water Effluent on a Stream Diatom Community — *David M. Bell* ... 51
BIOLOGY: Formed Blood Elements of the Mussel *Elliptio complanatum* — *Bonni J. Hazleton and George R. Isenberg* ... 54
BIOLOGY: Observations on the Nocturnal Behavior of Feral Ponies — *Dr. Ronald R. Keiper* ... 57
BIOLOGY: Fishes of the Conewago Creek Drainage, York and Adams Counties, Pennsylvania — *Philip C. Ritson, Janet L. Polk and Robert W. Malick, Jr.* ... 59
BIOLOGY: Initial Survey of the Plankton of Twenty-Seven Lakes Near Wilkes-Barre, Pennsylvania, 1976 — *Charles B. Reif* ... 67
GEOGRAPHY: Fertility and Levels of Development in Mid-Nineteenth Century Pennsylvania — *George A. Schnell* ... 70
GEOGRAPHY: Geographic Variations of Infant Mortality in Pennsylvania: 1960 and 1970 — *Mark S. Monmonier* ... 75
GEOGRAPHY: Residential Patterns of Blacks in Battle Creek, Michigan, 1850-1930 — *Juanita Gaston, Ph.D. and Walter C. Farrell, Jr., Ph.D.* ... 79
GEOLOGY: The Age of the Martinsburg Formation at Swatara Gap, Pennsylvania — *Thomas O. Wright, Susan M. Garwood and Kraig Derstler* ... 85
RESEARCH NOTE: *Succinate Dehydrogenase Activity in Rana catesbeiana* Tadpole Liver During 3, 3', 5-Triioda-L-Thyronine-Induced Metamorphosis — *David Ostrovsky and Robert Sahms* ... 89
RESEARCH NOTE: The Least Weasel, *Mustela nivalis*, from Maryland — *Joseph A. Chapman and Dan M. Harman* ... 91
Abstracts ... 93
Suggestions to Authors ... 100

PRESIDENT

PENNSYLVANIA ACADEMY OF SCIENCE

1976-78



Dr. George C. Shoffstall, Jr., President, Pennsylvania Academy of Science; B.S., M.S., and Doctorate in Biological Sciences. The Pennsylvania State University. Director of Radiologic Technology, Medical Laboratory Sciences, and Para-Professional Medical Aid Programs at the New Kensington Campus of Penn State; Assistant Director of Continuing Education in the College of Science, University Park, since 1966. Lecturer in the General Education Biology Program at Penn State since 1967. Selected as an Outstanding Educator of America in 1975. Member of American Association for the Advancement of Science, American National Metric Council, Botanical Society of America, Pennsylvania Association for Adult Education, Pennsylvania Teachers Association, Associate Member of the American Museum of Natural History, National Member of The Smithsonian Associates, Kappa Phi Kappa, and Phi Sigma. Secretary of the Pennsylvania Academy of Science 1971-1974, President-elect 1974-1976.

ACADEMY OFFICERS
Seated: (left to right): George C. Shoffstall, President; Sister M. Gabrielle Maze, President-Elect; Joseph A. Gennaula, Director of Junior Academy.
Standing: (left to right): Paul B. Griesacker, Assistant Treasurer; David S. Ostrovsky, Secretary; Shyamal K. Majumdar, Editor of the *Proceedings*; Stanley J. Zagorski, Treasurer.

53rd ANNUAL MEETING
APRIL 17, 18, 19, 1977

sponsored by
EAST STROUDSBURG STATE COLLEGE

Henry N. Fremount, Local Arrangements Chairman

PROGRAM CHAIRMAN

Robert F. Denoncourt, York College of Pennsylvania

EXHIBITORS

American Optical
Carolina Biological Supply Company
Dolbey Scientific Company
Hotpack Corporation
Parco Scientific Company
Wards Natural Science Establishment, Inc.
Fisher Scientific Company
Gordon Selter Associates

SUNDAY, APRIL 17, 1977

1:00 — 4:00 and 7:00 — 9:00 P.M. — Registration ..... Charleston Plaza
1:30 P.M. — Executive Council Meeting ..... Conference Room
2:00 — 5:00 P.M. — Exhibits ..... Charleston Plaza
5:00 P.M. — Dinner ..... Main Dining Room
7:30 — 9:00 P.M. — General Session ..... Sports Center, Parlor C

MONDAY, APRIL 18, 1977

8:00 — 12:00 Noon — Registration ..... Charleston Plaza
9:00 — 5:00 P.M. — Exhibits ..... Charleston Plaza
8:00 — 12:00 Noon — Geography/Geology ..... Sports Center, Parlor B-1
8:15 — 11:45 A.M. — Physiology/Biochemistry I ..... Sports Center, Parlor B-2
8:15 — 11:45 A.M. — Biology in Variety ..... Sports Center, Parlor C
12:00 — 1:15 P.M. — Lunch ..... Main Dining Room
1:30 — 4:30 P.M. — Poster Session ..... Charleston Plaza
1:15 — 4:45 P.M. — Physiology/Biochemistry II ..... Sports Center, Parlor B-2
1:15 — 4:30 P.M. — Aquatic Ecology ..... Sports Center, Parlor C
1:15 — 4:30 P.M. — Dental/Medical ..... Sports Center, Parlor B-1
6:00 — 7:00 P.M. — Happy Hour ..... Club Suzanne
7:00 P.M. — Dinner ..... Crystal Room
8:30 P.M. — Main Address ..... Crystal Room

Bud Shuster
U.S. House of Representatives
Keynote Speaker

TUESDAY, APRIL 19, 1977

8:00 A.M. — Breakfast ..... Main Dining Room
9:00 — 12:00 Noon — Exhibits ..... Charleston Plaza
8:30 — 10:00 A.M. — Business Meeting ..... Club Suzanne
10:00 — 12:00 Noon — Physics/ Chemistry/Math ..... Sports Center, Parlor B-1
10:00 — 12:00 Noon — Cellular Ultrastructure ..... Sports Center, Parlor B-2
10:00 — 12:00 Noon — Animal Behavior ..... Sports Center, Parlor C

MINUTES OF THE EXECUTIVE COUNCIL MEETING
April 17, 1977

MINUTES OF THE EXECUTIVE COUNCIL MEETING — April 17, 1977

Presiding: George C. Shoffstall, Jr., President
Place: Mount Airy Lodge, Mount Pocono, PA 1:30 p.m.
Present: F. Brenner, B. Fried, D. Ostrovsky, S. Zagorski, P. Griesacker, G. Shoffstall, Sister Gabrielle Maze, W. Uricchio, S. Majumdar, J. Gennaula, G. Boone, L. Naylor, K. Schreiber, T. Knepp, W. Guy, H. Fremount, R. Denoncourt, C. Rutschky, B. Martin, B. Hunter, R. Travis, D. Zappa, E. Hohman.

A. Reports from academy officers were presented and accepted by the executive council.

1. President — George C. Shoffstall. The President reported on his service on numerous committees. He also represented the PAS at varied state and national conferences during 1976-1977. In addition Dr. Shoffstall noted that the Darbaker Prize Committee announced that the paper entitled "A Light Microscopic Study of the Anatomical Development of the Golden Hamster Pineal Complex" by Rev. Joseph C. Gregorek, Ph.D., Susan L. Kerr, Michael H. Bojarski, and Diana S. Harakal, was the recipient of the 1976 Darbaker Prize Award.
2. President-elect — Sister M. Gabrielle Maze. Sister M. Gabrielle Maze attended two sessions of PJAS during the PSTA and MSTA Convention at Philadelphia December 2-4, 1977. She also represented PAS and PJAS at the AAAS meeting at Denver in February 1977 and was chosen by NABT Association to chair the State's OBTA Selection Committee.
3. Secretary — David Ostrovsky. Hans Nussbaum, business manager of the AAAS, notified the secretary that the AAAS research grant to the PAS for 1977 amounts to $292.

   The following is a list of the PAS membership as of April 15, 1977.

Life	1
Emeritus	15
Honorary	20
Sustaining	4
Active	583
Libraries	124

4. Treasurer — Stanley J. Zagorski. The treasurer presented a detailed financial statement concerning the revenues and expenditures of the PAS for the past year.
5. Assistant-Treasurer — Paul B Griesacker. Dr. Griesacker reported a donation by Karl F. Oerlein of the McCulloch Properties Credit Corp. 11.5% Debenture, the income of which is to be used for a suitable award to be presented at the annual meeting of the Pennsylvania Academy of Science.
6. Editor-*Proceedings* — Shyamal K. Majumdar. The 1976 Proceedings Volume 50, Issues #1 (1-110 pages) and #2 (111-221 pages) were published in December, 1976 and April, 1977 respectively, following the same editorial style as in the past. A total of 732 copies of the first issue was posted. The Editor answered many queries relating to publications in the *Proceedings*, and attended the following meetings to represent the PAS:
   (1) Editorial Processing Center (EPA) Project in Washington, D.C. on December 8, 1976.
   (2) The PJAS, 1977 Region 3 Meeting in Northampton County Area Community College, Bethlehem, February 26, 1977.
7. Editor-*Newsletter* — Frederic J. Brenner. The editor has received substantially more articles from Academy members during the past year providing an increase in the contents of the *newsletter*. In addition, the number of companies advertising the *newsletter* will be increased during the coming year.
8. PA Jr. Academy Director — Joseph A. Gennaula. Mr. Gennaula reported that Mr. M. Maholtz was appointed Co-Director of Region 6 and General Chairman of the 1978 State Meeting to be held at Seven Springs. The 1978 meeting will also be the first formal PJAS Alumni State Meeting. It was also reported that about 10 to 25% of the potential schools are participating in PJAS. Therefore, the increase in participating schools will be one of his chief aims. The PJAS has continued to grow and improve. The 1977 State Meeting will have 826 participants.
9. Historian — Thomas Knepp. During 1976-1977 the historian compiled a pictorial record of the Past-Presidents of the Academy, plus a collection of photos largely concerned with summer meetings.

B. Reports of Standing Committees and Councils

1. Report of the Advisory Council — Lewis M. Naylor. Early in the year the Advisory Council chairman suggested the investigation of a cooperative venture between industry and the Pennsylvania Academy of Science. Various possibilities were discussed. It was anticipated that the ideas generated would evolve and become more firm in the coming year.
2. Report of the Membership Committee — Warren Guy. It was proposed that one of the two following ideas be pursued: (1) Mail to all college science departments a "Call for Papers" for the 1978 annual meeting or (2) obtain a sample of 1000 mailing labels from AAAS-PA members and make a direct individual appeal to them to join.
3. Report of the Time and Place of Meeting Committee — William A. Uricchio. The 54th annual meeting will be held in conjunction with the Pennsylvania Junior Academy of Science on April 16, 17, and 18, 1978 at Seven Springs Mountain Resort in Champion, Pennsylvania. The sponsor and local arrangements committee will be Duquesne University. The following institutions have made offers to host the Academy for the 1979 annual meeting: Carlow College, York College of Pennsylvania, and Millersville State College.
4. Report of the Local Arrangements Committee — Henry Fremount. The Local Arrangements Committee has made the following specific recommendations for future meetings:
   (1) We would consider alternating our meetings between Seven Springs and Mount Airy Lodge.
   (2) There should be a local arrangements coordinator for each meeting. (Perhaps an Eastern and Western coordinator). This person should have a tenure of more than one meeting.

5. Report of the Program Committee — Robert F. Denoncourt. Ninety papers were forwarded for programming: 86 for regular sessions and 4 for the poster session. They were organized into approximate subject groups for each session and given a name to assist listeners to pick sessions of special interest. Two new items for the P.A.S. Annual Meetings were tried: (1) a general session in the evening of the first day, and (2) a poster session.

C. Reports of Special Committees

1. Report of Science Talent Search Committee — Bruce Martin. Dr. Martin reported on the Pennsylvania Science Talent Search conducted during fall 1976 and in spring 1977 in cooperation with the thirty-sixth annual Science Talent Search for the Westinghouse Science Scholarships and Awards.
2. Report of the Committee on Page Charges — Shyamal K. Majumdar and Bernard Fried. This committee has suggested changing page charges on a one year basis from the current figure of $25/page for authors who are PAS members to $20/page beginning with the *Proceedings* for 1977-78. The rational for this action is based mainly on a sufficiency of funds in the PAS treasury.

In addition reports were received from the affiliates and industrial relations committees concerning future prospectives and areas of interest for the PAS.

D. Motions passed by the Executive Committee

The following motions were passed by the Executive Committee:

(1) To give Thomas Knepp $100 to carry out the work of the historian.
(2) That Duquesne University host the 1978 PAS meeting at Seven Springs.
(3) That the dates of the 1978 PAS meeting be April 16, 17, and 18.
(4) That February 1 be set as a deadline for mailing a proposed PAS program to the newsletter editor and that March 1 be the deadline for the spring mailing of the *newsletter*.
(5) That Mr. Harold Yoder be given honorary membership in the academy.

Dr. Shoffstall presented a proposal for the Governor's Science Council and the President's Charge for 1977 in which the objectives of the academy were outlined.

The meeting was adjourned at 5:45 p.m.

Respectfully submitted,
David Ostrovsky
Secretary

MINUTES OF THE ANNUAL BUSINESS MEETING
April 19, 1977

MINUTES OF THE ANNUAL BUSINESS MEETING — April 19, 1977

Presiding: George C. Shoffstall, Jr., President
Place: Mount Airy Lodge, Mount Pocono, PA

The meeting began at 8:30 a.m. Forty members were present. The following business was carried out:

1. Dr. Shoffstall read the minutes of the executive council meeting. The minutes were approved.
2. Dr. Shoffstall outlined a proposal for the establishment of a governor's science council. A motion to establish an Ad Hoc committee as specified in the proposal was passed.
3. The following committee appointments were made by the President:

Honorary Council ..... Hon. Milton J. Shapp, Governor
Advisory Council ..... Lewis Naylor
Past Presidents Committee ..... Bernard Fried
Membership:
  Co-chairmen ..... Warren Guy & George Boone
Editorial ..... Shyamal Majumdar
Time and Place of Meetings ..... William Uricchio
Local Arrangements:
  Eastern meeting ..... Henry Fremount
  Western meeting ..... Co-chairmen — Bruce Martin & Jurt Schreiber
Program ..... Robert Denoncourt
Auditing ..... Virginia Carey & Donna Tubbs
Nominating ..... Charles Rutschky

SPECIAL COMMITTEES

Science Talent Search ..... Bruce Martin
Research Grants ..... Barry Hunter
AAAS Representatives:
  American Jr. Academies of Science ..... Sister Gabrielle
  AAAS — Section X ..... George Shoffstall
Affiliates ..... Robert Travis
Industrial Relations ..... Don Zappa
Internal Revenue Special Audit ..... Charles Rutschky
Darbaker ..... George Shoffstall
Committee on Page Charges:
  Co-chairmen ..... Bernard Fried & Shyamal Majumdar
Committee on Appointing an Executive Secretary ..... Ken Hoover
Guest Speaker ..... David Ostrovsky
Governor's Science Council ..... George Shoffstall

4. A motion was passed to maintain the $500 PAS guest speaker fee for the next two years.

The meeting was adjourned at 10:00 a.m.

Respectfully submitted,
David Ostrovsky
Secretary

REPORTS OF OFFICERS AND COMMITTEES

1. REPORT OF THE PRESIDENT — George C. Shoffstall, Jr.

This President served on numerous committees and represented the PAS at varied state and national conferences during 1976-77. A few of the programs are as follows:

1. Forty-second Annual State meeting of the PJAS at Seven Springs, April 21-24, 1976.
2. NSF Environmental Science Program at Shippensburg State College, July 14-15, 1976.
3. Title IV-C PDE Funding Workshop — Oakdale, August 3-4, 1976.
4. PAS Executive Council meeting, Monroeville, September 15-16, 1976.
5. Member, Selection Committee, Outstanding Biology Teacher of America Award.
6. "Trends in Science" conference — Lancaster, November 15, 1976.
7. Representative on the Committee of AAAS, Section X, February 19-25, 1977, Denver, Colorado.

Moreover, this President met with representatives from Pennsylvania Science Teachers Association and the Pennsylvania Association of College Chemistry Teachers to discuss affiliate roles.

The Darbaker Prize Committee announced that the paper intitled, "A Light Microscopic Study of the Anatomical Development of the Golden Hamster Pineal Complex" by Rev. Joseph C. Gregorek, Ph.D., Susan L. Kerr, Michael H. Bojarski, and Diane S. Harakal, was the recipient of the 1976 Darbaker Prize Award.

2. REPORT OF THE PRESIDENT-ELECT — Sister M. Gabrielle Maze

During the past year your President-elect did the following:

1. She attended and set-up two sessions of the PJAS during the PSTA and MSTA Convention at Philadelphia December 2-4, 1977.
2. She represented PAS and PJAS at the AAAS Meeting at Denver in February 1977. She was asked to chaperon two students representing the State at the American Academy of Science Meeting. They were:
   a) Rene M. Filipowski from St. Benedict Academy in Erie Presentation: "The Effect of SO_2 on the growth of Corn Seeds."
   b) John J. Spaltro from Cardinal O'Hara High School in Philadelphia Presentation: "The use of Cyanoacrylate Cement in Skin Grafting."
3. At the request of AAS- she presented a paper on "Financing Junior Academy Activities."
4. As a delegate of PAS to AAS- she attened all their paper presentations.
5. Her other assignment was to get funds and special speakers for a symposium at our next State Meeting. She met and corresponded with Dr. Jonas Salk but was unable to get a commitment because he will be in Europe at the time of our meeting.
6. In March of 1977, she visited the State Department in Harrisburg and met with a few Administrators. She was promised a meeting with Dr. G. Shoffstall, 3 members of the Department of Education and herself to plan for a three year grant amounting to $100,000

for students. This would be similar to the Governor's Arts and Humanities Program. This will be a beginning of PAS's contributions to PJAS.

7. Your president-elect was chosen by NABT Association to chair the State's OBTA Selection Committee. We are proud to note that for the Outstanding Bioloy Teacher's Award, the winner and the 3 semi-finalists are all members of PJAS.

3. REPORT OF THE SECRETARY — David S. Ostrovsky

During the past year the secretary carried out the following duties: Maintaining an updated mailing list, issuing new stationary to the officers of the Academy, supplying mailing labels on request to Academy officers, notifying members and libraries in arrears, compiling the September 1976 Executive Council Meeting minutes, reorganizing the abstract form for the newsletter, receiving abstracts for the spring 1977 meeting, mailing dues notifications, and responding to numerous queries concerning the Academy.

Hans Nussbaum, business manager of the AAAS, notified the secretary that the AAAS research grant to the PAS for 1977 amounts to $292.

The following is a list of the PAS membership as of April 1, 1977.

Life	1
Emeritus	15
Honorary	20
Sustaining	4
Active	572
Libraries	124

4. REPORT OF THE TREASURER — Stanley J. Zagorski

December 31, 1976
BALANCE SHEET

ASSETS		
Cash:		$ 2,788.56
Checking Account		
Savings Accounts:		
Publications Endowment Fund	$ 631.28	
General Savings Account	1,365.22	
Darbaker Savings	1,974.36	3,970.86
Savings Certificates:		
Life Membership	200.00	
General	2,500.00	
Marquette	5,000.00	
Darbaker	5,000.00	12,700.00
Total Assets		$19,459.42
LIABILITIES AND NET WORTH		
Net Worth		$19,459.42

STATEMENTS OF INCOME AND NET WORTH
For the year ended December 31, 1976

Revenue:		
Membership dues	$ 2,435.00	
Gifts and grants	818.26	
Interest and dividends	808.74	
Library Subscriptions	2,305.00	
Printing	4,050.00	
Advertising	200.00	
Miscellaneous	1.85	$10,618.85
Expenditures:		
Postage	$ 674.05	
Printing	5,808.49	
Salaries	403.30	
Scholarships	492.00	
Supplies	41.87	
Awards	434.78	
Travel	694.85	
Professional Services	25.00	
Memberships	22.00	8,596.34
Excess Revenue over Expenditures		$ 2,022.51
Net Worth — January 1, 1976		$17,436.91
Net Worth — December 31, 1976		$19,459.42

PENNSYLVANIA ACADEMY OF SCIENCE, INC., CAPITAL
EXHIBIT "A" Receipts and disbursements of the Pennsylvania Academy of Science, Inc., for the period of January 1, 1976, to December 31, 1976.

			1975	**1976**
RECEIPTS — Checking Account				
Membership Dues:	Student	$ 120.00		
	Sustaining	45.00		
	1975	229.00		
	1976	2,020.00		
	1977	21.00		
Total Membership Dues			$4,286.00	$2,435.00
Library Subscriptions:			3,693.75	2,323.75
Vol. 49		$2,036.25		
Vol. 50		287.50		
Grants:				
A.A.A.S.			292.00	292.00
Interest and Dividends:				
Darbaker Certificate		$ 225.00		
Life Membership Fund		13.00		
Savings Certificate		143.80		
Savings Account Certificate		207.18		
Total Interest and Dividends			574.30	588.98

		1975	1976
Annual Meeting		288.09	---
Page Charges and Reprints		2,485.00	4,050.00
Vol. 45	$ 300.00		
Vol. 47	200.00		
Vol. 49	2,275.00		
Vol. 50	1,275.00		
Miscellaneous Receipts		210.00	201.85
Ads	$ 200.00		
Loose Change	1.85		
TOTAL RECEIPTS		**$11,829.14**	**$9,891.58**
DISBURSEMENTS		**1975**	**1976**
Printing:			
Vol. 49, Proceedings	$1,735.00		
Vol. 49, Proceedings, No. 2	2,180.00		
Vol. 50, Proceedings (advanced payment)	600.00		
Newsletter	1,084.08		
Postage, Stationary	733.56		
Misc. printing			
Business cards	31.80		
Envelopes	64.45		
Gannon College	13.65		
	$6,442.54		
Total Printing		$5,187.46	$6,442.54
Wages		225.00	403.30
A.A.A.S. Dues		22.00	22.00
Travel Expenses for Officers		66.00	606.44
Refunds to Subscribers and Libraries		75.75	18.75
Post Office Permit		40.00	40.00
A.A.A.S. Award (in 1976, to E. Raisen)		292.00	292.00
Honorarium for PAS Banquet Speaker		500.00	---
Fine on 1973 Income Tax		167.33	---
Trophies, Plaques		---	434.78
Income Tax Consultants		25.00	25.00
Pennsylvania Talent Search		100.00	100.00
Computer Service		20.00	---
Dillsbury Agency (Position Schedule Bond)		30.00	---
Certificate Seals		---	29.92
Officer's Photo		---	5.00
Saving's Certificate (1-212792) — from Marquette Savings & Loan		---	5,000.00
Supplies from Gannon College Bookstore		---	6.95
Officer's Expenses at Annual Meeting		---	30.00
Dinner & Room Rental for Executive Council Meeting		---	58.41
Historian Expenses		---	100.00
TOTAL DISBURSEMENTS		$6,750.54	$13,615.09

EXHIBIT "B" Accounts for the Pennsylvania Academy of Science, Inc. for the period of January 1, 1976, to December 31, 1976.

I.	CHECKING ACCOUNT		
	Balance in Checking Account December 31, 1975		$ 6,512.07
	Deposits		9,891.58
			$16,403.65
	Disbursements		$13,615.09
	Balance in Checking Account December 31, 1976		$ 2,788.56
II.	PUBLICATIONS ENDOWMENT FUND		
	Balance on Hand December 31, 1975		586.47
	Receipts (Interest)		34.81
	Balance on Hand, December 31, 1976		$ 621.28
III.	GENERAL SAVINGS ACCOUNT		
	Balance on Hand, December 31, 1975		1,288.73
	Receipts (Interest)		76.49
	Balance on Hand, December 31, 1976		$ 1,365.22

IV.	DARBAKER ACCOUNT		
	Balance on Hand, December 31, 1975		1,339.64
	Receipts:		
	Interest on Savings	108.46	
	Deposits	526.26	
	Total Receipts		634.72
	Balance on Hand, December 31, 1976		$ 1,974.36
	SAVINGS CERTIFICATE LIFE MEMBERSHIP		
	Balance on Hand, December 31, 1975		$ 200.00
	Receipts (Interest)	13.00	
	Disbursements:		
	(Transfer to checking)	13.00	
	Balance on Hand, December 31, 1976		$ 200.00
	SAVINGS CERTIFICATE GENERAL		
	Balance on Hand, December 31, 1975		$ 2,500.00
	Receipts:Interest	143.80	
	Disbursements		
	(Transfer to Checking)	143.80	143.80
	Balance on Hand, December 31, 1976		$ 2,500.00
	SAVINGS CERTIFICATE DARBAKER		
	Balance on Hand, December 31, 1975		$ 5,000.00
	Reciepts: (Interest)	225.00	
	Disbursements		
	(Transfer to Checking)	225.00	
	Balance on Hand, December 31, 1976		$ 5,000.00
	SAVINGS ACCOUNT CERTIFICATE		
	Balance on Hand, December 31, 1975		0.00
	Receipts: (Deposits)	5,000.00	
	(Interest)	207.18	
	Disbursements		
	(Transfer to Checking)	207.18	
	Balance on Hand, December 31, 1976		$ 5,000.00

5. REPORT OF THE EDITOR OF THE PROCEEDINGS OF THE PENNSYLVANIA ACADEMY OF SCIENCE — Shyamal K. Majumdar.

The 1976 *Proceedings,* Volume 50, Issues #1 (1-110 pages) and #2 (111-221 pages) were published in December, 1976 and April, 1977 respectively, following the same editorial style as in the past. A total of 732 copies of the first issue was posted; 17 were undeliverable.

An Editorial Committee has been appointed consisting of the Editor and twenty-four members. The members are specialists in various fields (see Vol. 50, inside cover for names and their affiliation). In 1976, forty-eight manuscripts were submitted for publication, of which 41 were accepted (20 in Issue #1 and 21 in Issue #2) and published. Of these published papers, 29 were in biology, 2 in environmental sciences, 5 in geography, 2 in geology, 2 in mathematics and 1 in social science. Every paper was read and criticized by a reviewer or one member of the Editorial Committee in whose field the paper lies.

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, to Doris Lowe and Joan Clymer of the Department of Biology, Lafayette College, for their competent secretarial assistance and to Professor Louis T. Stableford, 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. The Editor answered many queries relating to publications in the *Proceedings,* and attended the following meetings to represent the PAS:

1. Editorial Processing Center (EPC) Project in Washington, D.C. on December 8, 1976.
2. The PJAS, 1977 Region 3 Meeting in Northampton County Area Community College, Bethlehem, February 26, 1977.

The expenses reported up to April 12, 1977 are as follows:

Carried over from April 6, 1976	$445.00
PAS check from Dr. Zagorski (December 1976)	150.00
PAS check from Dr. Zagorski (March 1977)	150.00
	$745.00

Disbursements:

Secretarial help	$ 50.00	
Stamps, handling & mailing The *Proceedings* Vol. 49 #2, and Vol. 50 #1	484.00	
Total disbursements		$534.00
BALANCE AS OF APRIL 12, 1977		$211.00

6. REPORT FROM THE EDITOR OF THE NEWSLETTER — Fred J. Brenner

The editor has received substantially more articles from Academy members during the past year providing an increase in the contents of the *Newsletter.* However, a greater number and variety of articles from the membership would greatly improve the publication. The *Newsletter* should be a product of the Academy and not of a few individuals. The number of companies advertising in the *Newsletter* will be increased during the coming year. One additional company has agreed to place an advertisement in the *Newsletter* beginning next fall and another firm is pending. This increase in advertising income should offset the increased cost of postage and/or printing.

7. REPORT OF THE PENNSYLVANIA JUNIOR ACADEMY OF SCIENCE FOR 1977 — Mr. Joseph A. Gennaula, State Director

The first year of my term has been a very active and productive one. At the 1976 State meeting the following appointments were made:

Finance Committe	Sister Gabrielle
State Secretary	Mrs. Bela Yakatis
State Treasurer	Dr. Norbert Pietrzak
Executive Advisor-West	Mr. Joseph Mascetta
Executive Advisor-East	Mr. Edward Testa
State Judging Committee	Dr. Lawrence Goldman Mrs. Marjorie Snyder
Science Talent Search	Dr. Bruce Martin
Technicians Committee	Mr. John Zitelli
Special Awards Committee	Mr. James Imler
Ethics Committee	Mr. Charles Bikle
1978 State Meeting	Region 6 Host Region
Constitution Committee	Mr. Edward Testa

Later in the year, Mr. Mickey Maholtz was appointed Co-Director of Region 6 and General Chairman of the 1978 State Meeting to be held at Seven Springs. The 1978 meeting will also be the first formal PJAS Alumni State Meeting.

During the year meetings were held with the PAS Advisor, Dr. George C. Shoffstall and Dr. William Uricchio, the PJAS Executive Advisors, the PJAS Finance Committee, and the PAS Executive Council.

On October 2, 1976 the regular fall meeting of the Regional Directors was held at Penn State University. The State Judging Committee also met and reported to the Regional Directors about the various Pilot Studies that are conducted.

The third annual Metric Week was conducted under the sponsorship of the State Director, Mr. Gennaula. This program is aimed at the general public and consists of placing "Metric Booths" in shopping centers where people are given souvenir cards with their weight in Kilograms and their height in centimeters. Over 10,000 people have been introduced to the Metric System in the three years of this PJAS program.

The Technicians organization has been growing and improving during the past year. All Regions were requested to send an honorary Room Team to this State Meeting.

In a research that I conducted I found that only about 10 to 25% of the potential schools are participating in PJAS, therefore, the increase in participating schools will be one of my chief aims. Other problems that are under consideration are: the spliting of the State Meeting, the training of good experienced judges, improving the Regional files and Regional Meeting program books, and the updating of the Judges' Handbook.

The PJAS has continued to grow and improve. The 1977 State Meeting will have 826 participants.

8. REPORT OF THE HISTORIAN — Thomas H. Knepp

During 1976-1977 the historian was primarily interested in compiling a pictorial record of the Past-Presidents of the Academy, plus a collection of photos largely concerned with summer meetings.

Getting pictures of Past-Presidents was somewhat of a problem, but proved to be rather successful. Many of the men who were Presidents prior to 1945 are deceased, and in some cases no photos wree available from their institutions, nor are there any records of relatives. I have had no success whatsoever in the matter of Dr. Samuel H. Williams (1933) of the University of Pittsburgh, Charles E. Mohr (1943), or Dr. E. P. Claus (1953) of the University of Pittsburgh. I am at a complete loss concerning Charles E. Mohr; I do not know if he is still living, what his last place of employment was, nor the address of any relatives.

I have no information concerning relatives of the late Dr. Walter S. Lapp (1952), who was for many years Head of the Science Department of the Overbrook High School, Philadelphia. I was promised a photo of Dr. S.H. Derickson (1935) and of Dr. V. Earl Light (1948) by Lebanon Valley College, but have not received them as yet.

The pictorial history of the Past-Presidents is contained in two white Kodak Gallery albums, size 13" x 14".

The other aspect of the pictorial record consists of five black and white and 72 color 3" x 5" pictures, largely concerned with summer meetings. These pictures are in a red Kodak Gallery Album, size 13" x 14".

Any member of the Academy who has pictures that can be used in the pictorial history is asked to send them to me. If owners of pictures would like to have the photo returned I can have copies made for inclusion in the history. Letters of historical interest are also needed.

9. REPORT OF THE ADVISORY COUNCIL — Dr. Lewis M. Naylor, Chairman

Early in the year the Advisory Council chairman, Dr. James R. Oyler, suggested the investigation of a cooperative venture between industry and the Pennsylvania Academy of Science. Various possibilities were discussed. It was anticipated that the ideas generated would evolve and become more firm in the coming year.

Due to a very demanding schedule, the committee chairman found he could not complete his term of office and requested Academy President George Shoffstall to name Dr. Lewis M. Naylor as an alternate. Dr. Naylor agreed to serve and was appointed as chairman of the Advisory Council. At a meeting held March 18, 1977 with Dr. Naylor, President Shoffstall discussed the responsibilities of the Advisory Council and its make up.

10. REPORT OF THE GRANTS AND PROPOSAL COMMITTEE — Barry B. Hunter, Chairman

This year's committee was expanded to five members, one of which is the chairman. This expanded membership provided new input and a more thorough evaluation of the research grants. The two new members are:

Dr. George A. Schnell, Department of Geography, State University of New York, College at New Paltz, New York

and

Dr. J. Robert Halma, Department of Biology, Cedar Crest College, Allentown, Pa.

The former members are:

Dr. Richard Medve, Department of Biological Sciences, Slippery Rock State College, Slippery Rock, Pa.

and

Dr. Frank Muzzopappa, Department of Biological Sciences, Kutztown State College, Kutztown, Pa.

The format for evaluating the proposals was altered somewhat so as to provide a better basis for evaluating each proposal. Each grant proposal was evaluated by each committee member who made both an objective and subjective appraisal of each grant proposal. This information was sent back to the chairman of the committee who had the responsibility of collating the evaluations of the individual committee members and selecting the proposal which was deemed the most meritorious. The committee has the perogative to deny a grant award any given year when the majority of its members do not endorse as acceptable any of the submitted proposals.

11. REPORT OF THE MEMBERSHIP COMMITTEE (East) of the PENNSYLVANIA ACADEMY OF SCIENCE — Warren Guy

No inquiries concerning PAS membership were received by this committee. Plans to have the current membership nominate new members were abandoned after it was learned that AAAS experienced a low return rate with this method. Letters were sent to all engineering schools in the state in an effort to interest them in the PAS and to diversify the make-up of the Academy. There have been no responses to this mailing.

Next year it is proposed that one of the two following ideas be pursued: (1) Mail to all college science departments a "CALL FOR PAPERS" for the 1978 annual meeting (cost about $100) or (2) Obtain a sample of 1000 mailing labels from AAAS-PA members and make a direct individual appeal to them to join (cost about $200).

12. REPORT OF THE TIME AND PLACE OF MEETING CHAIRMAN — William A. Uricchio

The 53rd annual meeting of the Pennsylvania Academy of Science was held jointly with the Pennsylvania Junior Academy of Science on April 17-19, 1977, at Mt. Airy Lodge, Mt. Pocono, Pennsylvania.

The Executive Council held their meeting after lunch on Sunday and papers were presented from Sunday evening until Tuesday noon. The business meeting was held Tuesday morning.

Since the Academy joined up with the PJAS for this meeting, they were able to offer its members a very attractive package for hotel accomodations and meals. The meeting was very well attended and we were pleased that many members of the Academy were accompanied by their wives.

13. REPORT OF THE LOCAL ARRANGEMENTS COMMITTEE — Henry N. Fremount

Letters were sent to the following 15 potential exhibitors inquiring as to their interest in participating in the 53rd Annual Meeting of the Pennsylvania Academy of Science.

American Optical Company	E. Leitz, Inc.
American Polarizers, Inc.	Eduquip-Macalaster Corporation
Bausch & Lomb, Inc.	Fisher Scientific Company
Carolina Biological Supply Co.	Gordon Seiter Associates
CEBCP/Standard Publishing Co.	Hotpack Corporation
Connecticut Valley Biological Co.	Lab-Aids, Inc.
Edward P. Dolbey & Co., Inc.	Parco Scientific Company
Ward's Natural Science Est., Inc.	

Postive replys were received from 9, a negative reply and apology from 2, American Polarizers, Inc. and Connecticut Valley Biological Company; no reply was received from the remainder. A total of $900.00 in exhibitors' fees was received and forwared to the treasurer.

Eight East Stroudsburg State College students were employed at $2.50 per hour to work during registration.

President Shoffstall contacted and made the final arrangements for our Keynote Speaker, the Honorable H. Bud Shuster of the U.S. House of Representatives.

Two pre-convention meetings were held with Mr. Logan and his staff at Mount Airy Lodge. The meetings were attended by Mr. William Uricchio, representatives of the Junior Academy and myself.

Three rooms in the Sports Center were selected for our meetings and specifics concerning menus, room arrangments, exhibitors, security, etc. were worked out.

We found Mr. Logan and his staff to be most efficient, helpful and eager to please.

The Local Arrangements Committee has worked closely with President George Shoffstall, William Uricchio, Program Chairman Robert Denoncourt and Mr. Logan of Mount Airy Lodge. We thank everyone for their time and patience in making this meeting a success.

Specific Recommendations for Future Meetings: —

1. We Should consider alternating our meetings between Seven Springs and Mount Airy Lodge.
2. There should be a local arrangements coordinator for each meeting. (Perhaps an Eastern and Western coordinator). This person should have a tenure of more than one meeting.
3. Registration fees should be increased to meet rising costs.
   (a) A policy should be established concerning registration of spouses. This is especially important if we continue to have meetings at Seven Springs and Mount Airy Lodge.
4. A rigid deadline should be established for the mailing of the meeting program and it should be sent via first class mail.

14. REPORT OF THE PROGRAM COMMITTEE — Dr. Robert F. Denoncourt

Ninety papers were forwarded for programming: 87 for regular sessions and 3 for the poster session. They were organized into approximate subject groups for each sessions and given a name to assist listeners to pick sessions of special interest.

At the time of printing, eight exhibitors had agreed to display materials and be available for questions.

Two new items for the PAS Annual Meetings were tried: (1) a general session in the evening of the first day, and (2) a poster session. It will be interesting to observe member reactions.

Recommendations. — A screening committee should be appointed to review abstracts for acceptance in the paper sessions. Also, a brief "suggestions to presentors" would perhaps be valuable to the development of more interesting and organized presentations for beginners.

15. REPORT OF THE 30th ANNUAL SCIENCE TALENT SEARCH

Bruce D. Martin, Ph.D., State Director, Science Talent Search.

The Pennsylvania Science Talent Search was conducted for the thirtieth year during fall 1976 and spring 1977 in cooperation with the thirty-sixth annual Science Talent Search for the Westinghouse Science Scholarships and Awards. The national contest is administered by the Science Service of Washington D.C. for the Westinghouse Educational Foundation.

The national contest and the state competition cooperate in the use of materials and standards of judging since both have similar goals. The Science Talent Searches were the pioneering endeavors to discover at the high school senior year level those who have the potential to become the research scientists and engineers of the future. It has fulfilled this function far beyond the hopes entertained when this educational project was conceived. many scholarships in colleges and universities throughout the United States have been given to those who have thus been discovered to have significant science talent. At least one of the former participants in the national science talent search, Dr. Leon N. Cooper of Brown University, has been a Nobel Prize recipient (Physics, 1972). Many others also have gained superior distinction in the Sciences.

The Pennsylvania Science Talent Search (PSTS) is conducted by the Pennsylvania Academy of Science which annually selects a state director for the program. In cooperation with the Pennsylvania Junior academy of Sciences, the regional meetings are used as the points of contact with PSTS entrants who often also enter the PJAS competition. The state director acknowledges with thanks the cooperation offered by the Junior Academy in providing both the time and place for judging activities of the PSTS.

In addition to the inititial list of national competitors, the PSTS invites all other eleventh and twelfth grade students who are competing in the PJAS to submit credentials for interviews. This activity provides each region with the opportunity to recognize the seniors who have achieved progress during their school years as well as to encourage eleventh grade students to continue their competition and to be ready to enter the Westinghouse contest when they reach the first few months of their senior year of high school. The competition therefore becomes more than a scholarship contest. It is a major step toward making scientific and engineering talent available for important tasks in our civilization.

Judges selected from among university and college financial aid officers, admissions directors, professors, teachers, advisors, and scientists in professional fields of science interview each candidate. Criteria used in judging include personal data reflecting scientific talent, evaluation of the science project, recommendations by the applicant's sponsor, relative standing in the graduating class, review of scores earned on national contests and the ability of the student shown during the interview.

Each successful applicant at the regional contests is awarded a certificate of achievement indicating the appropriate award chosen by the judges. Awards available are First Award, available to seniors who have entered the national WSTS competition; Junior Award for eleventh graders; and Judges Award for twelfth grade students who did not enter the national contest but who subsequently have accomplished a major achievement which in the eyes of the interview team is to be acknowledged. In addition, Honors Awards are made to Pennsylvania students who reach the final group of 300 students who are recognized by the Westinghouse contest. A Trip Award certificate is presented to any Pennsylvania student who reaches the finals of the national contest and is one of 40 chosen to undergo final nationwide competition in Washington. The certificates are awarded to students at either the PJAS regiooal meeting or at the State Meeing of PJAS and may be used in application to colleges and universities as recognition of scientific achievement. In addition, the State Director issues letters of recommendation for scholarship and financial aid to three colleges of the student's choice upon the achievement of an award. Many colleges of the Commonwealth have recognized the efforts of PSTS and annually request the list of winners and acknowledge the letters sent to them.

Each year more institutions are reserving financial help for the winners of PSTS which in itself is a recognition of the stature of the competition.

In the fall of 1976 the Science Service provided 683 sets of applications to those requesting them in Pennsylvania. From this number, 58 complete entries from 36 high schools were finally accepted by the judges and submitted to full evaluation. A total of 1009 fully qualified entries were judged nationwide. In 1976, 66 Pennsylvania students from 42 high schools entered the contest. Of the 58 entries, 13 students from 12 high schools reached the Honors Group, down from 11 winners in 1976. Three students were named to the list of 40 National Winners (in 1976). They were: Richard H. Ebright of Muhlenberg Township High School, Laureldale, Paul Michael Embree, also of Muhlenberg Township High School and Charles C. Mechem of the Episcopal Academy, Merion, Pa. These were the first trip winners for both the high schools and this fact was emphasized in national publicity released by Science Service. Each of these trip winners competed in Washington, D.C. in the final competition of the Science Talent Institute.

The 1977 awards bring the number to 78 of those Pennsylvania students reaching the Winners level and to 536 those who have achieved the Honors Group designation in the past thirty-six years of national activity. Pennsylvania remains fourth in the nation with the top number of award recipients, behind New York, Illinois and California.

At the time of this report, in April, 1977, the state-wide judging was still continuing at the regional level. The final award announcement was scheduled for the PJAS State meeting at the Mt. Airy Lodge, Pocono, Pa. on April 18, 1977. A full list of winners will be forwarded for publication in the Proceedings at the conclusion of all efforts.

New areas of activity in the Pennsylvania Science Talent Search include the preparation of printed brochures explaining the contest, advance mailing of announcements to all sponsors of the previous year alerting them to the availability of applications, publicity releases to local news media about the PSTS and communication of the PSTS efforts to local news media about the PSTS and communicaion of the PSTS efforts to the colleges of Pennsylvania. The three-year increase in requests for applicaion materials to WSTS from 696 in 1973 to 903 in 1975 dropped to 683 in 1976 even with all these new efforts of the post several years. This serious drop in interest is, as yet unexplained. We hope to encourage more teachers and students in 1977 and 1978 to participate in the competition and request the assistance of the Academy in forwarding information throughout the State about this contest.

We again encourage the Pennsylvania Academy of Science to offer membership to the Honors Group recipients even while they are still students. Such acknowledgement and national acclaim could help to further the interests of the students, the PAS and the PSTS.

16. REPORT OF PAS SPECIAL COMMITTEE ON AFFILIATES — R.V. Travis, Chairman

Ideally the Pennsylvania Academy of Science would be the principal organ of science, an initial source of science information for the entire state. The Academy would unbiasedly represent all of the many disciplines or subdivisions of science.

It may be universally accepted that we should each be broadly interested in the advancement of science on all fronts, but for practical purposes our intersts become very narrow. We can find the time and energy to attend and support those activities that are of particular interest to us individually.

Inter-relationships are important and interdisciplinary interests are to be encouraged, but, (for example) few biologists find the time to communicate with mathematicians, and few physicists interact with geologists. Some do, but all will agree that it is important that all individuals in science should be concerned with what is happening in other areas.

Even more disturbing is the layering that occurs within the various disciplines. For example, high school physics teachers do not attend meetings of college physics teachers, who have different interests from the industrial physicists, while their interests may be still different from the interests of the research physicists. Therefore, even in this one discipline there are at least four layers of interest and several different physics societies have been organized to meet the different needs of these different layers.

While all may agree as to the ultimate desirability of an integrated front representing total science within the state, more realistically the Pennsylvania Academy of Science, like anything else, will find it difficult, if not impossible, to try to be all things to all people. Some members of the Academy think that the Academy is wrong in not providing a more fertile environment for high school science teachers. Among other things, the papers presented at the meetings had little attraction to the high school teachers. Other academy members would drop out if the academy catered to these high school teachers, because it would no longer be meeting their needs. Several members reported that they were avoiding the current meeting because of the joint meeting with the Junior Academy of Science.

On a more positive note, there would be more interest in affiliating with the PAS if the Academy had a better image. Some members do not attend meetings because of the scarcity of papers in their areas of interest. Other scientists within the state do not belong to the Academy because they do not know of its existence. Thus it would appear that there is a need for increased activity in recruiting new members.

A "hard push", particularly at this time, to obtain affiliates would be very difficult. In part because the handful of people who are willing or can be persuaded to work at the running of an organization are already overworked and cannot think of adding even one more society or organization to share their time, energy, and money. There is additionally the fear of some that the smaller societies will lose their domain and be swallowed up by the Academy. Empire building is important, and once one has been obtained, it is to be jealously guarded.

We would recommend that the Academy use a "soft cell" in its attempts to encourage affiliates. We could let the other science groups know that the Academy exists and is interested in helping them. This could be in the form of acting as a liason or resource center for obtaining speakers, organizing workshops, or possibly providing some financial assistance to jointly sponsored meetings, symposia, etc. There are times when even a token financial aid could do a lot of good in spreading the word that there is an Academy of Science in Pennsylvania and that it is interested and willing to help in the advancement of science at all levels. The Academy might have an easier time soliciting funds from industry to help support a meeting of a particular discipline than the discipline itself.

When this occurs we thing that the various scientific societies will be delighted to affiliate with the Pennsylvania Academy of Science. Human nature being what it is, we are all reluctant to join or participate unless it will directly meet our needs.

17. REPORT OF THE INDUSTRIAL RELATIONS COMMITTEE — Dr. D. E. Zappa, Chairman

A. Dr. D.E. Zappa, Chairman

In discussing the P.A.S. and P.J.A.S. with personnel directors of various corporations the following areas should be pursued.

1) Communication between the students in college and the Academy in order to know what discipline the student is studying.
2) Liaison between the Academy and the personnel directors of different corporations to keep them abreast of the courses of study the students are pursuing.
3) Once this liaison is established, it will enable graduates at the high school and college level to contact the appropriate corporations for a position.

B. Dr. E.T. Hohman — Report was rpesented and accepted.

18. REPORT OF PAGE CHARGES COMMITTEE — Shyamal K. Majumdar and Bernard Fried

We believe that we should reduce page charges on a one year basis from the current figure of $25/page for authors who are PAS members to $20/page beginning with the *Proceedings* for 1977-78. The rational for this action is based mainly on a sufficiency of funds in the PAS treasury. We can not determine at this time whether this reduction will enhance the number of quality papers submitted to the *Proceedings*.

We should carefully consider what percentage of PAS income should go towards supporting the *Proceedings*. If the society feels that a high percentage of income from dues, interest on investments, money collected from library subscriptions, etc., should go into the direct support of the *Proceedings*, then conceivably in the future page costs to the author could be negligible. This matter should be discussed by the Executive Council.

19. REPORT OF THE RESOLUTIONS COMMITTEE — Warren Guy

Be it resolved that the Pennsylvania Academy of Science express its sincere appreciation to:

Dr. Henry N. Fremount, Chairman, and his Local Arrangements Committee for organizing an excellent 53rd annual meeting of the Academy,

East Stroudsburg State College for the resources they made available to make this meeting successful,

Dr. Robert F. Denoncourt for putting together an excellent program, and

Dr. William A. Uricchio who was responsible for the arrangements which made it possible to have our meeting at Mount Airy Lodge.

Our continued thanks go to

Mr. Gene Wood of Carolina Biological Supply Co. for chairing and organizing the Exhibits Committee, and to the exhibitors American Optical Company, Carolina Biological Supply Company, Dolbey Scientific Company, Fisher Scientific Company, Gordon Selter Associates, Hotpack Corporation, E. Leitz Co., Parco Scientific, and Ward Natural Science Establishment, Inc.

On behalf of the membership we further resolve that our special gratitude be shown to

Dr. Shyamal K. Majumdar, Editor of the *Proceedings*, for being responsible for the continued growth (now two issues) and quality of the Academy's *Proceedings*.

Mr. Joseph A. Gennaula for his efforts and hard work as Director of the Junior Academy, and finally to

Dr. George C. Shoffstall, Jr., President, whose guidance in the past year has heightened the exposure and prestige of the Academy.

The Academy records with sorrow the Passing of its former members: Tom L. Guyton and George F. Deasy. Both are past presidents of the Academy, Mr. Guyton in 1947 and Mr. Deasy in 1963.

MINUTES OF THE EXECUTIVE COUNCIL MEETING
September 15, 1976

Presiding: George C. Shoffstall, Jr., President
Place: Holiday House, Monroeville, PA. 2:00 PM
Present: F. Brenner, B. Fried, D. Ostrovsky, S. Zagoraki, P. Griesacker, G. Shoffstall, Sister Gabrielle Maze, W. Uricchio, S. Majumdar, and J. Gennaula.

President Shoffstall called the meeting to order and briefly discussed his proposed meeting with Governor Shapp as well as the agenda for the 1977 spring meeting of the academy at Mt. Airy Lodge.

A. Reports from academy officers were presented and accepted by the executive council.
   1. President-elect, Sister M. Gabrielle Maze — It was proposed that the academy present a seminar on a particular subject and that an attempt be made to acquire a grant to support the seminar. D. Ostrovsky moved to hold the seminar at our annual meeting with speakers of international reputation dealing with topics of broad and current interest. The motion was seconded by S. Majumdar and approved. Sister Gabrielle Maze was appointed as chairperson of a committee to seek funds and develop a format for the 1977 seminar. The proposal for an annual seminar will be brought before the business meeting for endorsement. Sister Gabrielle Maze proposed that an award be presented to outstanding science teachers at both the high school and college levels. She also moved that the titles of papers from both the senior and junior academies be included in a common program for the 1977 spring meeting. The motion was seconded by S. Majumdar and approved. It was also suggested that we honor outstanding scientists in the program.
   2. Secretary — D. Ostrovsky — The membership list was updated last April and will be updated again this September. The new abstract form was included in the Newsletter and delinquent members for 1975 have been notified.
   3. Treasurer — S. Zagorski — A current state fiscal report and balance sheet were presented. There was also a current summary of journal page charges due, money owed by libraries for the *Proceedings*, and delinquent membership dues. G. Shoffstall moved that S. Zagorski be commended for his fine work as treasurer — the motion was seconded by W. Uricchio and approved.
   4. Assistant Treasurer — P. Griesacker — No report at this time.
   5. Editor of the *Proceedings* — S. Majumdar — The suggestion was made that the paper received from Rober Frock for publication in the *Proceedings* be submitted to referees for evaluation before academy's support for the publication is considered. S. Majumdar reported receiving 45 manuscripts. Twenty of these manuscripts are ready for publication in the November issue of the *Proceedings*. Fifteen manuscripts were received for the second issue of the *Proceedings*. Three of four papers have been found to be suitable for consideration for the Darbaker prize. These papers will also be considered for publication in the second issue of the *Proceedings*. S. Majumdar has expressed interest in attending the *special meeting of the Editorial Processing Center (EPC) sponsored by the NSF*. He has contacted the NSF regarding this matter.
   6. Editor of the *Newsletter* — F. Brenner — The next issue of the *Newsletter* will go to press at the beginning of October. It will contain information for authors as well as details concerning the inclusion of feature articles and Junior Academy information in the *Newsletter*.
   7. Pennsylvania Junior Academy Director — J. Gennaula — J. Gennaula expressed the desire of the Junior Academy to involve more schools in its program. He also outlined a series of future projects which include: a review of the constitution, review of the judging manual, establishment of a judging pool, establishment of an alumni association, and a metric workshop. Sister Gabrielle Maze was invited to be a financial advisor to the Junior Academy. Edward Testa and Joseph Mascetta were also appointed to assist J. Gennaula.
   8. Historian — T. Knepp — T. Knepp could not be present at the meeting, but has requested that the academy allocate $100 for compiling a photographic history of the academy. W. Uricchio moved that the $100 be allocated. The motion was seconded by S. Majumdar and approved.

B. W. Uricchio presented a detailed report concerning arrangements for the spring meeting to be held at Mt. Airy Lodge on April 17, 18 & 19. Reservations for the meeting will be made through the Senior Academy and a registration form will be included in the January *Newsletter*. W. Uricchio moved that $20 down payment for registration be requested. D. Ostrovsky seconded the motion and it was approved. D. Ostrovsky moved that the expenses for the 1977 April meeting package ($41) incurred by the executive council be covered by the local arrangements committee. The motion was seconded by S. Zagorski and approved. D. Ostrovsky moved that participants at the spring meeting be given the option of presenting their papers at a poster session. The motion was seconded by B. Fried and approved.

The meeting was adjourned at 5:15 PM.

Respectfully submitted,
David Ostrovsky
Secretary

MINUTES OF THE EXECUTIVE COUNCIL MEETING
September 28, 1977

Presiding: George C. Shoffstall, President
Place: Gold Room, Holiday House, Monroeville, PA 1:30 p.m.
Present: G. Shoffstall, Sister Gabrielle Maze, D. Ostrovsky, S. Zagorski, P. Griesacker, S. Majumdar, J. Brenner, J. Gennaula, W. Uricchio and L. Naylor.

A. Reports from academy officers were presented and accepted by the executive council.
   1. President — George C. Shoffstall, Jr. The President reported his attendance at a meeting of the Pennsylvania Association of College Chemistry Teachers in April, 1977. He served as guest speaker at the meeting and discussed the advantages of membership in the PAS. Dr. Shoffstall received an invitation by Widener College for the 1980 summer meeting of the PAS. He also presented the executive council with an updated brochure dealing with the objectives of the PAS.
   2. President-elect — Sister M. Gabrielle Maze. Sister M. Gabrielle Maze reported on contributions and fund raising activities. A general fund raising procedure was suggested for the simultaneous collection of funds for the PAS and PJAS. Implications of the plan were considered by the executive council.
   3. Secretary — Dr. David Ostrovsky. Dr. Ostrovsky reported that the mailing list has been updated and dues notices sent out.
   4. Treasurer — Dr. Stanley J. Zagorski. Dr. Zagorski presented reports concerning the resolution of the IRS tax matter and the PAS research grant.
   5. Assistant-Treasurer — Dr. Paul B. Griesacker. Dr. Griesacker presented the balance sheets for the PAS. He also presented the report of the state commission on charitable organizations regarding contributions received by the Academy.
   6. Editor-*Proceedings* — Dr. Shyamal K. Majumdar. Volume 51, issue 1 will be published in late November or early December and issue 2 will be published in April. Papers for consideration for the Darbaker Prize have been accepted.
   7. Editor-*Newsletter* — Dr. Frederic J. Brenner. Dr. Brenner reported on the forthcoming newsletter as well as the response to the questionnaire concerning summer meetings. The response to this questionnaire has not been sufficient to date to warrant conclusions as to the wishes of the membership.
   8. Pennsylvania Junior Academy Director — Mr. Joseph A. Gennaula. Mr. Gennaula brought the executive council up to date on developments in the P.J.A.S. He reported that 2779 students have participated in regional meetings.

B. Reports of committees were presented and accepted by the general council.
   1. Guest Speaker Committee. Dr. Ostrovsky reported that Dr. Stephan Jay Gould would present two talks before the P.A.S. on April 17, 1978. One talk to be scheduled for the afternoon will be entitled "Sociobiology, A New Synthesis" and the dinner talk will be "Size and Shape: or why flies walk on ceilings and tall churches are narrow."
   2. Time and Place of Meetings Committee. Dr. William Uricchio announced that the 54th annual meeting of the Pennsylvania Academy of Science will be held jointly with the Pennsylvania Junior Academy of Science on April 16-18, 1978, at Seven Springs Mountain Resort, Champion, Pa. The executive council will hold their meeting after lunch on Sunday and papers will be presented on Monday morning and afternoon as well as on Tuesday morning. A special feature this year will include a symposium on the History and Philosophy of Science to be held on Sunday evening, April 16. This symposium will be followed by a beer party to enable the participants to interact with the academy members.
      Accomodations will be at Seven Springs Mountain Resort and the cost of the total package will be $40 per person. This price will include two nights in a double room (Sunday and Monday) and five meals (Sunday dinner, Monday breakfast, lunch and banquet, and Tuesday breakfast).
   3. Advisory Council. Dr. Lewis M. Naylor reported that during June and July, Knouse Foods and Shippensburg State College jointly sponsored an environmental chemist intern, a third year chemistry major. He has suggested that this is one type of industry/college program which the PAS could publicize and promote through its membership.
   4. Membership Committee. Drs. Warren Guy and George Boone are developing a letter to be sent to science departments in colleges and universities in Pennsylvania. The letter will include copies of the *Call for Papers* for the 1978 meeting and membership forms.

C. Motions Passed by the Executive Committee:
   1. To mail out membership dues notices on November 1.
   2. To consider new membership dues paid after August 31 to be dues applied for the following year.
   3. To withhold payment of attorney fee regarding the IRS tax matter until final payment has been made by the IRS to the PAS.
   4. That Dr. C. Allan Miller be awarded the 1977 PAS research grant contingent on verification of Dr. Millers membership in the P.A.S. at the time the grant was awarded. This motion was prompted by the A.A.A.S. requirement that A.A.A.S. awards are restricted to state academy of science members.

The meeting was adjourned at 4:00 p.m.

Respectfully submitted,
David Ostrovsky
Secretary

PENNSYLVANIA SCIENCE TALENT SEARCH WINNERS FOR 1977. — Bruce D. Martin, Director, Science Talent Search.

TRIP WINNERS

Richard High Ebright, Muhlenberg Township High School, 5611 Stoudt's Ferry Road, Reading, PA 19605
Paul Michael Embree, Muhlenberg Township High School, 3225 Eisenbrown Road, Reading, PA 19605
Charles Crawford Mecham, Episcopal Academy, 641 Clovelly Lane, Devon, PA 19333

HONORS GROUP

Maura E. Burns, Bishop Hafey High School, 149 South Wyoming Street Hazleton, PA 18201
Steven Brent Hearon, Hempfield High School, 2796 Spring Valley Road Lancaster, PA 17601
Jeffrey Lee Kegarise, Upper St. Clair High School, 1734 Partridge Run Road, Pittsburgh, PA 15241
Stanley M. Novacki III, Our Lady of the Sacred Heart High, 338 Jenny, Lynn Drive, Coraopolis, PA 15108
Alan Thomas Remaley, West Mifflin South High School, 410 Glencoe Drive, West Mifflin, PA 15122
Timothy John Rydel, North Hills High School, 252 Sewickley Oakmont Road, Pittsburgh, PA 15237
Melanie Sabo, Kennedy Christian High School, R.D. 3 Box 86, West Middlesex, PA 16159
James C. Springer, Neshaminy-Langhorne High School, 14 Scarlet Oak Road, Levittown, PA 19056
William Alan Titus, Taylor Allderdice High School, 566 Braircliff Road, Pittsburgh, PA 15221
Leonard Weiss, Akiba Hebrew Academy, 21 Downs Circle, Wynnewood, PA 9096

FIRST AWARD WINNERS

Barbara Brozoski, Bishop Hafey High School, Hazleton, PA 19601
Wendy Coates, Sacred Heart High School, 5529 Fifth Avenue, Pittsburgh, PA 15232
Robert M. Cygnarowicz, West Mifflin South High School, 609 Irwin Run Road, West Mifflin, PA 15122
Tina M. D'Amario, St. Maria Goretti High School, 2020 South 29th Street, Philadelphia, PA 19145
Mark A. Dininno, Quaker Valley High School, 897 Thorn Street, Sewickley, PA 15143
James E. Dvorsky, West Mifflin South High School, 1033 Merion Drive, West Mifflin, PA 15122
Rene M. Filipowski, St. Benedict Academy, 725 East 33rd Street, Erie, PA 16504
William Finch, Avonworth High School, Ritter Road R.D. #2, Sewickley, PA 15143
Craig Freudenrich, West Mifflin South High School, 800 Shadyside Drive, West Mifflin, PA 15122
Leslie Marie Houtz, West Snyder High School, Box 38, Troxelville, PA 17882
Kim A. Kauffman, West Snyder High School, Box 176, Beavertown, PA 17813
Gwen Kaufman, West Snyder High School, Box 182, Beavertown, PA 17813
Fred Krebs, West Snyder High School, R.D. #1, Beavertown, PA 17831
Tamra Kline, West Snyder High School, Box 162, Beavertown, PA 17841
Crystal Moyer, West Snyder High School, R.D. #1, Beaver Springs, PA 17812
Donald T. Nardone, Bishop Hoban High School, 360 South Grant Street, Wilkes-Barre, PA 18702
Edward Skokowski, St. Pius X High School, 36 West 9th Street, Pottstown, PA 19464
Jonathan Speak, Quaker Valley High School, 36 West 9th Street, Pottstown, PA 19464
Garry L. Wagner, West Snyder High School, Box 305, McClure, PA 17841
Scott Whalen, West Mifflin South High School, 1120 Fidelity Drive, Pittsburgh, PA 15236

JUDGES AWARD WINNERS

Bert J. Altmanshofer, Hollidaysburg High School, Box 506 R.D. #3, Duncansville, PA 16635
Reginald Auford, Hollidaysburg High School, 441 Cedar Boulevard, Hollidaysburg, PA 16648
Shirley Bentlejewski, North Hills High School, 112 Holly Hill Drive, Pittsburgh, PA 15237
Joseph R. Brendel, Serra High School, 104 Bonita Court, McKeesport, PA 15131
Charles L. Cain, Bedford High School, R.D. 2, Box 678, Cumberland, MD 21502

Christie Claar, Hollidaysburg High School, R.D. #3, Box 597, Hollidaysburg, PA 16648
Rose Confer, Highlands High School, R.D. #2, Box 347A, Tarentum, PA 15084
Charles Dallara, Quaker Valley High School, 107 Priscilla Drive, Sewickley, PA 15143
Mary P. Deffner, Vincentian High School, 1924 Mt. Royal Boulevard, Glenshaw, PA 15116
Daniel E. Durci, Plum High School, 429 Tangle Drive, Pittsburgh, PA 15239
Therese Errigo, Valley View High School
Elizabeth Fadale, Hollidaysburg High School, R.D. #3, Box 620, Duncansville, PA 16635
Regina Gamrat, Cardinal O'Hara High School, 363 Hastings Boulevard, Broomall, PA 19008
Elsie Graham, New Castle High School, P.O. Box #5, Clark's Mills, PA 16114
Joy Huntley, Laurel Highlands High School, R.D. #4, Box 31, Uniontown, PA 15401
Karl Klimek, Quaker Valley High School, 200 Elwick Street, Sewickley, PA 15143
Joseph Mattis, St. Thomas High School, 902 Coalmont Street, North Braddock, PA 15104
Keith Miller, Jr., Allentown Central Catholic High, 1125 Webster Avenue, Allentown, PA 18103
Sue Moreno, Upper Merion High School, 221 Chapel Road, King of Prussia, PA 19406
Anila Murcko, Mt. Alvernia High School, Little Flower Woodland road, Pittsburgh, PA 15232
William Osolinski, Serra Catholic High School, 1616 Versailles Avenue, McKeesport, PA 15132
Anthony J. Parisi, Serra Catholic High School, 211 Marguerite Avenue, Wilmerding, PA 15148
Charles Peters, Quaker Valley High School, 1429 Beaver Road, Sewickley, PA 15143
Daniel Reichner, Plum High School, 120 Poree Drive, Pittsburgh, PA 15239
Gregory Rodgers, Crestwood High School
Lauar Soisson, Geibel High School, 505 East Crawford Avenue, Connellsville, PA 15425
Kurt Sopp, Quaker Valley High School, R.D. #4, Fern Hollow Road, Sewickley, PA 15143
John Spaltro, Cardinal O'Hara High School, 11 Althea Lane, Morton, PA 19070
Robert A. Wanet, Bishop O'Reilly High School
Lori Webster, Hollidaysburg High School, 910 Allegheny Street, Hollidaysburg, PA 16648
Marie Ellen Wick, Quaker Valley High School, 1461 Beaver Road, Sewickley, PA 15143
Jay D. Wilson, Plum High School, 4827 Hialeah Drive, Pittsburgh, PA 15239
Raymond Wisniewski, Plum High School, 261 Shasta Drive, Pittsburgh, PA 15239

JUNIOR AWARD WINNERS

Barry Edward Auman, Shikellamy High School, 433 Third Street, Northumberland, PA 17857
Tom Belliotti, Central Catholic High School, 255 East Meyers, Pittsburgh, PA 15210
Andrew Bernoff, Upper Dublin High School, 3201 Ayr Lane, Dresher, PA 19725
Sandra Barndon, St. Francis Academy, 900 Fredericka Drive, Pittsburgh, PA 15236
William Britton, Shikellamy High School, 318 Race Street, Sunbury, PA 17801
Karen Dalansky, Geibel High School, R.D. #0 Box 148, Scottsdale, PA 15683
Cathy DiThomas, South High School, 746 Joyce Drive, West Mifflin, PA 15122
Brian Fedorko, Avonworth High School, 206 Alegheny Avenue, Pittsburgh, PA 15202
John Del Ferro, Cardinal O'Hara High School, 2144 Franklin Avenue, Morton, PA 19070
Joy Esterlitz, Upper Dublin High School, 1580 Derry Drive, Dresher, PA 19025
Lee Fleisher, Cheltenham High School, 311 Highland Road, Cheltenham, PA 19012
Jim Ganopulus, West Mifflin South High School, 714 Camp Hollow Road, West Mifflin, PA 15122
Maria C. Grabowski, Sacred Heart High School, 64 Bates Street, Pittsburgh, PA 15213
Marianne Halbach, Cardinal O'Hara High School, 114 Haller Road, Ridley Park, PA 19078
Linda Hamberg, Cheltenham High School, 35 Edgemoor Road, Cheltenham, PA 19012
Michael Hryckowian, Quaker Valley High School, R.D. #5 Camp Meeting, Sewickley, PA 15143
Laurel Jeannette Hummel, Clearfield Area High School, 401 Park Avenue, Clearfield, PA 16830
Susan Jacobsen, Upper Dublin High School, 235 Wenner Way, Ft. Washington, PA 19034
Brian Jung, Upper Dublin High School, 1539 Norristown Road, Ambler PA 19002
Louis J. Konopelski, Bishop Hoban High School, 804 Aspen Drive R.D. #8, Wilkes-Barre, PA 18707
Theresa Lanowitz, St. Thomas High School, 305 Oakland Avenue, North Braddock, PA 15104
Neil Lesitsky, Upper Dublin High School, 742 Wright Drive, Maple Glen, PA 19002
Thomas McCormack, Quaker Valley High School, 106 William Penn Circle, Sewickley, PA 15143
John R. Mulvey, Upper Dublin High School, 1109 Wallace Drive, Ft. Washington, PA 19034
Kim Niemela, Avonworth High School, 7306 Terrance Avenue, Pittsburgh, PA 15202
Kelvin Okamoto, Upper Dublin High School, 1732 Bentry Drive, Dresher, PA 19025
Jean Payne, Greensburg Central Catholic High, 154 Alexander Avenue, Greensburg, PA 15601
Susan Reilly, Geibel High School, 151 Van Drive, Connellsville, PA 15425
Mark Rosar, Central Catholic High School
Rebecca Schaffer, North Hills High School, 808 Washington Drive, Pittsburgh, PA 15229
Marie Schreffler, Shikellamy High School, 461 King Street, Northumberland, PA 17857
Andrew Sebok, Cheltenham High School, 7902 Knox Road, Laverock, PA 19118
Mary Ann Synder, St. Francis Academy, 515 Broughton Road, Bethel Park, PA 15102
Scott Sparks, Altoona High School, R.D. #4 Box 281, Altoona, PA 16601
Judith L. Spring, St. Francis Academy, 6518 Zupancic Drive, Pittsburgh, PA 15236
Titus Stauffer, Selinsgrove High School, 206 South Front Street, Selinsgrove, PA 17870
Lucille Stea, Upper Dublin High School, 1700 Penns Lane, Ambler, PA 19002
Vida Lynn Tyc, Upper St. Clair High School, 317 Oaklawn Drive, Pittsburgh, PA 15241
David Wasil, Geibel High School, 98 State Street, Mt. Pleasant, PA 15666
Paul Wolfe, Avonworth High School, 98 State Street, Mt. Pleasant, PA 15202
Chris M. Yanckello, Quaker Valley High School, Box 78 - Merriman Road, Sewickley, PA 15143

Proceedings of the Pennsylvania Academy of Science 51:19—22. 1977.

THE DARBAKER PRIZE PAPER

ELECTRON MICROPROBE ANALYSIS OF COLLOIDAL IODINE IN THYROID GLAND OF WHITE-THROATED SPARROW, ZONOTRICHIA ALBICOLLIS[1]

by
JACK HARCLERODE and DAVID ZEIGLER
Department of Biology, Bucknell University
Lewisburg, PA 17837
and
WILLIAM ZEIGLER and EUGENE W. WHITE
Materials Research Laboratory
The Pennsylvania State University
University Park, Pa. 16802

ABSTRACT

Colloidal iodine content of the white-throated Sparrow thyroid gland was analyzed by spot analysis, using the electron microprobe and compared with histological ratings of thyroid activity. The three groups of White-throats used in this investigation were the following: (1) Wild-netted, control; (2) Outdoor-caged, stock diet fed; and (3) Outdoor-caged, KI supplement fed. The wild-netted group had the greatest Thyroid Activity Index (TAI) and the least colloidal iodine concentration. The two caged groups had identical, moderate TAI. The caged-KI supplemented group had the greatest colloidal iodine concentration of the three groups, and the wild-netted birds had the least.

INTRODUCTION

The analysis of iodine in the thyroid gland has a long and varied history. The earliest method (1) employed chemical determinations, entailing ashing the organic matter and measuring the residual iodine titrimetrically or colorimetrically. The main problem with these types of analyses is the loss of iodine by either volatilization of incomplete ashing of organic matter. Also, reliability is difficult to maintain. Finally, the limit of detectability inherent in each method presents a further problem although this limit of detection has been extended with increasing sophistication of analytical procedure. Since its discovery in the thyroid gland by Baumann(1), the smallest detectable amount of thyroidal iodine has been extended from 10^{-5} to 10^{-9} grams.

Recently, autoradiography has been employed as a semiquantitative means of determining thyroidal iodine. One disadvantage of this technique is that the animal must be pre-treated with radioiodine, thereby possibly affecting thyroid iodine metabolism in the process. While the effect my be too small to be detectable in animals acclimated to laboratory conditions, it is a factor to be considered when one is trying to determine thyroid function in animals obtained in the wild state.

The recent development of the electron microprobe, which is capable of *in situ* X-ray emission spectrographic analysis, has extended the limit of detectability of iodine to 10^{-14} grams. First developed by Castaing for use in metallurgical research, the microprobe has only recently begun to assume an important role in elemental analysis of micron-sized volumes in biological specimens (2, 3, 4, 5, 6, 7, 8).

This paper presents the application of the microprobe in the determination of colloidal iodine concentrations in the thyroid glands of wild White-throated Sparrows, *Zonotrichia albicollis,* and White-throated sparrows caged and fed iodide supplemented diets. These data are compared with thyroid activity from the same birds when determined by standard, conventional histological evaluation.

[1]Received January 31, 1977; revised; accepted June 18, 1977.

MATERIALS AND METHODS

The two caged groups of White-throated Sparrows used in this study were caught in mist nets during the spring and fall migration. The six wild-netted birds (wild-netted or control group) were netted in the early part of December and killed immediately upon capture. Nine birds (caged, stock diet group) were fed stock Purina Layena diet containing a moderate amount of iodide (8 μg iodine/gm of diet) and were maintained in separate, visually isolated cages in an outdoor aviary until their sacrifice in December.

A potassium iodide pre-mix was prepared, using a mortar and pestle, containing enough finely ground KI plus pulverized Purina Layena feed to produce a very high iodide diet. This pre-mix was homogeneously diluted with amounts of the stock pulverized Purina Layena feed and adminstered to the six birds in the KI supplemented group (caged, KI supplemented group) for two weeks prior to their sacrifice (25 μg KI/gm of diet).

All birds were killed by pressure on the rib cage which prevented the heart from beating. The paired thyroid gland lobes of each bird were dissected and trimmed of connective tissue on a moistened paper towel, weighed to the nearest 0.1 mg, and immediately fixed in AFA (acetic acid:formalin:ethanol (80%, 95%, 100%, and ethanol:cedar oil, 50:50), cleared in cedar oil for three days, embedded in paraffin, and sectioned at 6 μ. Duplicate sets of central cross-sectins were taken from each gland — one set (two sections per gland) for Thyroid Activity Index (TAI) study, and the other (one section per gland) for microprobe analysis of colloidal iodine.

For TAI study, sections were stained with Harris' hematoxylin and

TABLE 1

Thyroid activity index

Stage	Cell	Nucleus	Vacuolization	State
1	Very flat $< 1.5\mu$	Flat or concave	Without vacuoles	Inactive
2	Flat 1.5-2.25μ	Flattened ovoid	Very few	Fairly active
3	Low cuboidal 2.26-3.00μ	Ovoid	Few	Moderately active
4	Cuboidal 3.01-3.50μ	Spherical, touching cell membrane	Many	Active
5	Columnar 3.51-4.0μ	Spherical, not touching cell membrane	Very many	Strongly active
6	High columnar $> 4.0\mu$	Spherical, located at basal end of cell	Little colloid present	Very active

eosin. Using a TAI modified from Harclerode and Dropp (9), the functional state of each gland pair wasnumerically rated 1 to 6 (inactive to very active), on the basis of epithelial cell height, shape of nucleus, and degree of vacuolation of the colloid. The procedure consisted of following two traverses at right angles to each other in a representative central cross-section of each lobe of a gland. Each cell lying along the traverse was rated, and a weighted mean TAI for each gland was calculated. Interpretation of the numerical result of a TAI is based on the assumption that a thyroid gland with high epithelium, spherical nuclei and vacuolated colloid is more active than one with low epithelium, flattened nuclei and non-vacuolated colloid. Experimental evidence justifies these assumptions (10, 11). Table 1 summarizes the six stages of activity in the TAI and includes the corresponding histological features of each.

Sections for microprobe iodine analysis were mounted on precleaned quartz circular coverslips, deparaffinized, and mounted on brass holders. Sections were subsequently vacuum-coated with a very thin layer of carbon (several hundred angstroms) to make the surface of the tissue electrically and thermally conductive. A path of metallic silver was painted on the glass coverslip, encircling the tissue and leading to opposite sides of the brass holder, to conduct the electron charge away from the tissue.

A series of three iodided standards was prepared from hot aqueous solutions of gelatine and potassium iodide. The resultant dense gels were freeze-dried, and a vacuum-evacuated die and press were used to prepare pellets having essentially zero porosity. The calculated weight percents of iodide in the standards were 0.44%, 1.54%, and 3.76%.

The procedure for microprobe iodine analysis consisted of bringing into focus of the electron beam first a reference standard, followed by the three iodide standards and finally the thyroid sections. The reference standard, pure crystal of CdI_2, was used to peak the microprobe spectrometer at the characteristic wavelength of the iodine Lμ X-ray emission. With the spectrometer peaked, a maximum iodine count rate resulted. The spectrometer background setting was determined by rotating the spectrometer off the I Lμ wavelength to the maximum wavelength of the characteristic X-ray continuum generated by the reference standard.

The theoretical significance of the iodine intensities is based on the assumption that the number of X-rays generated per unit time is proportional to the number of atoms of the X-ray source element present in the sample, and is called Castaing's "first approximation" (15). This assumes that X-ray production is dependent only on the characteristics of iodine, and is independent of the matrix in which it is found. This assumption is valid in this study since KI standards were prepared whose matrix closely approximates the tissue matrix, thyroid colloid, in mean atomic number.

In this study, the electron microprobe was operated at 15 Kev, 3 x 10^{-8} amps, and 1-2 μ beam diameter. A four-inch radius LiF spectrometer crystal having a take-off angle of 52.5° was used to disperse and detect the iodine Lμ line at 3.14Å. The detector was an argon-filled proportional counter.

The thyroid sections analyzed were 6 μ in thickness. Under the specific microprobe operating conditions in this study, 6 μ was determined to be the minimum thickness which would totally accommodate the volume of analysis in the thyroid colloid. To elucidate this point, a linear deceleration of the incident beam electrons within the tissue is assumed (12), whereby the effective electron range in the specimen ($p \approx .8$) is 8 μ, operating at a beam accelerating potential of 15 Kev (13). Furthermore, it is assumed that the depth of X-ray production is approximately two-thirds the effective electron range (13); and that the volume of analysis is a pear-shaped shpere, submerged below the target surface, whose lateral extent approximates its vertical dimension (12). Under these assumptions, a submerged sphere of approximately 6 μ in diameter comprises the volume of analysis in the thyroidal colloid. A good general reference to electron microprobe analysis may be found in McKinley (14).

Ten iodine intensity counts and ten background counts were taken from each of the three iodide standards. The mean value of each of these series of counts was computed and the true iodine intensity count of each of the three standards was computed. These standards of known amounts of iodine homogeneously distributed in a protein matrix were used to construct a linear calibration curve of counts vs. weight percent iodine (Fig. 1). Spot analysis of colloidal iodine consisted of taking iodine intensity counts from the randomly chosen peripheral follicles and ten randomly chosen central follicles, followed by ten background counts from any ten follicles. True, mean intensity counts were computed for peripheral and central colloid of a representative central cross-section from each thyroid gland. Colloid iodine concentrations (weight percent of dehydrated tissue) of each gland were extracted from the standard curve. All data were evaluated statistically using Students' t-test.

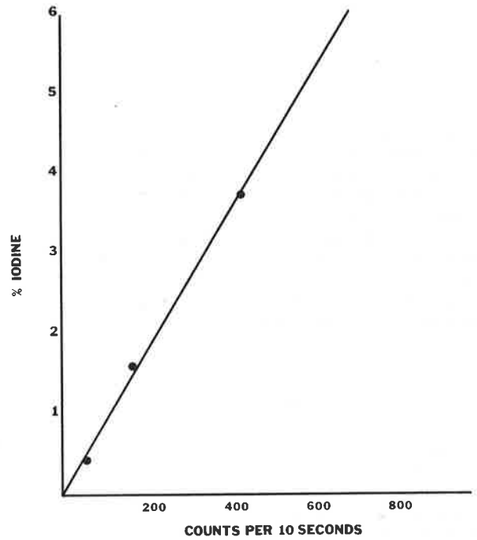


FIGURE 1. Standard Calibration Curve for % Iodine. (Line beyond last point of data is extrapolated.)

RESULTS

GLAND WEIGHT AND THYROID ACTIVITY INDEX. Thyroid glands of the wild-netted control birds were the smallest of the three groups (mean weight, 2.4 mg). This was true whether the glands were compared on an absolute weight basis (Table 2) or compared as milligrams per 100 grams of body weight (Fib. 2). Both caged groups, caged stock diet fed and caged KI supplemented, had significantly heavier glands than the wild-netted birds ($p < .02$), with the KI supplemented birds having significantly the largest and heaviest glands (5.8 mg) of the three groups.

Wild-netted birds were shown to have a significantly higher TAI (Fig. 2) than either of the other two groups ($p < .02$ in both instances). The two caged groups had almost identical, moderate TAI (2.82 and 2.83). The high TAI of the wild-netted birds (4.07) represents a 35% increase in epithelial cell height over the glands from both the caged groups. Birds used in this study showed an inverse relationship between thyroid gland weight and Thyroid Activity Index.

COLLOIDAL IODINE CONCENTRATION. Figure 3 summarizes the results of microprobe spot analysis of iodine concentration in the colloid of the thyroid glands. The iodine concentrations (as weight percent) in representative peripheral follicles and central follicles are reported as averages for each group of birds. No group showed a significant difference in colloidal iodine concentration between peripheral

TABLE 2

Thyroid gland weights

Group	N	Mean weight (mg) ± Standard Error
Wild-netted	6	2.4 ± 0.2
Caged stock-diet fed	9	3.3 ± 0.6
Caged KI-supplemented	6	5.8 ± 1.0*

* $P < 0.02$

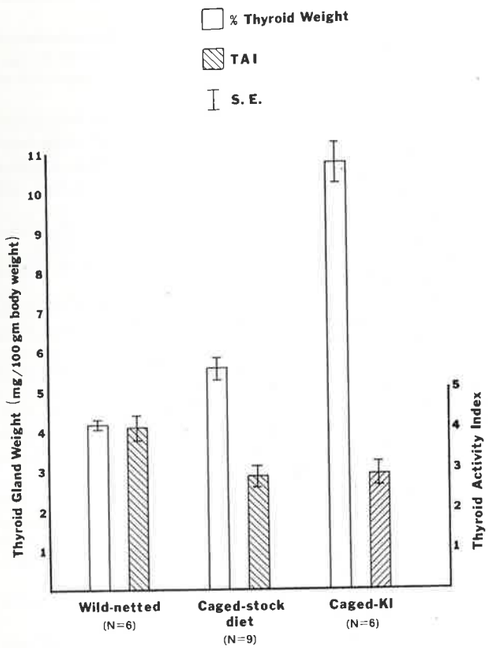


FIGURE 2. Thyroid Gland Weights (mg/100 gm body weight) and Thyroid Activity Index of White-throated Sparrows.

and central follicles. This constant level of intrathyroidal iodine within each group is contrasted with the interthyroidal iodine concentrations which varied significantly among all three groups ($p < .001$). The colloid of the wild-netted birds had the least iodine (1.2%). The colloid iodine concentration of the two caged groups increased proportionately with the increase in dietary iodine level, viz., the birds fed stock diet (8 μg iodide/gm of diet) were shown to have a mean colloidal iodine concentration of 3.9% and the birds fed iodide supplement (25 μg KI/gm of diet) had the greatest mean colloidal iodine concentration (6.0%).

DISCUSSION

Due to the phenomena of hypertrophy and hyperplasia, thyroid glands in the hyperactive state may be larger than glands of normal activity (16). Increase in gland weight is not a realiable indicator of activity, however, because the gland may become heavier in the resting state due to colloid accumulation (17).

The thyroid glands of the two caged groups of sparrows used in this study represent an example of this particular situation. Even though the stock diet fed group and the KI supplement fed group had 37% and 144%, respectively, heavier glands than the wild-netted control birds, both groups had almost identical and only "moderate" TAI's. conversely, the wild-netted birds, which had the lightest mean gland weight, showed signs of an hyperactive thyroid state. The histological TAI of 4.07 represents a 37% increase over the two caged groups. This inverse relationship between gland activity and weight was also observed in wild pheasants (9) but is not universal even among birds. Colloid accumulations, resulting in increased gland weight in the two caged groups, is possibly the result of decreased secretory stimulation of the thyroid gland by pituitary TSH, which manifests itself in the low TAI found in both these groups.

Two isotopes of iodine, ^{123}I and ^{131}I, have been widely employed to study the quality of iodine in the thyroid. Through the combined techniques of equilibrium labeling of iodoproteins with ^{125}I and autoradiography, colloidal iodine concentration was found to be constant in follicles throughout the gland (18, 19). The results of the present study using the microprobe corroborate these findings. Direct determination of natural iodine by microprobe spot analysis showed a constant level of intrathyroidal colloidal iodine. Robison and Davis (2) also showed the iodine distribution to be quite uniform across the colloid area of different sized follicles using scanning pictures and step-scan analysis with the electron microprobe. This fact is contrasted with the results of radioiodine uptake studies in rats in which the uptake and distribution of ^{131}I several hours after injection had been shown to vary among follicles (20) as a function of its size or, more specifically, its surface-to-volume ratio. Thus the central gland area, generally the locus of the smaller follicles, contained follicles which were more heavily labeled than the gland periphery. The heavier labeling of smaller follicles, however, does not necessarily mean that they have a greater ^{127}I content or concentration.

A comparision of interthyroidal colloidal iodine concentrations among the three groups of sparrows in this study shows highly significant differences between groups. Colloidal iodine concentration was shown to be inversely related to thyroid gland activity, and directly related to the amount of iodine in the diet. The physically active, wild-netted birds had the greatest TAI, probably produced by pituitary

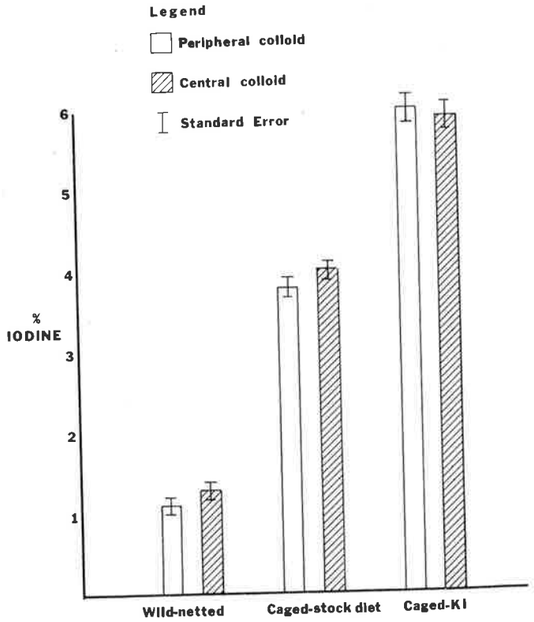


FIGURE 3. Colloidal Iodine Concentration Determined by Microprobe Analysis.

TSH stimulation, which was characterized by colloid depletion, i.e., colloidal iodine depletion. On the other hand, the two caged groups had low TAI's and increased colloidal iodine concentrations, relative to the level of iodine in the diet. The fact that iodide supplemented in the diet increases the iodine content of the thyroid gland has long been established (1) and has been repeatedly confirmed. Increased iodine titer (via increased absorption of iodide by the gut) results in increased thyroid hormone titers which subsequently, by negative feedback to the pituitary, result in decreased TSH titer and decreased thyroid hormone secretion. Thus, iodine is stored and colloid accumulated.

These data indicate that the percentage of iodine in the colloid of these birds is higher than previously found in mammals. Thyroglobulin extracted from thyroid glands of several species of animals has been analyzed to contain approximately 1% iodine when the animals were maintained on a normal diet (21). In our study, the wild-netted birds contained slightly over 1% iodine (1.2%) and would represent animals whose diet should be considered normal. Those birds maintained on a diet containing 8 μg iodine/gram probably received much more iodide than birds living in a wild state and had 3.8% colloidal iodine while birds which had 25 μg KI/gram of diet had about 6% colloidal iodine.

The high iodine content of colloid reported for birds in this study had been confirmed for rats by Robison and Davis (2) in an independent study at Lawrence Radiation Laboratory using microprobe analysis. They measured iodine content of about 1% in colloid of thyroid glands from rats maintained on a low iodide diet and about 2.2% in rats maintained on normal laboratory rat food. In their study several different techniques of tissue preparation were used. No significant differences were found in the iodine concentration of the thyroid sections which were either frozen, lyophilized, thawed, fixed, or stained.

It is not unreasonable to expect to find a higher iodine content in colloid measured *in situ* than in thyroglobulin extracted from thyroid glands. One possible explanation for the discrepancy between the findings reported here and those employing chemcial extraction is that most studies which report percent iodine in thyroglobulin do not report how much iodine was lost in the various extraction and purification rocedures. The present studies indicate that the loss of iodine may be considerable.

The electron microprobe has only begun to make a contribution to histological research today. Electron microprobe analysis emobdies the advantages of quick, contamination-free procedure and direct quantification of natural elements *in situ*. These important features are particularly advantageous for measuring *in situ* elemental concentrations which characterize the wild state of an animal. Coupled with cryostat techniques, microprobe analysis reduces the time between capture and final elemental measurement to as little as 30 minutes.

REFERENCES

1. Bauman, E. (1896). Uber das normale vorkommen des jods im thierkörper. Z. Phtsiol. Chem. *22*, 1-17.
2. Robison, W.L., and Davis, D. (1969). Determination of iodine concentration and distribution in rat thyroid follicles by electron-probe microanalysis. J. Cell Biol. *43*, 115-121.
3. Simon, C., and Peyron, C. (1968). Perte d'iode par la thyroide pendant sa préparation histologique pour la microscopie électronique. Etude préliminaire chez le Rat. C. R. Acad. Sci. (Paris) *267*, 1393-1396.
4. Martoja, M., and Vu Tan Tue (1971). Analyse de la thyroide et des corps ultimobranchiaux de *Chimaera monostrosa* L. par spectrographie des rayons X. J. Microsc. 12, 41-50.
5. Simon, C., and Drox, B. (1973). Quantitative distribution of bound iodine in the rat thyroid follicle. I. Relationship between the iodine concentration of the luminal colloid and its size. J. Physiol. (Paris) *66*, 51-64.
6. Setoguti, T. (1973). Electron microscopic study on the thyroid gland of the salamander *Hynobius nebulosus* in the breeding season. II. Observation under experimental conditions. Z. Zellforsch. Mikr. Anat. *137*, 195-208.
7. Hourdry, J., and Regard, E. (1975). Incidences des techniques de préparation sue la détection de l'iode dans la thyroide du Xénope à la microsonde électronique. Coll. de la S.F.M.E. (Montréal, mai 1975). J. Microsc. *22*, 90a.
8. Hourdry, J., and Regard, E. (1975). Mesure relative de la quantité d'lode décelable dans la colloide des follicules thyroidiens chez la larve du Xénope, par spectrométrie des rayons X. Effets de l'hypophysectomie et de l'administration de TSH. Gen. and Comp. Endocrinol. *27*, 277-288.
9. Harclerode, J.E., and J.J. Dropp. (1966). Seasonal variation in thyroid gland activity in pheasants. Ohio J. Sci. *66*, 380-386.
10. Dempsey, E.W. (1949). The chemical cytology of the thyroid gland. Ann. N.Y. Acad. Sci. *50*, 336-357.
11. Lever, J., J. Miltenburg, and G. J. van Oordt. (1949). The effect of a short treatment with thiourea upon the fish thyroid gland. Proc. Kan. Ned. Akad. Wet. *52*, 396-400.
12. Duncumb, P., and P.K. Shields. (1966). Effect of critical excitation potential on the absorption correction. *In* T.D. McKinley (ed.), *The Electron Microprobe*. John Wiley and Sons, Inc., New York.
13. Anderson, C.A. (1967). An introduction to the electron probe microanalyzer and its application to biochemistry. Methods Biochem. Anal. *15*, 147-270.
14. McKinley, T.D. (ed.). (1964). *The Electron Microprobe*. John Wiley and Sons, New York. 1035 pp.
15. Castaing, R. (1951). Application des sondes electroniques a une methode d'analyse ponctuelle chimique et cristallographique. Thesis, University of Paris.
16. Gorbman, A., and H.A. Bern. (1962). *A Textbook of Comparative Endocrinology*. John Wiley and Sons, New York. 468 pp.
17. Hohn, E.O. (1961). Endocrine glands, thymus, and pineal body. *In* A.J. Marshall (ed.), *Biology and Comparative Physiology of Birds*. Academic Press, New York. 468 pp.
18. Woolman, S.H. (1965). Heterogeneity of the thyroid gland. *In* C. Cassano and M. Andreoli (eds.), *Current Topics in Thyroid Research*. Proc. 5th Int. Thyroid Conf., Rome.
19. Simon, C., and B. Droz. (1965). Iodine distribution in the thyroid follicle as determined by isotopic equilibrium and electron microscopic radioautography. *In* C. Cassano and M. Andreoli (eds.), *Current Topics in Thyroid Research*. Proc. 5th Int. Thyroid Conf., Rome.
20. Nadler, N.J., C.P. Leblond, and R. Bogoroch. (1954). The rate of iodine metabolism by the thryoid follicle as a function of its size. Endocrinology *54*, 154-172.
21. Rolland, M., J. Bismuth, J. Fondarai, and S. Lissitzky. (1966). Composition en acides amines de la thyroglobuline de differentes especes animales. Acta Endocrinologica *53*, 286.

Proceedings of the Pennsylvania Academy of Science 51:23—25. 1977.

SPONTANEOUS ACTIVITY OF PREGNANT AND NONPREGNANT CONTROL CF-1C MICE[1]

HOWARD S. PITKOW, Ph.D, MARK WARNQUIST, STEVEN PHILLIPS, and ROBERT H. DAVIS, Ph.D.

Department of Physiological Sciences
Pennsylvania College of Podiatric Medicine
Philadelphia, Pennsylvania 19107

ABSTRACT

In order to establish a normal baseline of behavior for mice during pregnancy and post-partum, for future comparison with abnormal pregnancies such as anomalies and prematurity, spontaneous movements per minute (mv/min) were obtained on CF-1C mice with a Stoelting electronic activity monitor. Significantly, more movement was observed in pregnant mice (45.1 mv/min) when compared to nonpregnant controls (38.1). For days 1 to 7 post-partum the average mv/min was 101.5 as compared to the nonpregnant value of 42.5 for the corresponding days 21 to 27. The spontaneous activity of the nonpregnant mice ran in four day cycles, the high points presumably indicating estrous. A study of the percent mean coefficient of standard error variation (SEV) showed that pregnant mice exhibited much less variation during pregnancy and lactation than that of nonpregnant control mice. Since the mice were in visual contact with each other and that the SEV in nonpregnant mice increased during days 1 to 23 (corresponding to pregnancy) and decreased during days 23-33 (the equivalent of days 11 or 12 of lactation) we speculated that the pregnant mice influenced the variance of the nonpregnant mice by some pheromonal-like effect. Increased litter size caused an increase in the spontaneous movements on the day of parturition.

INTRODUCTION

Gonadal hormones are released in large quantities during pregnancy and post-partum. Studies concerning animal behavior following injections of gonadal hormones have been conducted by many investigators, including Greep and Porter (1) and Quandango et al (2) which show a marked increased in exploratory activity. Slonaker et al (3) correlated a rise in spontaneous activity with the peak of the estrous cycle using vaginal smears in his control mice. He found a 50 percent rise in exploratory behavior which occurred at four day intervals. Gorski (4) and Harris (5) have shown that gonadal hormones influence the central nervous system which leads to increased mating behavior and exploratory activity. Stern et al (6) found that castration reduced spontaneous activity levels of male rats by 95 percent. He also reported that testosterone therapy returned the activity levels to within 90 percent of their normal values. The results of Wang et al (7) are consistent with those of Stern et al(6) showing a 95 percent decrease in spontaneous activity after castration in female rats. He also found that implanted ovarian grafts returned this low activity level to near normal control levels.

This study attempts to establish a normal baseline of spontaneous activity behavior for mice during pregnancy and post-partum and to observe how this baseline differs from that of nonpregnant control mice.

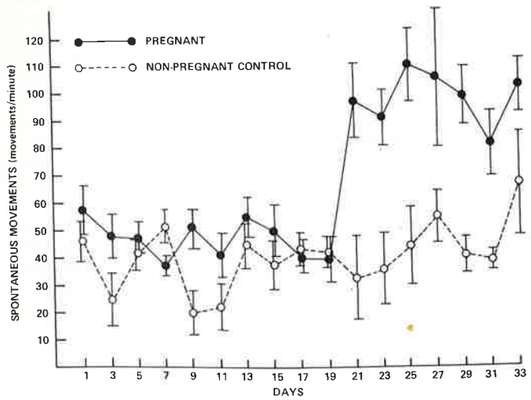


FIGURE 1. Spontaneous movements of pregnant and nonpregnant control CF-1C mice.

MATERIALS AND METHODS

Twelve adult female CF-1C mice were mated with adult males of the same strain. The females were examined each morning to determine pregnancy. Day 1 of pregnancy was the day a vaginal plug ws first observed. Each pregnant mouse was put in a separate cage. On day 1 of pregnancy and alternate days thereafter each female's cage, with pups removed, was individually placed on the stage of an electronic activity monitor (Stoelting) with a printout counter for ten minutes and spontaneous movements per minute (mv/min) were obtained between the hours of 10:00 A.M. and 12:00 noon. Fields are generated electronically at sensors so that any movement by the individual animal disturbs the field. This signal is then sensed electronically, without attachments to the animal, processed, and recorded as a count. The activity was recorded from day 1 of pregnancy to day 13 after delivery. The spontaneous movements of 8 nonpregnant control mice were also measured on alternate days from day 1 to day 33, the equivalent of day 13 after delivery of the pregnant mice.

RESULTS

During the first trimester of 6 to 7 days, the activity of the pregnant mice decreased sharply from 57.5 to 37.1 mv/min (Table 1). The activity then increased during the second trimester to 55.3 mv/min. During the last trimester the activity steadily declined to 40.1 mv/min immediate before delivery. On every day except days 7, 17, and 19, there was much more movement in the pregnant mice, averaging 45.1 mv/min for day 1 to 19, when compared to the nonpregnant control value of 38.1 mv/min for the same time period. After delivery, the spontaneous activity of the mice increased very rapidly to 97.1 mv/min (Figure 1). During lactation the activity first increased to a peak of 110.2 mv/min then steadily decreased to 81.3 mv/min. For days 1 to 7 post-partum the average mv/min was 101.5 as compared to the nonpregnant control value of 42.5 for the corresponding days 21 to 27. The spontaneous activity of the nonpregnant control mice was cyclic, with

[1]Received April 15, 1977; revised; accepted July 8, 1977.

TABLE 1

The effect of pregnancy and nonpregnancy on spontaneous movements of control CF-1C mice

Day	*Pregnant* Spontaneous Movements per minute (mv/min)	*Nonpregnant* Spontaneous Movements per minute (mv/min)
1	57.5 ± 9.7[a]	46.7 ± 7.6
3	49.9 ± 8.3[d]	25.6 ± 9.2
5	47.5 ± 5.8	42.3 ± 6.9
7	37.1 ± 3.1[d]	51.3 ± 9.0
9	51.3 ± 6.3[c]	20.2 ± 5.1
11	41.9 ± 7.8[d]	23.8 ± 7.6
13	55.3 ± 7.5	45.4 ± 8.1
15	50.6 ± 9.8	38.1 ± 7.9
17	40.9 ± 6.1	44.7 ± 6.5
19	40.1 ± 8.3	43.0 ± 5.5
21	97.1 ± 12.8[b]	33.3 ± 15.5
23	91.8 ± 9.6[b]	36.7 ± 12.2
25	110.2 ± 13.8[b]	44.5 ± 13.1
27	106.8 ± 24.3[c]	55.3 ± 9.8
29	98.4 ± 10.1[b]	40.3 ± 6.4
31	81.3 ± 11.4[b]	39.3 ± 3.9
33	103.8 ± 9.4[d]	68.5 ± 18.8

[a]mean ± standard error
[b]significantly greater ($p < 0.01$) than corresponding nonpregnant control day
[c]significantly greater ($p < 0.02$) than corresponding nonpregnant control day
[d]significantly greater ($p < 0.05$) than corresponding nonpregnant control day

each cycle lasting about 4 days (Figure 1). The high points of these cycles presumably indicate estrous. Even though some cycles were at an entirely different activity level, the difference between the highest and lowest values of each cycle remained fairly constant at 25 mv/min.

Figure 2 depicts the percent mean coefficient of standard error variation (SEV) of pregnant and nonpregnant control CF-1C mice. The SEV measures how the standard error varies around the mean. Pregnant mice exhibited much less variation during pregnancy and lactation than that of nonpregnant control mice. In nonpregnant mice the SEV gradually increased during the first 15 days (corresponding to the first two trimesters of pregnancy), after which there was a marked increase until day 23 (corresponding to the last trimester of pregnancy). However, there was a noticeable decrease in the variation between days 23 and 33 (the equivalent of the first 11 or 12 days of lactation). That is, the SEV became less variable during this time interval in nonpregnant mice.

The effect of litter size on spontaneous movements during parturition was studied in pregnant CF-1C mice (Figure 3). Increased litter size caused an increase in the spontaneous movements during parturition.

DISCUSSION

The decrease in activity in the first trimester was probably due to the added demands upon the pregnant mouse in carrying and nourishing the fetuses. However, the increase in activity during the second trimester could be attributed to the surge of estrogen during this time which increased the activity in much the same way that estrous of a nonpregnant mouse's estrogen-progesterone cycle increases activity. The rapid increase in activity after delivery can most likely be explained by the greatly reduced burden of the mouse. However, during lactation, the activity decreases, probably because of the new added demands on the mother to nourish her young. By day 13 post-partum the reduced

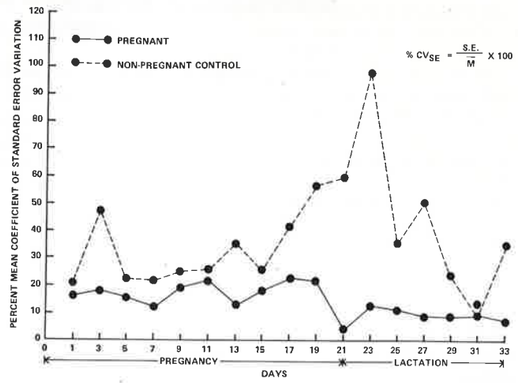


FIGURE 2. Percent mean coefficient of standard error variation of pregnant and nonpregnant control CF-1C mice.

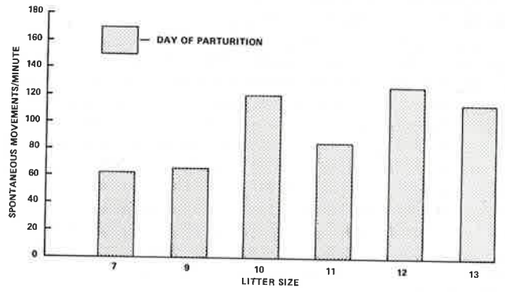


FIGURE 3. Effect of litter size on spontaneous movement during parturition in CF-1C mice.

nursing intensity of the young has decreased the requirements made upon the lactating female so that her activity increases again.

Our observation that spontaneous activity of nonpregnant control mice was cyclic, reaching a peak every four days, agrees with the findings of Slonaker et al (3). He also reported an increase in exploratory activity at four day intervals corresponding with the peak of the estrous cycle.

One might speculate that the percent mean coefficient of standard error variation (Figure 2) indicates that in some way pregnant mice influenced the SEV of nonpregnant mice. Since the pregnant and nonpregnant cages were placed side by side in the animal room, one could postulate that the presence of the pregnant mice caused an increase in the SEV of nonpregnant mice movement during pregnancy and a decrease during lactation. These behavior patterns might be attributed to some pheromonal-like effect of pregnant mice on nonpregnant mice movement.

Increased litter size (Figure 3) caused an increase in spontaneous movements on day of parturition. It seems that the increased mechanics required during labor and parturition with larger litters accounted for the great increase in spontaneous movements at parturition (Table 1, Figure 1).

CONCLUSION

These data show that pregnancy and delivery greatly increased the spontaneous movement of pregnant mice when compared to nonpregnant control mice. This activity increased much more dramatically following parturition. We hope that this normal baseline for pregnancy will be

used for comparison in further studies with abnormal pregnancies, such as anomalies and prematurity.

REFERENCES

1. Greep, R.O. and Porter, J.E. 1973. A vista of research on mammalian gonadotropins. J. Reproductive Fertility supple. 20:1-170.
2. Quandango, D.M., Shayne, J., Anderson, L. and Gorski, R.A. 1972. The effects of testosterone and estrogenon exploratory activity in the rat. J. Endocrinology 90:1025-31.
3. Slonaker et al. 1923. Behavioral studies on female spayed rats. American Journal of Physiology 69:301-303.
4. Gorski, R. A. 1973. Steroid hormones in brain research: Progress in Brain Research 39:150-163.
5. Harris, G. W. 1964. The effects of estrogens on thyroid functions and behavior in rats. Endocrinology 75:627-634.
6. Stern, J. J., and Murphy, M. 1971. The effects of cyproterone acetate and testosterone proprionate on the spontaneous activity and seminal vesicle weight of male rats. Journal of Endocrinology 50:441-443.
7. Wang, G. H., Richter, C. P. and Guttmacher, A. F. 1925. Activity Studies on male castrated rats with ovarian transplants and correlation of the activity with the histology of the grafts. American Journal of Physiology 73:581-599.

Proceedings of the Pennsylvania Academy of Science 51:26—28. 1977.

MERCURY IN NORTH ATLANTIC LOBSTER OF THE NEW YORK BIGHT[1]

SALVATORE J. ALI, JR., MARY JANE BRADFORD and G. EARL PEACE

Departments of Biology and Chemistry
Lafayette College
Easton, PA 18042

ABSTRACT

This study confirms by thin-layer chromatography the presence of methylmercury in tissues of North Atlantic lobsters dredged from the dump site for industrial and municipal wastes and dredging spoils which lies near the entrance to New York Harbor. The study also compares amounts of total mercury in dump-site lobsters with that in tissues of control animals using a flameless atomic absorbtion method. Although all tissues of dump-site lobsters tested contained more mercury than tissues of control lobsters, only one sample out of twelve exceeded the U.S. maximum permissible level. Gill tissue showed higher mercury levels than tail muscle in dump-site specimens.

INTRODUCTION

Mercury enters the marine environment via several major pathways. Sewage in average municipal wastes may contain 120 milligrams of mercury compounds per kilogram. The Minamata Bay disaster of 1953-1960 in which a vinylchloride and acetaldehyde plant released methylmercury into Minamata Bay in levels up to 120 parts per million created the current interest in aquatic concentrations of mercury. The effects of consumption of mercury in seafood in Minamata were: death, impaired vision, loss of motor coordination and other neurological abnormalities. Hormonal and enzymatic disturbances were common. Because of Minamata, world governments established maximum permissible levels for seafood. The Unites States allows a maximum of 0.5 parts per million.

Investigators have found that various conditions affect mercury ingestion and concentration in seafood. Löforth (1969) indicates that older individuals exhibit greater mercurial concentrations than younger members of the same species. Differences in feeding habits account for wide variations in Hannerz' (1967) study of mercury in finfish. The North Atlantic lobster, a localized bottom-feeder, is present at the dump site in the New York Bight and should provide some insight into the effect of sustained high mercury concentrations on a local bottom feeder.

The dump site is located in the New York Bight near Ambrose Tower, 40°25′ N. latitude, 74°15′ W. longitude in twenty-three to twenty-seven meters of sea water (see Figure 1). This site receives up to six bargeloads of sewage sludge per day. 50% raw and 50% partially treated. The sludge beds are a chemically semi-contained system. Sludge, containing high mercury levels and methylating bacteria, produces both dimethylmercury and methylmercuric ions by bacterial action. The chemical mechanism for this biogenic conversion of methylmercuric ions and dimethylmercury involves vitamin B_{12}, hydrogen, adenosine tri-phosphate, and a "Factor 111" enzyme (Wood, 1968). Dimethylmercury is highly volatile and escapes from the water into the atmosphere while the methylmercuric ions attach themselves to living organisms by means of the sulphhydryl groups of skin enzymes.

[1]Received January 2, 1977, revised; accepted May 10, 1977.

MATERIALS, METHODS AND RESULTS

Lobsters were obtained from the dump site in the New York Bight through the Sandy Hook Marine Laboratory. Control specimens were caught on a clean sandy bottom (Figure 1). The presence of mercury as methylmercuric ion was confirmed by thin layer chromatography. Yamaguchi's method (Fishbein, 1970) was intially tried using benzene and petroleum ether 5:1 as the solvent system. However we failed to show any organic mercurials in lobster tissues by this method. Tatton and Wagstaffe's method (1969) was subsequently used. It is an adaptation of Westoo's extraction (Fishbein, 1970) using cellulose medium and a hexane-acetone 9:1 solvent system. A five-parts-per-million standard of dimethylmercury in benzene was treated with hydrochloric acid and extracted with benzene to provide a control. Our only alteration of Tatton and Wagstaffe's procedure was macro-application of

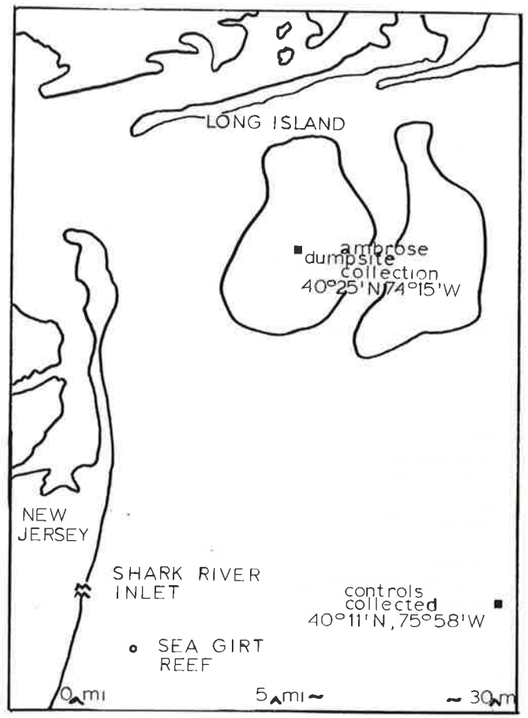


FIGURE 1

Map of the New York Dump Site Showing Collection Sites for "Dump site" Lobsters and Control Lobsters. (Note: the site of the control collection is not actually part of the New York Bight.)

methylmercury chloride as dithizonate, as opposed to micro-application, on the chromatogram sheets. Because of the highly volatile nature of the compound in benzene, repeated applications of methylmercury chloride as dithizonate at the starting point were futile. No discernible concentrations were found until a capillary pipette of larger capacity was used for application allowing a larger initial deposit of the sample on the cellulose immediately before placing it in the chamber plate apparatus. The pale pink spots had R_f values which compare favorably with the accepted R_f value for methyl mercury in this method. See Table 1 for the results of our chromatographic analyses of samples of lobster gill, tail and claw muscle taken from dump-site animals. Presence of methylmercury is indicated in all tissues.

Flameless atomic absorption spectroscopy was used to quantitate mercury levels in dump-site as compared with clean control specimens. The method selected necessitates a digestion of the sample, oxidation of all mercurials to the ionic form of mercury, and subsequent reduction back to the elemental state. The method is specific for total mercury and is taken from J. G. Gonzales (adapted from Ulthe) of the U. S. Environmental Protection Agency (1972). We used a Perkin Elmer Model 305 Atomic Absorption Spectrophotometer equipped with a mercury cathode lamp. The results for various lobster tissues analyzed at 2537Å, both experimental and control, are indicated in Table 2.

TABLE 1

Results of chromatographic analysis for methylmercuric ion in various tissues taken from dump site lobsters. The method is that of Tatton and Wagstaffe (1969). The methylmercury standard was run with each test.

	Sample	R_f Value
Lobster #1	gill	.74
Lobster #2	tail muscle	.67
	claw muscle (a)	.62
	claw muscle (b)	.61
Lobster #3	tail muscle	.67
	claw muscle (a)	.72
	claw muscle (b)	.71

Tatton and Wagstaffe Standard R_f = .64

DISCUSSION

As seen in Table 2, lobster specimens from the dump site exhibit mercury concentrations according to the following tissue order: gill > nervous > tail muscle > ovary. Stomach contents showed the lowest mercury concentration although they contained artifacts such as human hair, directly associated with sludge-bed feeding. The order of mercury concentration is different for the control specimens. Tail muscle has greater amounts than nervous sytem > gill > digestive tract. Typical gills from dump site specimens are dark and sediment-laden. Two additional gill samples were selected from dump site lobsters for their lighter coloration (numbers 6 & 7, Table 2). The results of tests on these cleaner dump site gills show mercury concentrations intermediate between those found in gills of clean control specimens and the very dirty dump site gills. All dump site specimens were noticeably smaller than controls. It is quite possible that the accumulation of mercury in the gill tissue is a purely physical phenomenon and does not involve chemical bonding. The data obtained in this study do not explain how the mercury accumulates nor what effect the accumulation has on gill function or on the physiology and growth of the lobster. Further studies are obviously necessary. Hannerz (1967) states that gills should have higher mercury concentrations than other tissue because of the lamellar structure and their salt-excretory function. The large amounts of sea water filtered through gills makes them a natural collection site.

The high value found for nervous tissue in the dump-site specimens is in agreement with previous investigations of seafood. Löforth (1969) states that in basic medium, methylmercuric ion has a lipophilic property similar to that observed for DDT. On the other hand, it should be noted that since the National Lead Company disposes of 49.5% of America's acid wastes in the New York Bight, one would hardly expect an alkaline pH in these waters. Further study of the effects of low pH media on methylmercuric ion localization are certainly suggested.

Although the average total mercury value for dump-site lobster tail muscle is slightly higher than that in the controls, it is not high with relation to the other dump-site lobster tissues. Assuming that the tail muscle mercury value of the controls represents background mercury level, there seems to be little localization of mercurials in tail muscle at the dump site.

TABLE 2

Results of flameless atomic absorbtion tests for total mercury in various lobster tissues using a Perkin Elmer 305 Spectrophotometer with a mercury cathode lamp. Results are given in parts per million.

DUMP SITE LOBSTERS			CONTROL LOBSTERS		
	Tissue	PPM		Tissue	PPM
*Lobster #1	gill	.52	Lobster 1c	gill	.15
*Lobster #2	gill	.20		gill	.09
	nervous	.24	Lobster 2c	gill	.07
	tail muscle	.15		gill	.07
*Lobster #3	tail muscle	.21	Lobster 3c	gill	.08
	tail muscle	.11		gill	.08
**Lobster #4	tail muscle	.19	Lobster 4c	gill	.06
	tail muscle	.16		tail muscle	.15
**Lobster #5	tail muscle	.18	Lobster 5c	nervous	.10
	tail muscle	.19		digestive	.07
	ovary	.14			
	stomach contents	.08			
**Lobster #6	gill	.15			
**Lobster #7	gill	.10			

*Lobsters 1, 2, and 3 are tissues from the same three animals reported in Table 1 (chromatographic analysis).

**Lobsters 4, 5, 6 and 7 are additional dump site lobsters. Of these, numbers 6 and 7 had lighter colored gills than any of the other dump site specimens.

To summarize, although dump-site lobster tissues generally showed higher mercury concentrations than corresponding tissues from control lobsters, in this study only one dump-site specimen (a gill sample) exceeded the U.S. government maximum of 0.5 parts per million.

ACKNOWLEDGEMENT

Thanks to Dr. J. Pearce and his staff at Sandy Hook Marine Laboratory, Highlands, N.J. for the dump site specimens and technical assistance rendered. Thanks also to Dr. A. J. Barnard and Dr. J. Brooks of J. T. Baker Chemical Company for advice and encouragement.

LITERATURE CITED

Fishbein, Lawrence. 1970. Chromatographic and Biological Aspects of Organomercurials. *Chromatographic Reviews* XIII:83-112.

Hannerz, Lennart. 1967. *Experimental Investigation on the Accumulation of Mercury in Water Organisms.* Drottningholm, Sweden, National Nature Conservancy Board.

Löfroth, Goran. 1969. *Methylmercury: A Review of Health Hazards and Side Effects Associated with the Emission of Mercury. Compounds into Natural Systems.* Stockholm, Swedish National Science Research Council, Working Group on Environmental Toxicology.

Tatton, J.O.G. and P.J. Wagstaffe. 1969. Identification and Determination of Organomercurials Fungicide Residues by Thin Layer and Gas Chromatography. *J. Chromatography* 44:284-289.

U.S. Environmental Protection Agency. 1972. *Detection of Mercury Compounds.* EPA Course Manual, pp. 11-15.

Proceedings of the Pennsylvania Academy of Science 51:29—31. 1977.

A SIMPLE CULTURE TECHNIQUE FOR EQUISETUM HYEMALE THROUGH THE ENTIRE LIFE CYCLE[1]

FRANK M. HOFFMAN[2]

Department of Biology
Slippery Rock State College
Slippery Rock, PA 16057

ABSTRACT

Sterile spores of *Equisetum hyemale* L. were obtained from surface sterilized strobili and sown in petri dishes on solidified Bold's Basal Medium supplemented with micronutrient solution plus 20 mg/liter silicon. Germination occurred within two days.

After six weeks, cultures were flooded with distilled water to promote fertilization. Sporophyte initiation occurred within three weeks, at which time they were transferred to one liter erlenmeyer flasks. Sporophyte initiation and subsequent development continued when kept at 800 ft-c at room temperature. Strobili containing viable spores were produced in culture flasks which contained the original gametophyte, the sporophyte, plus the new gametophyte generation. Cultures can be maintained one to two years by adding some liquid medium to prevent desiccation.

INTRODUCTION

The class Sphenopsida is one of the most primitive of the vascular plants, containing the genus *Equisetum* L. as the sole living representative (5). Members of this genus are commonly recognized as the scouring rushes and the horsetails. *Equisetum hyemale* L. (5) represents one of the scouring rushes and is found throughout this area. This species is routinely used in botany as an example of the genus. The anatomy and morphology of *Equisetum* spp. may be found in any number of morphology texts (2, 3, 4).

The use of live material in the botany laboratory is highly preferable to preserved material. A unit involving a survey of the plant kingdom often tends to leave a lot to be desired as far as student interest. The life cycles of many groups of vascular plants are studied in detail. However, when it comes to observations of the various stages of the life cycles, the sporophyte is the only one available. Live fern gametophytes are often provided, otherwise the gametophytic generation is either not available or available only as preserved specimens or slides.

Gametophytes of *Equisetum*, being rather small and difficult to find in nature, may be cultured fairly easily in the laboratory. The spores have a very short viability once they are shed from the strobili (10). They can be collected from mature cones following surface sterilization and then placed into aseptic culture (7, 8, 9). This paper describes the culture techniques that can be used to provide live material demonstrating all of the stages in the life cycle of *Equisetum*. This provides the botany student with excellent study material, enabling him/her to observe alternation of generations and all aspects of the life history of *Equisetum*.

MATERIALS AND METHODS

The majority of the strobili of *E. hyemale* are mature in late summer; however, a few cones may be mature at anytime throughout the growing season. Mature strobili were picked just prior to their opening.

The sterilization technique was basically that of Hauke (6). The strobili were washed for 15 minutes in a flask containing autoclaved 50% Clorox solution to which 1 drop of Tween 20 was added. By using sterile techniques, the strobili were transferred to beakers containing sterile distilled water to rinse off the Clorox solution. They were washed three times. The strobili were then transferred to a sterile petri dish containing a few ml of sterile nutrient solution. A sterile scalpel was used to cut the strobili open, thus releasing the spores into the solution. The spores were then transferred via a sterile pipet to the culture plates, using approximately two-three ml of the suspension.

Culturing was accomplished on full strength Bold's Basal Medium (1) fortified with a standard micronutrient solution. To each liter of culture medium sodium metasilicate was added so that the silicon concentration was 20 mg/liter. Finally, the nutrient medium was solidified by adding 15 g of Bacto agar per liter of solution. After autoclaving, the medium was dispensed into petri dishes.

The inoculated plates were placed into a Sherer-Gillette environmental chamber which provided a 12-12 photoperiod with a night time temperature of 18 ± 1°C, a day time temperature of 23 ± 1°C, and a light intensity of 100 ft-c. Subculturing was necessary after two or three days if the plates showed any contamination. Uncontaminated areas were located by observing the plates under a dissecting scope. Small portions of the agar containing the uncontaminated, germinating spores were transferred to new petri plates. Dozens of sterile plates were obtained, each containing several developing gametophytes.

Since gametophytes produce mature antheridia and archegonia within six to seven weeks (6), the surfaces of the plates were flooded with sterile distilled water in an attempt to insure fertilization. When sporophytes were observed two to three weeks later, they were transferred to liter erlenmeyer flasks containing 100 ml of the sterile solidified medium. The flasks were stoppered with cotton to allow gas exchange and placed into an environmental chamber with a light intensity of 800 ft-c. The development of the new sporophytes was observed over the next several months. Ten ml of the sterile nutrient solution was added to each flask weekly to prevent the agar from desiccation.

RESULTS

The inoculated plates were observed daily under a binocular dissecting scope. Within one to two days after inoculation, small colorless rhizoids were produced. A few days later, green three-dimensional gametophytes began to form. A typical gametophyte may be seen in Figure 1. This gametophyte was approximately 10 weeks old when it was transferred to the flask and photographed.

Developing sporophytes were observed two weeks after flooding the cultures with sterile distilled water (Figure 2). At this time they were transferred to the erlenmeyer flasks (Figure 1). The cultures developed slowly over the next several months. New sporophytes were constantly initiated from the original gametophytes, with some producing over 100 sporophytes (Figure 3). Eventually strobili were

[1]Received April 18, 1977; revised; accepted August 6, 1977.
[2]Portions of this paper represent part of the thesis of F. M. H. submitted to the Pennsylvania State University, University Park, Pa., in partial fulfillment of the Ph.D. degree.

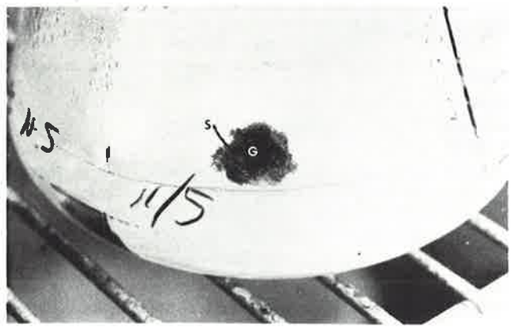


FIGURE 1. A typical gametophyte of *Equisetum hyemale* producing a young sporophyte. G = gametophyte; S = sporophyte.

FIGURE 2. Detail of young developing sporophyte of *Equisetum hyemale.* G = gametophyte; S = sporophyte.

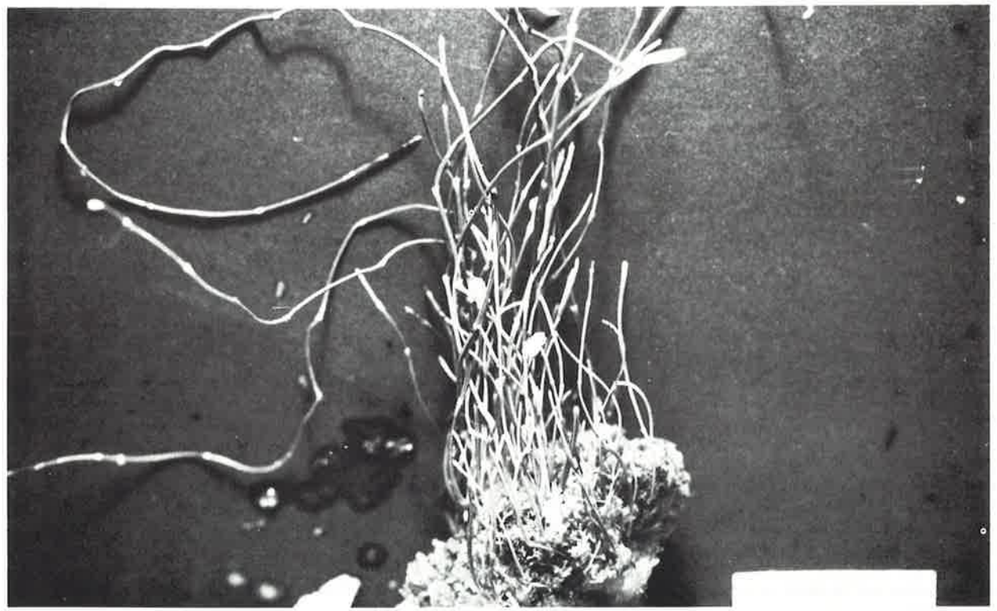


FIGURE 3. Mass of sporophytes of *Equisetum hyemale* produced from a 10-11 month old gametophyte culture.

produced in several cultures (Figures 4 and 5). The strobili developed slowly, and eventually a few matured and dehisced. The spores that were released from these strobili were viable as can be seen from Figures 6 and 7. New gametophytes began to develop from the spores. Thus, in one flask can be seen the original gametophytic generation, the sporophytic generation arising from it, and the new gametophytic generation.

DISCUSSION

Equisetum hyemale is an excellent organism, cultured under aseptic conditions, to show all stages of a life cycle. One may observe the spores with their hygroscopic elaters, and within a few days after culturing, the filamentous rhizoids may be seen emerging from the spore. After several more days, the green three-dimensional gametophytes develop and continue to enlarge for several weeks. After five or six weeks, some of the short, upright branches of the gametophytes could be sectioned to observe the antheridia and archegonia.

After flooding the surfaces of the plates, one could observe the fluid at various intervals for the presence of the rather large multiflagellate sperms. The gametophytes will remain green and healthy for several months as long as the medium does not dry out. This can be prevented by adding a few ml of sterile distilled water to the surface of the agar every few days.

Once sporophytes have been initiated, the gametophyte along with its sporophyte, must be transferred to flasks to allow room for the sporophytes to develop. It is better to allow the gametophytes to develop initially in petri dishes to insure no possible contamination. The cultures in the flasks will last for months if 10 ml of the nutrient

FIGURE 4. *Equisetum hyemale* strobili produced by a 12-month old culture. S = strobilus.

FIGURE 5. Strobili of *Equisetum hyemale* produced by a 12-month old culture. Detail. S = strobilus.

FIGURE 6. Twelve-month old culture of *Equisetum hyemale* showing three generations in the life cycle of the organism. G_1 = first generation gametophyte; G_2 = second generation gametophyte; S = sporophyte.

medium is added approximately once a week. After one year in the flasks the medium still had shown no signs of desiccation. The older cultures show the gametophyte plus a variety of stages in the development of the sporophyte. Some odd growth forms may occur if the sporophytes become too tall and too crowded for the flask.

If strobili are produced that yield viable spores, then they will be shed and new gametophytes will form in the same flask. This provides a very nice demonstration for study in the botany laboratory — three generations are present in the same container.

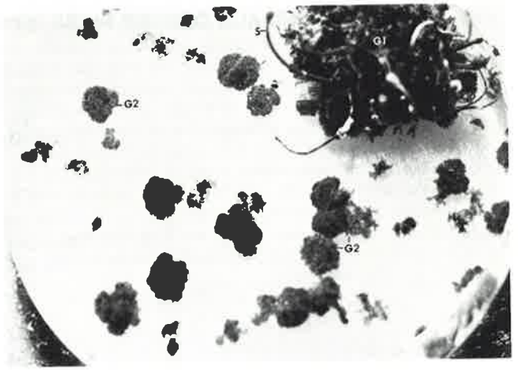


FIGURE 7. Twelve-month old culture of *Equisetum hyemale* showing three generations in the life cycle of the organism. Detail G_1 = first generation gametophyte: G_2 = second generation gametophyte: S = sporophyte.

The older cultures provide excellent material for students to use for other studies, if desired. The stems, strobili, roots, and gametophytes are easy to embed in paraffin and section for anatomical studies. Since these plants can be kept in culture for such a long period of time, one is assured of having plenty of plant material without having to spend a great deal of additional time after the initial culture preparation.

ACKNOWLEDGEMENTS

The author is indebted to Dr. C. J. Hillson, Professor of Botany, The Pennsylvania State University, for his advice and encouragement throughout this study.

REFERENCES

1. Bold, H.C. 1957. *Morphology of Plants.* Harper and Brothers, Publishers, New York.
2. Bold, H.C. 1973. *Morphology of Plants.* Third Ed. Harper and Row Publishers, Inc., New York.
3. Eames, J. 1936. *Morphology of Vascular Plants. Lower Groups.* McGraw-Hill Book Co., New York.
4. Foster, A.S. and E.M. Gifford, Jr. 1974. *Comparative Morphology of Vascular Plants.* Second Ed. W.H. Freeman and Co., San Francisco.
5. Hauke, R.L. 1963. A Taxonomic Monograph of the Genus *Equisetum* Subgenus *Hippochaete.* Beih. Nova Hedwigia, Heft 8. Verlag Von J. Cramer, Weinheim, Germany.
6. Hauke, R.L. 1969. Gametophyte development in Latin American horsetails. Bull. Torrey Bot. Club 96: 568-577.
7. Hurel-Py, G. 1949. Sur la culture aseptique des prothalles de quelques *Equisetum.* Compt. Rend. Soc. Biol. 143: 149-151.
8. Hurel-Py, G. 1949. La culture indéfine des prothalles d'*Equisetum.* Compt. Rend. Soc. Biol. 143: 1501-1502.
9. Slade, B.F. 1964. Gametophytes of *Equisetum fluviatile* L. in agar culture. Phytomorphology 14: 315-319.
10. Wollersheim, M. 1957. Entwicklungphysiologische Untersuchungen der Prothallien von *Equisetum arvense* und *Equisetum limosum* mit besonder Berüchsichtigung der Frage nach der Geschlechtsbestimmung. Zeit. Bot. 45: 245-261.

Proceedings of the Pennsylvania Academy of Science 51:32—34. 1977.

FIELD OBSERVATIONS INCLUDING ACOUSTIC BEHAVIOR OF THE BLACK-DIGGER WASP, SPHEX PENNSYLVANICUS (LINN.)[1]

LOUIS RIGLEY

Biology Department
Wilkes College
Wilkes-Barre, PA 18703

and

HERBERT HAYS

Biology Department
Shippensburg State College
Shippensburg, PA 17257

ABSTRACT

The black digger wasp *Sphex pennsylvanicus* was observed digging horizontal nesting tunnels in a vertical bank along the Port Tobacco River, Port Tobacco, Maryland. The nesting sites were used for at least three consecutive years. The tunnels were situated in small groups and as the tunnels were cleaned out, the exoskeletons from last years larvae were removed with the dirt. While digging the tunnels, the female wasps produced sounds which appeared to prevent other wasps from entering the active tunnels. An experiment using a play-back of wasp sounds reduced the tendency of other female wasps to enter the tunnels. The female wasps captured Katydids, *Microcentrum retinerve* to provide food for the larvae. The tunnel entrances were then sealed with fine grains of sand placed in a complex of fine silk web.

INTRODUCTION

The black digger wasp *Sphex pennsylvanicia* is widely distributed over the United States, especially in the northeast coastal area (1). Frisch (2) reported the life-history of *Ammobia pennsylvanicia*, describing the annual cycle, nesting behavior, prey capture, and reproduction. Rau (3) described the nesting habits of *Chlorion pennsylvanicum*. A review of the classification of *Sphex pennsylvanicus* was reported by Boghart and Menke (1).

There are few reports of acoustic communication by wasps in the literature. Schaudinischky and Ishay (4) reported a hunger signal by fourth and fifth instar larvae in hornet colonies. Ishay and Schwartz (5) studied the sound frequencies of *Vespo crabo* and *V. orientalis* and concluded that the sounds were species specific. Evans (6) described acoustic communication among several species of wasps when threatened. The threatened wasp produced sound reported to stimulate the remaining wasps in the nest into defensive behavior.

METHODS

A colony of the black digger wasp *Sphex pennsylvanicus* inhabited the eastern bank of the Port Tobacco River at Port Tobacco, Maryland. The bank was composed of sany loam and the experimental site reported here was 20m long and 5m high. Observations were made from the waters edge along the bank.

During the observation period, wasps were marked for identification purposes. A small dot of acrylic paint was placed on the abdomen of the female wasps as they backed out of the tunnels. Male wasps were marked by first capturing them in an insect net and touching them with a small paint brush.

[1]Received April 27, 1977; revised; accepted August 12, 1977.

As the female wasps produced sounds, they were recorded on a Sony 800 TC tape recorder and analyzed on a Key Sona-Graph Mod. 6061A with the analyzing filter band set at 300 Hz.

RESULTS AND OBSERVATIONS

The wasps had dug horizontal tunnels into the vertical bank and left and returned to the site along the same path. When leaving, the females frequently flew in a large circle, 5-15m in diameter, from one to six times and then followed the bank downstream. At the end of the site they turned about 90° east over open fields. Activity was first observed in the latter part of July and lasted through August.

In the first year approximately 75 tunnels were visable, 50 tunnels in the second year, and only 10 tunnels in the third summer. The change in population was apparently due to storm activity washing away part of the bank destroying the nesting site. The tunnels were dug in small groups of four to six per group with the groups 0.5 to 2.0m apart. A few single tunnels were randomly spaced throughout the groups. A mean tunnel diameter of 1.8cm was determined from a sample of 25 tunnels.

Only females were involved in digging the tunnels and capturing food. The old tunnels were used for at least three consecutive years. As the old tunnels were cleaned out, the exoskeletons from the food supply of larvae from the previous year were removed with the dirt. As the female dug, the dirt was rolled into a ball about 12mm in diameter and pushed backward out of the hole. The anterior and middle legs were used to push the dirt ball out. When the female left the area, she backed out of the hole, paused for several seconds on the bank, and departed. The digging continued from 0700 to 2100 hours. The most active digging and provisioning times of the colony were from 1100 hours to 1800 hours.

The females used the same group of holes most of the time. Ten females were marked on the abdomen with a small dot of acrylic paint. The marked females returned to the same group of holes about 95% of the time. Occasionally a non-marked female would enter the holes of the marked females.

The females captured only Katydids, *Microcentrum retinerve*, to provide food for the larvae. The females carried the prey head first and slung under their abdomen and thorax, supported primarily by the middle legs. When the female returned with prey, she entered the site from over the water at a 90° angle to the bank. When arriving without prey the female flew straight in and landed at the hole. When prey was being carried, the female flew in about 25cm above the hole, and during the last 15 cm of the approach dropped down to the hole. Females that did not compensate for the extra weight landed below the hole and then climbed up the bank, dragging the prey with them. If the prey was dropped following a collision with the bank or during climbing, it was never picked up and the female would leave.

During the digging and the egg-laying process the females produced a loud buzzing sound that could be heard 10m from the hole (Fig. 1).

Sound production started off slowly during the digging period and reached its peak during the period when females were capturing prey. Late in July a few individuals could be heard producing sounds, and by August the majority of individuals were producing sound.

The buzzing sound produced by the female wasp usually began slowly, built up to a peak and then slowed down. The duration of the sound was highly variable and lasted from a few seconds to about thirty minutes. Each sound was composed of tone bursts which had a mean duration of 100msec as measured at 1 kHz. The tone bursts ranged in duration from about 25msec to 200msec. The tone burst was composed of short duration pulses of about 5msec. The mean intertone burst time was about 100msec and ranged from 60msec to 150msec. The method of sound production was not determined.

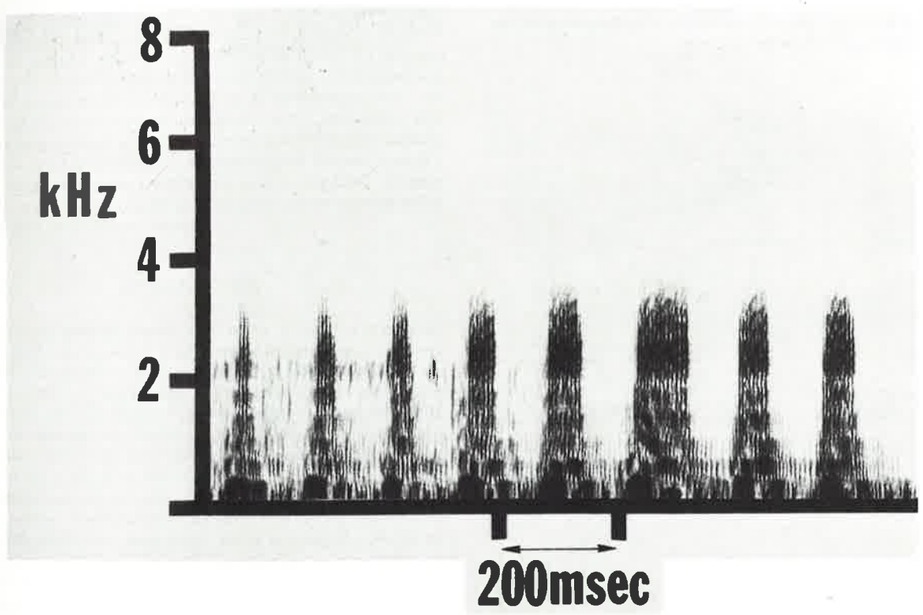


FIGURE 1. Sonagram of buzzing sound of female *Sphex pennsylvanicus*. The analyzing filter band was 300 Hz.

Observations suggested that females did not enter a hole if sound was being produced in the hole. Seven females were seen to approach and leave the entrance as the wasp in the hole made sounds. Only one female was seen to enter. To test this hypothesis, buzzing sounds were recorded and played back. Playback of a continuous buzzing sound was presented to 15 marked wasps as they entered their respective burrows. A small earphone speaker was placed 5cm into the tunnel. As the wasp approached the hole, the sound was turned on. Out of 15 attempts, the female left the hole 10 times. A control sound was recorded by holding a microphone up in the air and recording wind and wave sounds at the site. Eight females entered the burrow while two approached and fled during control playback.

Three male wasps were observed in the area for about a week during the latter part of July, prior to the beginning of the prey collection by the females. The males were about ¼ the size of the females. The males were also marked with identifying acrylic paint.

There appeared to be a dominance order among the three males at the site. The dominant male positioned himself on a small bush at the top of the bank with the other two males remaining farther from the females. The dominant male was observed on five occasions to chase other males when they entered the site area. The dominant male would approach the intruding male and fly in close approximation to him, within 2-3cm. If the intruder did not leave, the resident male attached himself to the intruder and they would fall to the ground. These bouts lasted from 10sec to 1 minute.

The resident male was observed to solicit females at the tunnel entrance. He would fly to the entrance of the hole and flick his wings back and forth. It could not be determined if sounds were being produced at this time. The male would inspect the hole entrance and enter for about half of his body length. However, he never completely entered the tunnel. If no female appeared, the male would move to another hole after 15-30 sec. If no females appeared after 6-8 holes, he would fly back to the bush or leave the area.

When a female appeared at the hole and flew away, the male immediately pursued her, about 15 cm behind her. About 5m high and 8m from the site the male joined to the female and the two would fly away from the site together. The male returned after a 2-5 minute period.

During the latter part of August the holes were sealed. What appeared to be a fine silk strand acted as a support for fine grains of sand. The plug covered the hole entrance, and was 5mm thick. When closed, the holes were not visible to the observer. It was not determined if the fine threads were produced by the wasps or by spiders living on the side of the bank.

DISCUSSION

The observations of this colony of wasps were unique in several ways. Digger wasps do not usually dig horizontal tunnels in vertical banks or use the same tunnels for two or three years. While the tunnel digging behavior by most wasps was probably similar, mandibles removing the dirt particles, the removal of the dirt from the entrance

was quite different. Wasps normally throw the dirt away from the entrance with the hind legs. However, this population simply backs out of the hole and lets the dirt fall to the ground. Since most insect behavior is highly genetically controlled, one would expect these wasps to make some sort of throwing motion with the hind legs, but none was observed.

The sounds produced by the wasps were typical stridulatory sounds similar to those produced by other wasps and probably a result of mandibles removing dirt (personal observations of mud-dabber wasps). It is interesting that the sounds produced by a semi-solitary wasp are used to keep intruders from entering active tunnels.

At the end of the reproductive season the tunnels were sealed. The seal consisted of fine sand grains supported by a thin fine web material. The tunnel openings were not visible to the observer after they were sealed. This is very interesting because other wasps simply fill the tunnel entrance with dirt and pack it down to form a plug. It is not known if the wasps spin web material or if spiders living on the bank edge might spin webs in the entrances.

LITERATURE CITED

1. Boghart, R.M. and A.A. Menke. 1963. A reclassification of the Sphecinae. U. of Calif. Entomol. 30(2): 91-182.
2. Frisch, S.J. 1938. The Life History of the Digger Wasp *Ammobia pennsylvanicia* (Linn.). Amer. Midland Natur. 19: 673-677.
3. Rau, P. 1944. The Nesting Habits of *Chlorion pennsylvanicum*. Ann. Ent. Soc. Amer. 33: 590-595.
4. Schaudinischky, L. and Ishay. 1968. On the Nature of the Sounds Produced Within the Nest of the Oriental Hornet *Vespa orientalis*. F. (Hymenoptera). J. Acoust. Soc. Am. 44: 1290-1301.
5. Ishay, J. and A. Schwartz. 1971. Acoustical Communication Between the Members of the Colony of the Oriental Hornet (*Vespa orientalis* Hymenoptera). 7th Int. Congr. Acoustics, Budapest.
6. Evans, E.E. and M.J. West Eberhard. 1970. "The Wasps." Ann Arbor Science Paperbacks, 1-265.

Proceedings of the Pennsylvania Academy of Science 51:35—39. 1977.

A HISTOLOGICAL STUDY OF THE SHORT TERM EFFECTS OF ANTHOPHYLLITE FIBERS ON GUINEA PIG LUNGS[1]

STEPHAN R. SANKO[2] and ALLAN F. WOLFE

Department of Biology
Lebanon Valley College
Annville, PA 17003

ABSTRACT

The early effects of anthophyllite asbestos fibers on mature guinea pig lungs were studied histologically to ascertain the role of the fibers as an air pollutant. Animals were exposed to the fibers for 1 or 2 days with recovery times ranging from 1 hour to 112 days. The predominant staining technique in this experiment was Perl's method for ferric iron because asbestos causes a considerable increase in intracellular iron within the lungs of exposed organisms. The concentration of intracellular iron within the lung phagocytes of experimental animals showed a definite progressive pattern at the light microscope level. Asbestos bodies were observed in the lungs of all experimental animals with a recovery time of 62 days or longer.

INTRODUCTION

For efficient gaseous exchange to occur within the respiratory system it is imperative that foreign material be removed quickly and thoroughly. Large fibers and particles are cleared early from the tracheobronchial tree by a "sol-gel" mechanism (1). Asbestos fibers that penetrate into the alveolar region are removed by the phagocytic activity of alveolar macrophages, interstitial macrophages, and differentiated epithelial cells. These phagocytes often aggregate on the longer fibers forming giant cells (2,3,4).

The fibers that are not cleared from the lung often develop into asbestos bodies. The bodies have an inner acid mucopolysaccharide layer which may induce phagocytosis and is probably responsible for the adhesion of iron to the fibers (3,5,6,). Various investigators have suggested that the source of iron for the body coat originates from intracellular hemosiderin formation or pinocytosis of degraded hemoglobin (3,7,8,). The latter source results from erythrocytosis and transportation of iron by transferrin. The iron coating progresses from a smooth to a beaded texture preceeding fragmentation. It should be emphasized that asbestos bodies are not solely the result of fibers remaining in the lung for long periods of time, but are the result of an active intracellular process (9).

The two major respiratory diseases related to asbestos exposure are asbestosis and lung cancer (Figure 1). Depending on the specific site of fibroblast deposition, asbestosis is termed interstitial or intraalveolar fibrosis (10,11,12,13,14). Such proliferation of fibroblasts causes the lung to become more rigid and eventually to apper as a honeycombed structure (15). The incidence of lung cancer, in particular mesothelioma, after a 30 to 40 year latent period has been shown to increase after exposure to asbestos (16,17,18). Recent evidence that asbestos fibers may pass from one body cavity to another, as well as across the placenta, suggests the possibility that the fibers are harmful to various organs (15,19).

Asbestos fibers exist in four common forms: amosite, chrysotile, crocidolite, and anthophyllite; whose structural and chemical compositions vary slightly (7,15). Although chrysotile and crocidolite are the most

[1]Revised; accepted August 8, 1977.
[2]Present Address: Temple University School of Medicine, Philadelphia, Pa. 19140.

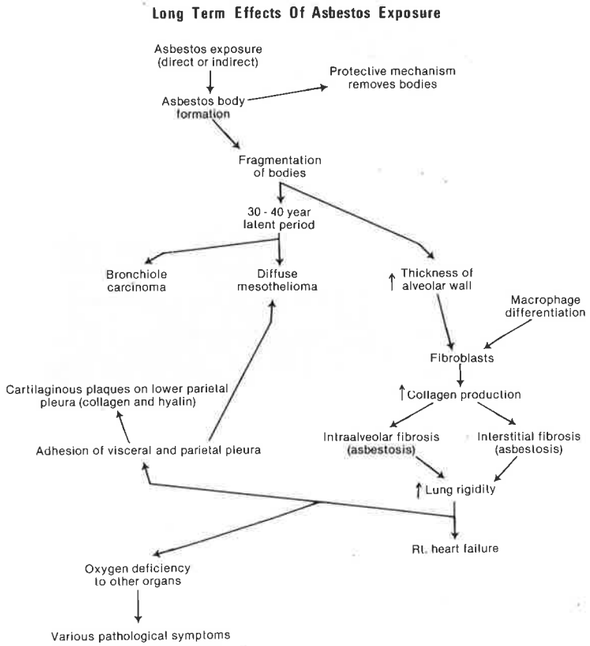


FIGURE 1. The long term effects of asbestos exposure are summarized in this flow diagram. The two primary types of respiratory diseases resulting from such exposure are asbestosis and lung cancer.

commonly usd commercial fibers, anthophyllite fibers induce the formation of asbestos bodies most rapidly and they do not cause mesotheliomas (7,15). Therefore, anthophyllite fibers were chosen as the safest and most expedient method to study the short term effects of asbestos fibers.

The impetus for this research was provided by the increased concern with air pollutants, especially asbestos fibers, as a health problem. Although pathological conditions are not usually evident during short term exposure to asbestos fibers, it was thought that a study of the early histological changes might lead to a better understanding of the long term effects.

MATERIALS AND METHODS

Fifteen mature guinea pigs were exposed to an atmosphere containing anthophyllite fibers for approximately 24 or 48 hours; the exact times of exposure and recovery are shown in Table 1. Two control animals

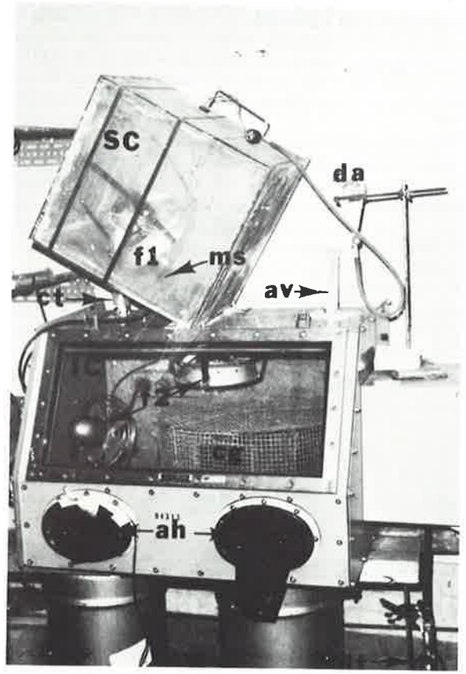


FIGURE 2. The suspension chamber (SC) contained a fan (FI), had a magnetic stirrer located beneath the floor at (MS) and opened into a dehumidifying apparatus (DA). A connecting tube (CT) joined the suspension chamber to the inhalation chamber (IC), which housed two fans (F2) and the cages (CG). Opening into the inhalation chamber were two arm holes (AH), a dust trap (DT), and an air ventilator (AV). X 1/20.

TABLE 1

Results of Perl's stain for ferric iron and for asbestos bodies.

Animal	Exp.	Rec.	Perl's Reaction	Asbestos Bodies
1	22 hrs	1 hr	+	–
2	25 hrs	25 hrs	–	–
3	24 hrs	2 da	–	–
4	24 hrs	5 da	+	–
5	24 hrs	17 da	+	–
6	24 hrs	62 da	++++	+
7	24 hrs	85 da	+++++	+
8	24 hrs	112 da	+++++	+
9	50 hrs	2 da	+	–
10	50 hrs	5 da	++	–
11	50 hrs	10 da	–	–
12	48 hrs	17 da	+++	–
13	48 hrs	41 da	++++	–
14	48 hrs	64 da	+++	+
15	48 hrs	97 da	+++++	+
1C			–	–
2C			–	–

Exp. = Exposure time to anthophyllite
Rec. = Recovery time after inhalation
C = Controls not exposed to anthophyllite
+ = observable positive reaction
– = negative reaction

were not exposed to the fibers or the experimental room in which the inhalation chamber was located.

A plexiglass suspension chamber, containing three openings, was designed to saturate the air with asbestos fibers (Figure 2). The fibers were introduced into the chamber through one opening and dehumidified air was forced through a second one, while the third opening transferred the asbestos-saturated air into the inhalation chamber. The fibers were suspended with the aid of a magnetic stirrer and three fans. The experimental guinea pigs were placed in one of the five triangularly-shaped cages, which rotated within the inhalation chamber at 45 turns/hr. As each animal was removed from the chamber, it was vacuumed to prevent the transfer of fibers among animals.

After the guinea pigs were exposed to the asbestos, they were taken from the inhalation chamber and sacrified at various time intervals (Table 1). The animals were anesthetized with a 1% sodium nembutal solution at a dosage of 35 mg/kg. A mid-ventral incision was made to expose the trachea which was ligated before decapitation to prevent blood from entering the lung. After both lungs were removed and rinsed in Ringer's solution, the upper left lobe was fixed in glutaraldehyde for 24 hours (20) and then placed in a phosphate-buffered 0.2M sucrose solution (ph 7.4). The remaining lobes were attached at the trachea to a hypodermic needle, placed in a bell jar under vacuum, and perfused with neutral buffered formalin for 24 hours.

The upper left lobe was frozen in Cryoform and sectioned at 16 μm on a cryostat. The sections were stained for acid phosphatase using the Naphthol AS-TR Phosphate mehod (21). The lower left lobe, fixed in buffered formalin, ws dehydrated in a graded series of ethanol, cleared in toluene, embedded in Tissuemat, and sectioned at 10 μm. For general orientation Mayer's hematoxylin and eosin (H and E) ws used, while the Modified Van Gieson technique was used to demonstrate the presence of hemoglobin and collagen (21). The periodic acid Schiff-Alcian blue (PAS/AB) method, one with AB at pH 2.5 and one at pH 0.4, was used to stain mucopolysaccharides. Both ferric and ferrous iron were demonstrated by Hukill-Putt and Lillie's methods. Perl's method, which was specific for ferric iron, was used as a primary staining procedure throughout the experiment (22). The slides were examined with an American Optical photomicroscope and photographed on Kodak CPS 135 professional film.

RESULTS

The concentration of intracellular iron within the guinea pig lungs exhibited a progressive pattern as the recovery time increased (Table 1). In those animals whose recovery times exceeded 17 days, considerable deposits of iron were demonstrable. In fact, it was difficult to locate an area within those animals whose recovery times were 97 and 112 days that did not contain iron-positive material within any field of view. No intracellular iron was observed in the sections of lungs from three experimental animals, while four other animals exhibited only minimal amounts of iron.

The cytoplasmic Perl's positive material in the alveolar septal and epithelial cells was usually granular. These granules were located within a non-granular matrix of positive material. Occasionally within this positive mass, there was a central region which was stained darker (Figure 3). The nucleus of these iron-containing cells was often pushed to one side of the cell, while the positive granules occupied the cytoplasmic area at the opposite side.

Primitive and maturing asbestos bodies were observed within sections from 5 animals. There was much variability in the structure of these bodies. They consisted of a central core of dense material with an agranular peripheral zone of Perl's positive material. Some extracellular bodies had a characteristic head and tail although there was much structural variability in the beading pattern. The distribution of the beads ranged from certain localized areas to the entire length of the body (Figures 4,5).

The modified Van Gieson stain for hemoglobin was used to demonstrate hemoglobin, collagen, and the debris within the airways. Very little hemoglobin was stained, so if hemolysis did occur, it was not readily

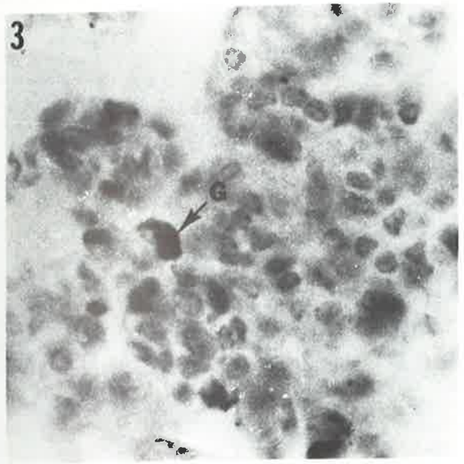


FIGURE 3. Intracellular Perl's reaction in the alveolar region of animal 14. Note the dark central granule (G) within the Perl's positive material. X 3000.

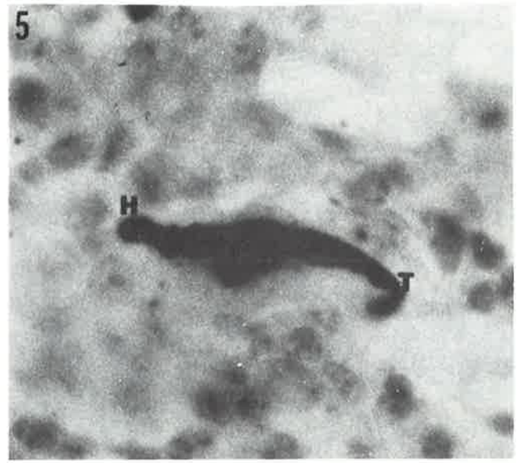


FIGURE 5. Perl's positive asbestos body with beading (B) extending along its entire length from head (H) to tail (T), animal 15. X 7000.

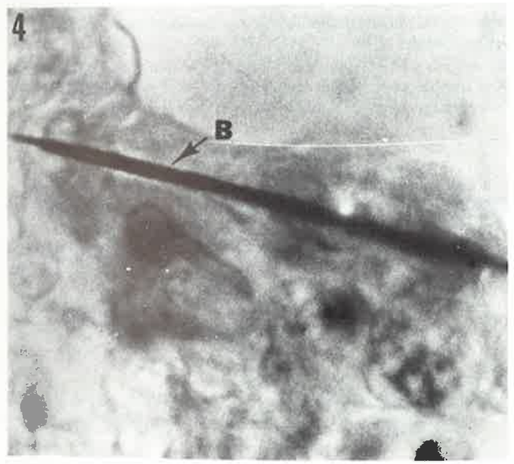


FIGURE 4. A long Perl's positive asbestos body (B) with no beading, animal 14. X 4500.

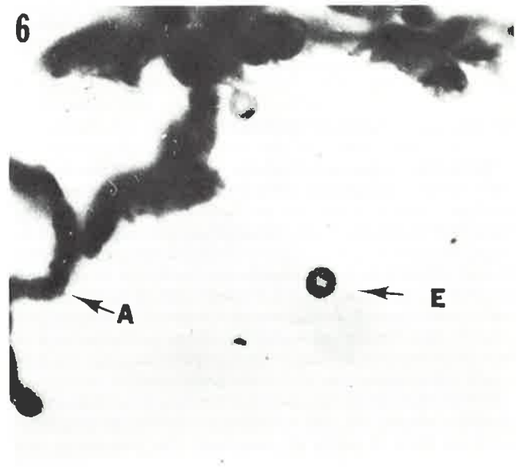


FIGURE 6. Erythrocytes (E) within the alveolar space (A) of animal 7. H and E. X 3700.

visible. Collagen stained strongly and although one or two of the sections of animals with longer recovery times may have shown primitive fibrosis, it was not extensive enough to permit one to draw the conclusion that it was caused by the asbestos. However, in several animals an increase in the thickness of the alveolar epithelium was noted. Erythrocytes were observed in the alveolar airways of all but two experimental animals (Figure 6). This phenomenon was most apparent in animals 1, 2, and 3, especially animal 2 which had a particularly isolated area containing the greatest concentration of erythrocytes seen throughout the experiment.

H and E, along with the Van Gieson technique, was excellent for observing acellular debris within airways. Although there were no obvious patterns to the distribution and quantity of debris, many interesting observations were made. There were considerable amounts of dust, fibers and other debris located within the alveolar region of all experimental animals. Mucous plugs were also observed in most experimental animals (Figure 7).

AB/PAS was used to study any changes in polysaccharides that occurred due to the anthophyllite intrusion into the lung tissue. The goblet cells were, of course, PAS positive and when there was acellular debris within the higher airways containing the goblet cells, a PAS and AB (pH 2.5) positive granular secretory material was observed in all experimental animals. This material, along with a more amorphous PAS positive material, was mixed with the debris. Although small amounts of AB (pH 2.5) positive material were observed within the debris, it was predominantly PAS positive material.

The napthol AS-TR phosphate method ws used to demonstrate acid phosphatase within the phagocytic cells of those animals whose recovery

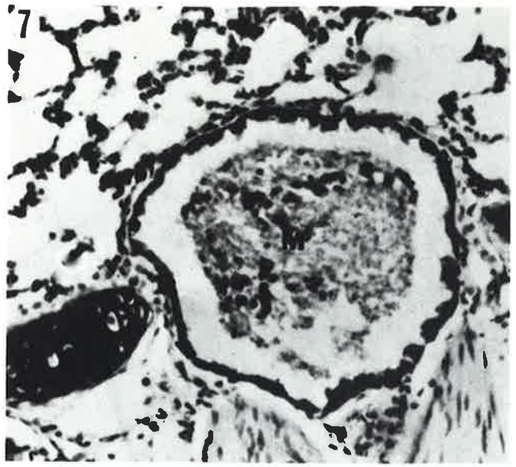


FIGURE 7. Mucous plug (M) containing Hukill-Putt positive iron within the debris of bronchiole of animal 3. X 370.

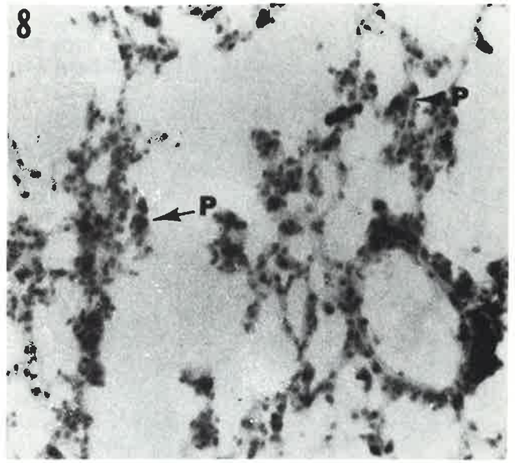


FIGURE 8. Phagocytes (P) within the alveolar region of animal 15. Naphthol AS-TR method. X 370.

times exceeded 62 days (Figure 8). Giant cells and other phagocytes were demonstrated within the alveolar region. It was noted that often a phagocytic cell was located within the epithelium along an alveolar duct, which positioned them ideally for phagocytosis of any debris.

DISCUSSION

The first two experimental animals were used to determine the initial effects of anthophyllite fibers on the lungs. These animals were sacrificed shortly after exposure and small amounts of intracellular iron were observed within the alveolar phagocytes of the animal with the one hour recovery period. This observation indicated the capability of rapid intracellular iron accumulation. Since it is thought that hemoglobin is the primary source of iron for asbestos body formation (2,3,7,), these observations suggested that phagocytosis of hemoglobin occurred almost immediately after stimulation by the presence of fibers. No free hemoglobin was demonstrated indicating that hemolysis must have been an entirely intracellular phenmenon.

No intracellular fibers were observed; therefore, it was impossible to determine whether the iron was located within those phagocytes containing fibers or within all phagocytes. The intracellular iron concentrations increased in those animals with a recovery time of 17 days to that of 112 days; however, a definite progressive pattern was not apparent for those animals with recovery times from 1 day to 10 days. The latter observation suggested that the effectiveness of the early clearance mechanisms varied considerably among animals as reported previously by other workers (1). More careful control on maintenance of a constant concentration of fibers in the atmosphere would be necessary prior to any conclusion on the effectiveness of these clearance mechanisms within each animal. Bronchial mucous, a constituent of the early clearance system, was secreted into and along the higher airways suggesting an attempt at removal of acellular debris from the lungs. Occasionally, the secretory material and the debris within it became concentrated enough to cause mucous plugs.

The localized increase in phagocytes suggested the possibility of debris pockets within the lungs. It would be advantageous to compare the concentration of phagocytes between animals with short recovery times and those that had longer recovery times. Presumably, there would be a sharp increase in the concentration of phagocytes, followed by a gradual decrease to normal levels of these cells as most of the extracellular debris was removed (3,12). Phagocytes are known to converge on fibers, attempt to digest them, and transform some into asbestos bodies (2,4).

In animals with longer recovery periods granular iron often clustered at a specific point within the cytoplasm of the cell resulting in a concentrated area of positive material within an amorphous iron

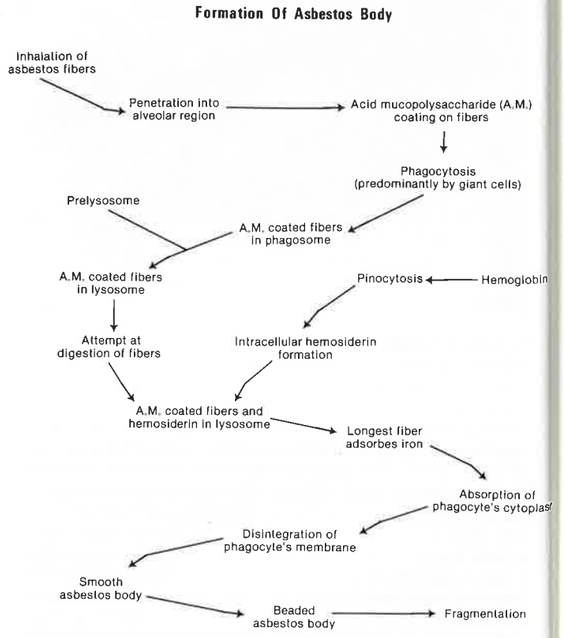


FIGURE 9. Short term effects of asbestos fibers culminating in the formation of asbestos bodies.

matrix. The fiber absorbs the iron and receives a smooth coating of iron which may later become beaded (9). If the intracellularly transformed hemosiderin originates as hemoglobin, an increase of intraalveolar erythrocytes should be observed and this was, in fact, demonstrated. Since the concentration of erythrocytes was not sufficient to suspect massive hemorrhage, it was concluded that the erythrocytes left the circulatory system by erythrocyte diapedesis (23). Although there was no direct evidence for this mechanism in the experiment, it seemed to be the most logical explanation for the source of iron.

By studying the structure of the asbestos bodies, which resulted after a relatively short recovery time, some conclusions were drawn about their formation. After the longest fiber within the phagocyte adsorbs iron and forms a body, it causes absorption of the phagocyte's cytoplasm and disintegration of its membrane (5,7,9). These phenomena caused the fiber to be released into the airways of the lung. It was easy to see that the iron coat, which blunted the fiber, had caused an increase in the surface area of the fiber thereby increasing the probability of irritation although it may have been less severe. Since the asbestos bodies had a characteristic head and tail, it was concluded that the ongoing process of its formation followed a definite pattern (Fig. 9). Normally, the beading of the bodies occurred as they matured in a progressive manner from head to tail. However, it was occasionally observed that some of the bodies had the beading along the central portion of the body and not at either end. The asbestos body with its central fiber core tended to form as a smooth structure and then progressed to a beaded structure (5).

Since the mature bodies are easily fragmented, these pieces of foreign material definitely increase irritation to the alveolar wall (12). This increase in particulate material within the lungs of the organism is reinforced by additional exposure to fibers from the environment. The sequence tends to have a "snowball effect" causing increased irritation which leads to asbestosis and mesothelioma after a thirty to forty year latency period (5,14,15,16,17).

ACKNOWLEDGEMENTS

We thank Harold Hartman for his assistance in the construction of the inhalation chambers and William McComsey and Dennis Enck for their assistance with the photography.

REFERENCES

1. Schlesinger, R. 1973.Mucociliary interactions in the tracheobronchial tree and environmental pollution. Bioscience 23:5767-572.
2. Suzuki, Y. and J. Churg. 1969 a. Structure and development of asbestos bodies. Am. J. of Path. 55:77-91.
3. Suzuki, Y. and J. Churg. 1969 b. Formation of asbestos bodies. Environmental Res. 3:107-118.
4. Suzuki, Y., J. Churg, and T. Ono. 1972. Phagocytic activity of the alveolar epithelial cells in pulmonary asbestosis. Am. J. of Path. 69:373-379.
5. Davis, J. M. G. 1970. Dust as a nucleation center in the calcification of old fibrous tissue lesions and the possible association of this process to the formation of asbestos bodies. Experiment. and Mol. Path. 12:133-147.
6. Governa, M. and C. Rosanda. 1971. A histochemical study of the asbestos body coating. Brit. J. of Indust. Med. 29:154-159.
7. Botham, S. K. and P. F. Holt. 1968. Mechanism of formation of asbestos bodies. J. Path. and Bacteriol. 96:443-453.
8. Macnab, G. and J. S. Harington. 1967. Hemolytic activity of asbestos and other mineral dusts. Nature 214:522-523.
9. Botham, S. K. and P. F. Holt. 1971. Chrysotile and crocidolite fibers in guinea pig lungs. J. of Path. 105:159-168.
10. Crafton, J. and A. Douglas. 1969. Respiratory disease. F. A. Davis Co., Philadelphia, Pa., 16-18, 48.
11. Greshan, G. A. and A. R. Jennings. 1961. An introduction to comparative pathology. Academic Press, New York, N.Y., 194.
12. Holt, P. F., J. Mills, and D. K. Young. 1965. Experimental asbestosis with four types of fibers. Ann. of N.Y. Acad. Sci. 132:87-97.
13. Kuhn, C. and T. T. Kuo. 1973. Cytoplasmic hyalin in asbestosis, a reaction of injured alveolar epithelium. Arch. of Path. 95:190-194.
14. Liebow, A. A. and D. E. Smith (eds.). 1968. The lung. Williams and Wilkins Co., Baltimore, Md., 100-106, 142, 290-296.
15. Muir, D. C. F. 1972. Clinical aspects of inhaled particles. F. A. Davis Co., Philadelphia, Pa., 84-126.
16. Deeley, T. J. (ed.). 1971. Carcinoma of the bronchus. Appleton-Century-Crofts, New York, N.Y., 33-44.
17. Selikoff, I. J., J. Churg, and E. C. Hammond. 1964. Asbestos exposure and neoplasia. J. of Am. Med. Assoc. 188:22-26.
18. Selikoff, I. J., J. Churg, and E. C. Hammond. 1965. Relation between exposure to asbestos and mesothelioma. New England J. of Med. 272:560-565.
19. Cunningham, H. N. and R. D. Pontefract. 1974. Placental transfer of asbestos. Nature 249:177-178.
20. Pease, D. C. (ed.). 1964. Histological techniques for electron microscopy, 2nd ed. Academic Press, New York, N.Y. 52-53.
21. Thompson, S. W. 1966. Histochemical and histopathological methods. Charles C. Thomas Co., Springfield, Ill., 593, 644, 1278.
22. Luna, L. G. 1968. Manual of histological staining methods, 3rd ed. McGraw-Hill Co., New York, N.Y., 37, 114, 162-164, 180-184.
23. Florey, L. 1970. General pathology, 4th ed. W. B. Saunders Co., Philadelphia, Pa., 77-78, 154-168.

Proceedings of the Pennsylvania Academy of Science 51:40—42. 1977.

A SEASONAL STUDY OF THE ECTOPARASITES OF SYLVILAGUS TRANSITIONALIS[1]

DAN M. HARMAN and JOSEPH A. CHAPMAN

Appalachian Environmental Laboratory
Center for Environmental & Estuarine Studies
University of Maryland, Frostburg State College Campus
Frostburg, Maryland 21532

ABSTRACT

New England cottontail rabbits were studied in collections made periodically throughout one year from one general locality in Tucker County, West Virginia. A total of four ectoparasitic species were identified. Three species, *Cecidopsylla simplex, Odontosyllus multispinosus,* and *Ixodes dentatus* were new ectoparasitic records for the New England cottontail.

INTRODUCTION

Although parasites of various species of *Sylvilagus* have been previously reported, relatively few have dealt with parasites of *Sylvilagus transitionalis* (Bangs), the New England cottontail. The known ectoparasites and internal parasites were listed by Chapman (1975). They include the internal parasites *Obeliscoides cuniculi, Passalurus ambiguus, Cittotaenia variabilis, Cysticercus pisiformis* and *Coccidia* sp. (*Eimeria* sp.) Dalke (1937, 1942), Erickson (1947) and Rankin (1946); the filarial nematode *Dirofilaria scapiceps,* Eabry (1968); the rabbit tick *Haemphysalis leporispalustris,* and the dog flea *Ctenocephalides canis* (Curtis) and botflies *Cuterebra* sp., Dalke (1937).

Previous studies of the parasites of *S. transitionalis* have consisted mainly of observational information on parasite forms found attacking *S. transitionalis* hosts. The present study expands the list of known parasites and provides seasonal and host data to complement numerical information on ectoparasite species.

METHODS AND MATERIALS

In the present study, New England cottontail rabbits were collected periodically throughout one year from one general locality in Tucker County, West Virginia. The present study was conducted as a secondary aspect of a major investigation on the New England cottontail and took advantage of rabbit specimens taken for other purposes. In the progress of the study, 51 *S. transitionalis* specimens were sampled for ectoparasites. Rabbits were collected by trapping or shooting. If shot, the rabbits were placed immediately into polyethylene bags, and a cotton wad soaked in chloroform was enclosed to kill the ectoparasites as they left the carcass. If trapped, the rabbits were taken to the laboratory, euthanized, and placed immediatley into polyethylene bags with chloroform included as previously described. All specimens in polyethylene bags were deep-frozen for an indefinite time, then removed from the freezer for further study. At this time the ectoparasites in the bags were picked out and shipped to specialists for identification.

Data on age, sex, body measurements and reproductive organs were recorded for each rabbit and utilized in the analysis of the ectoparasite data.

The data were subjected to an analysis of variance, in which ectoparasite numbers were tested against (1) month collected and (2) sex. The analysis used was a 2 x 8 factorial (2 sexes and 8 months). September data were omitted since observations were not present for both sexes. All parasite data were analyzed as $\sqrt{x}$ since group variances were not homogeneous. If the sex by month interaction or the month main effect was significant a Student-Newman-Keuls multiple range test was conducted to identify specific treatment differences. Regression analysis tested for a relationship between parasite numbers and body weight.

[1]Received March 12, 1977; revised; accepted June 20, 1977.

RESULTS

A total of four ectoparasitic species were collected in the present study. Three of the species, *Cecidopsylla simplex, Odontosyllus multispinosus,* and *Ixodes dentatus,* were new records, not having been reported previously for *S. transitionalis.* A list of all known ectoparasitic species, including those of the present study is included in Table 1. The tick, *Haemaphysalis leporispalustris,* was the only species recorded in the present study which previously had been reported from *S. transitionalis.*

Seasonal information was available for January through September, representing each season of the year. The period of October-December was not represented, however. Two species, *C. simplex* and *H. leporispalustris,* occurred in substantially greater frequencies (84.3% and 66.7% of the hosts, respectively) than the other two species, *O. multispinosus* and *I. dentatus* (7.8% and 13.7%, respectively). All four species collected in the present study are shown in Table 2.

TABLE 1

List of ectoparasite species known to attack the New England Cottontail, Sylvilagus transitionalis

Ectoparasitic Species	Reported in this study	Reported Previously [1]/
Insecta		
Order Siphonaptera Fleas		
Family Pulicidae		
Cediopsylla simplex (Baker)	X	
Ctenocephalides canis (Curtis)		X
Family Leptopsyllidae		
Odontosyllus multispinosus (Baker)	X	
Order Diptera		
Family Cuterebridae Botflies		
Cuterebra sp.		X
Arachnida		
Order Acarina		
Family Ixodidae Hard Ticks		
Haemaphysalis leporispalustris (Pack.)	X	X
Ixodes dentatus (Marx)	X	

[1]/ Previously reported from *S. transitionalis* by Dalke (1937), Chapman (1975).

TABLE 2

Seasonal abundance of ectoparasites of the New England cottontail for Jan. - Sept. 1974, including all animals sampled.

		Siphonaptera (Fleas)				Acarina (Ticks)			
		C. simplex		*O. multispinosus*		*H. leporispalustris*		*I. dentatus*	
Month Collected	n	$\bar{x}$	Coef. Var.*	$\bar{x}$	Coef. Var.	$\bar{x}$	Coef. Var.	$\bar{x}$	Coef. Var.
January	7	13.57	41.0	0.0	—	0.0	—	0.0	—
February	5	23.00	71.6	0.80	152.4	0.20	223.6	0.0	—
March	13	23.77	68.2	0.0	—	2.77	110.9	0.31	244.1
April	4	36.50	70.1	1.00	123.4	2.50	28.0	0.0	—
May	5	28.80	91.8	0.0	—	3.40	32.0	0.40	136.9
June	5	1.60	223.6	0.0	—	8.00	51.3	0.60	223.6
July	4	1.75	76.3	0.0	—	4.00	46.8	0.50	200.0
August	7	11.57	62.0	0.0	—	7.57	57.7	0.14	264.6
September	1	6.00	0.0	0.0	—	11.00	0.0	0.0	—
	51	17.86	79.9	0.08	318.9	3.61	92.6	0.24	259.4

* Coefficients of variation based on transformed data.

including their abundance for each month of the study. The fleas, particularly *C. simplex,* were present in each season, occurring in greater numbers per host in April than in any other month. The ticks, particularly *H. leporispalustris,* were more plentiful per host in June, and occurred very sparsely in winter. By the month of March, however, the rabbits collected were heavily infested with *H. leporispalustris.* For the entire study, *C. simplex* averaged 17.86 individuals per host, and *H. leporispalustris* 3.61 individuals per host. The other two ectoparasite species, *O. multispinosus* and *I. dentatus,* averaged fewer than one per host.

Frequency of ectoparasites was also determined for body weight classes, as shown in Table 3. Numbers per host of the flea, *C. simplex,* followed a generalized pattern of increase with increased body weight (class) of the host rabbits. However, no significant relationship was found when the transformed data were regressed on body weight.

A significant difference ($p < .05$) was found in the number of fleas between male and female rabbits (Table 3). Fleas per host on female rabbits exceeded the numbers per host on males. Ticks per host were more numerous on males, although the difference was not statistically significant.

To determine the relationship between occurrence of ectoparasites and thrift of the host, ratios of body weight (gms) to over-all body lengths were calculated. Rabbits with higher weight/length ratios, therefore, were heavier in relation to length of the body than those with lower weight/length ratios. A similar ratio, termed the Condition Index, has been used by Bailey (1968) and Chapman et al. (1977) and was defined as:

$$K = \text{Condition Index} = \frac{W}{L^3}$$

where W is the weight of the rabbit and L is the greatest length, defined as the length (mm) from the tip of the nose to the tip of the hind feet of a fully extended rabbit. In the present study we used the simplified formula:

$$\frac{W \text{ (gm)}}{L \text{ (mm)}}$$

Occurrence of ectoparasites according to the weight/length ratio is shown in Table 4. Combining all ectoparasites, average occurrence per host increased with increasing weight/length ratios, from 1.0 ectoparasites per host for those with 0-0.5 W/L ratio to 22 ectoparasites per host for those with 2.1-2.5 W/L ratio. Juvenile rabbits, which had lower body weights, were infested substantially more lightly than adults. Combining

TABLE 3

Occurence of the ectoparasites Cediopsylla simplex and Haemophysalis leporispalustris, according to sex and body weight of the New England cottontail hosts.

	C. simplex									*H. leporispalustris*								
	Male rabbits			Female rabbits			Total			Male rabbits			Female rabbits			Total		
Rabbit Body Wt. of	n	$\bar{x}$	Coef. Var.*	n	$\bar{x}$	Coef. Var.	n	$\bar{x}$	Coef. Var.	n	$\bar{x}$	Coef. Var.	n	$\bar{x}$	Coef. Var.	n	$\bar{x}$	Coef. Var.
1-200	0	—	—	1	0.0	—	1	—	—	0	—	—	1	1.0	0.0	1	1.0	0.0
201-300	0	—	—	0	—	—	0	—	—	0	—	—	0	—	—	0	—	—
301-400	0	—	—	2	1.5	24.3	2	1.5	24.3	0	—	—	2	3.0	24.3	2	3.0	24.3
401-500	0	—	—	1	4.0	0.0	1	4.0	0.0	0	—	—	1	2.0	0.0	1	2.0	0.0
501-600	0	—	—	1	7.0	0.0	1	7.0	0.0	0	—	—	1	5.0	0.0	1	5.0	0.0
601-700	2	0.5	141.4	0	—	—	2	0.5	141.4	2	13.0	22.3	0	—	—	2	13.0	22.3
701-800	5	7.0	61.9	6	15.8	65.0	11	11.8	65.3	5	9.4	96.5	6	3.3	88.7	11	6.1	95.0
801-900	3	5.0	86.7	3	16.8	103.8	6	10.5	95.9	3	3.3	87.9	3	7.7	53.8	6	5.5	66.0
901-1000	6	19.5	50.8	6	34.7	66.4	12	27.1	59.6	6	0.7	245.0	6	1.5	87.9	12	1.1	132.5
1001-1100	0	—	—	8	24.6	68.6	8	24.6	68.6	0	—	—	8	1.6	69.2	8	1.6	69.2
1101-1200	0	—	—	3	42.7	81.0	3	42.7	81.0	0	—	—	3	1.7	18.7	3	1.7	18.7
1201-1300	0	—	—	1	22.0	0.0	1	22.0	0.0	0	—	—	1	0.0	0.0	1	0.0	1.0
total	16	10.5	74.3	32	22.2	75.1	48	18.3	77.0	16	5.4	112.9	32	2.7	71.6	48	3.6	90.0

* Coefficients of variation based on transformed data.

all ectoparasites the infestation rate per juvenile rabbit was 6.8 ectoparasites, whereas for adults the rate was 22.8 ectoparasites.

Numbers of the tick *H. leporispalustris* were significantly correlated to month of the year ($p<.01$). The months of January and February differed significantly from June and August. The months of March, April and July did not significantly differ from each other (Table 2).

DISCUSSION AND CONCLUSIONS

Seasonal variation in the flea and tick populations on the New England cottontail appear to relate to biological factors associated with both the ectoparasites and the host. Although the fleas were present on the rabbits in each season, their occurrence was lowest in June and July, and highest in April and May. The low occurrence in June and July could be associated with the high temperatures, which are known to inhibit development of fleas, and probably to impair egg hatching (Herms and James 1961). Furthermore, the above authors assert that temperatures of 65-80 degrees, combined with high humidity, favor egg laying. Moderate temperatures likely to favor egg laying would occur in April and May, and could acount for the heavy presence of fleas during these months. In addition to the effects of favorable temperatures, the female rabbits would be required to spend time in the nest with their first young of the year during April and May. Fleas prefer to oviposit in nests, where the immature forms feed on the excrement of the adult fleas, and therefore, time spent in the nest by rabbits would be a likely factor influencing infestation rates by fleas. The low rates of flea infestation observed in June and July could also be associated with a tendency of the adult rabbits to utilize nests to a lesser degree during this period. The high occurrence of *C. simplex* on female rabbits over that on male rabbits could be accounted for in terms of the time the females spend in the nests with the young.

A regression of the transformed data for *C. simplex* number on rabbit body weight was not significant due to the high variability of numbers at high body weights (Table 3). Juvenile rabbits were infested at a rate much below the adults, despite the fact that juveniles which had recently emerged from the nests where contact with the fleas would be unavoidable.

Although the occurrence of the dog fleas *Ctenocephalus canis* was so low in the present study as to be considered incidental, the presence of various flea species could be expected. According to Herms and James (1961), host specificity in fleas is not strongly marked in many species, but they add that ordinarily one species of flea predominates in a given host species.

The tick most common in the present study, *H. leporispalustris,* is widely distributed and is commonly known as the rabbit tick. It has been collected on a number of birds and domestic animals (Herms and James, 1961). Both *H. leporispalustris* and *I. dentatus* belong to the family Ixodidae, which has but one nymphal stage. After the engorgement, the ticks drop off the host, molt to the adult stage and deposit eggs. Larval ticks climb vegetation from where they attach to hosts which come in contact with the vegetation. Under these circumstances, winter temperatures probably restrict most activities of the ticks. Despite this, ticks were collected from the hosts in all months of the present study except January. This is an indication that activities of *H. leporispalustris* may continue at cool to cold temperatures, as the climate in the collection area is severe even in February and March. Occurrence of greater numbers of *H. leporispalustris* per host on males than females might result from a greater activity of males among the vegetation containing larval ticks.

TABLE 4

Ectoparasite species according to weight/length ratios.

Ectoparasite Species	Numbers of ectoparasites				
	Rabbit weight/length ratio				
	0– 0.5	0.6 – 1.0	1.1– 1.5	1.6– 2.0	2.1– 2.5
Fleas					
C. simplex	*0*	*2.3*	*11.4*	*30.3*	*22.0*
O. multispinosus	0	0	3.0	2.2	0
Ticks					
H. leporispalustris	1.0	3.3	9.0	2.9	0
I. dentatus	0	1.0	2.0	0	0
Total ectoparasites	1.0	2.6	9.7	17.8	22.0

ACKNOWLEDGMENTS

The authors express appreciation to Dr. Kenneth R. Dixon, biometrician for the Appalachian Environmental Laboratory, and Dr. Larry Douglas of the University of Maryland, Department of Poultry Science, for statistical assistance. We also gratefully acknowledge the taxonomic services of the Smithsonian Institution for verification of specimen identifications in this study.

REFERENCES CITED

Chapman, J.A. 1975. *Sylvilagus transitionalis.* Mammalian Species. No. 55 pp. 1-4.

Chapman, J.A., A.L. Harman, and D.E. Samuel. 1977. Reproductive and physiological cycles of the cottontail complex in western Maryland and nearby West Virginia. Wildlife Monogr. No. 56 pp. 1 -73.

Dalke, P. D. 1937. A preliminary report of the New England cottontail studies, Trans. N. Amer. Wildlife Conf. 2:542-548.

Dalke, P.D. 1942. The cottontail rabbits in Connecticut. Bul. Conn. Geol. Nat. Hist. Surv. 65:1-97.

Eabry, H.S. 1968. An ecological study of *Sylvilagus transitionalis* and *S. floridanus* of northeastern Connecticut. Agr. Exp. Sta. Univ. Conn. 27 pp.

Erickson, A.B. 1947. Helminth parasites of the genus *Sylvilagus.* Jour. Wildlife Mgt. 11:255-263.

Herms, W.B. and M.T. James. 1961. Medical entomology. 5th ed. The MacMillan Co., New York. 616.

Rankin, J.S., Jr. 1946. Helminth parasites of birds and mammals in western Massachusetts. Amer. Midland Nat. 35:756-768.

Proceedings of the Pennsylvania Academy of Science 51:43—46. 1977.

A RE-EXAMINATION OF THE SUBSPECIFIC STATUS OF THE MARYLAND SHREW, SOREX CINEREUS FONTINALIS HOLLISTER[1]

GORDON L. KIRKLAND, JR.

The Vertebrate Museum
Shippensburg State College
Shippensburg, Pennsylvania 17257

ABSTRACT

The Maryland shrew, *Sorex fontinalis* Hollister, was designated as a subspecies of the masked shrew, *Sorex cinereus* Kerr, by Poole in 1937 on the basis of his examination of a series of recently collected specimens from Berks and Chester counties, Pennsylvania. These specimens were described as being intermediate in character between *S. fontinalis* from Maryland and *S.c. cinereus* from the mountains of eastern Pennsylvania. This paper re-examines the taxonomic status of *S.c. fontinalis* based on analyses of cranial and external measurements of Poole's specimens plus *S.c. cinereus* and *S.c. fontinalis* from Pennsylvania and adjacent states. The results do not support Poole's taxonomic revision of *S. fontinalis* in that specimens from southeastern Pennsylvania are not intermediate in character between specimens from Maryland/ Delaware/Virginia and those from northeastern Pennsylvania and New York State. Likewise, two distinct morphotypes occur in sympatry in southern and southeastern Pennsylvania with specimens assignable to *S.c. cinereus* and *S.c. fontinalis* having been collected from the same localities.

INTRODUCTION

The Maryland shrew, *Sorex cinereus fontinalis,* was originally accorded full specific rank as *Sorex fontinalis* by Hollister (1) based on a type specimen from Cold Spring Swamp, near Beltsville, Prince Georges Co., Maryland. Jackson (2) retained *S. fontinalis* as a species since, at that time, no specimens were available for study from the geographic region between the known ranges of *S. fontinalis* in Maryland and *S.c. cinereus* in the mountains of Pennsylvania. Jackson acknowledged the possibility that specimens from this intervening region might exhibit characters intermediate between *S. fontinalis* and *S.c. cinereus.*

In 1937, Poole (3) described a series of recently collected *Sorex* from southeastern Pennsylvania as being intermediate in character between typical *S. fontinalis* from Maryland and *S.c. cinereus* from the mountains of Pennsylvania. On the basis of these specimens, he relegated *S. fontinalis* to subspecific status; however, he presented no data from either skins or skulls to substantiate his taxonomic revision. During the ensuing 40 years, mammalogists who have examined *Sorex cinereus* from the southeastern quadrant of Pennsylvania have noted the difficulty in ascertaining the correct subspecific identity of specimens from this region (4,5).

In the process of studying soricids in the Appalachian region, I have observed the distinctive characteristics of *S.c. fontinalis* in specimens from southeastern and south-central Pennsylvania. In most cases, these specimens were indistinguishable from *S.c. fontinalis* from Maryland, Delaware and Virginia and did not appear to be of intermediate character. As a result, I initiated a study to re-examine the subspecific status of *S. cinereus* in eastern Pennsylvania and thereby to resolve the question of taxonomic position of *S.c. fontinalis.* This paper presents the preliminary results of this work based on analyses of external and skull morphology of series of specimens labelled as *S.c. fontinalis* from Pennsylvania, Virginia, Delaware and Maryland and *S.c. cinereus* from Pennsylvania, New York and West Virginai. Included in these samples are some of the specimens examined by Poole (3).

[1]Received April 18, 1977; revised; accepted August 11, 1977.

METHODS AND MATERIALS

Specimens of *S.c. cinereus* and *S.c. fontinalis* from the following collections were examined: American Museum of Natural History (AMNH), Carnegie Museum of Natural History (CM), Puget Sound Museum of Natural History (PSU), New York State Museum (NYSM), Reading Public Museum and Art Gallery (RPMAG), Academy of Natural Sciences at Philadelphia (ANSP), Museum of Vertebrate Zoology, University of California (MVZ) and The Vertebrate Museum, Shippensburg State College (SSC). External measurements, localities, and subspecific identifications were recorded from specimen labels. Fourteen skull and mandibular measurements (Figure 1) were taken by the author with the aid of a binocular microscope and Helios dial micrometers (1/20 mm calibration). Of 141 specimens examined, only 97 had unbroken skulls and complete measurements and thus were suitable for use in the analyses.

Analyses of morphological data were performed using computer programs from the SPSS (Statistical Package for the Social Sciences) package and the discriminant analysis program BMDO7M. Discriminant analysis was performed on five groups: (1) *S.c. fontinalis* from Maryland, Virginia and Delaware, (2) *S.c. fontinalis* from Pennsylvania, (3) *S.c. cinereus* from Pennsylvania, (4) *S.c. cinereus* from New York, and (5) *S.c. cinereus* from West Virginia. Specimens were initially assigned to the five groups on the basis of identification as recorded on the specimen label.

RESULTS AND DISCUSSION

The results of a discriminant analysis of the 97 specimens in this study illustrated the degree of uncertainty previously associated with assigning subspecific designations of *Sorex cinereus* from south-central and southeastern Pennsylvania. Of 24 specimens labelled as *S.c. cinereus,* four (16.7%) were reassigned to *S.c. fontinalis.* Of 35 specimens labelled as *S.c. fontinalis,* 14 (40%) were re-designated as *S.c. cinereus.* Also, two of 11 *S.c. fontinalis* (16.7%) from non-Pennsylvania localities (Maryland, Virginia, Delaware) were re-assigned to *S.c. cinereus.* In contrast, no subspecific redesignations were indicated for the 27 *S.c. cinereus* from New York and West Virginia.

The prime reason for Poole's (3) relegation of *S. fontinalis* to subspecific status was his assessment that the specimens of the *S. cinereus* group from the lowlands east of the Appalachian Mountains exhibited a definite intergradation between *S. fontinalis* and *S.c. cinereus.* In order to substantiate this pattern of intergradation, the size relationships of four species of specimens were compared. These were (1) Non-Pa *Sc. fontinalis* from Delaware, Virginia and Maryland (11 specimens), (2) *S. cinereus* from southcentral and southeastern Pennsylvania: Adams, Bedford, Berks, Chester, Cumberland, Delaware,

TABLE 1

External and skull morphology of S.c. cinereus *and* S.c. fontinalis *(Measurements in mm; means ± 1 standard deviation). Skull measurements as defined in Figure 1.*

TAXON	*S.c. fontinalis*		*S.c. cinereus*	
GEOGRAPHIC REGION	Del., Va., Md.	Penna.	Penna.	New York
SAMPLE SIZE	11	23	26	24
Total Length	85.36 ± 2.64	85.63 ± 4.53	94.04 ± 5.03	97.17 ± 4.29
Tail Length	32.55 ± 1.68	33.33 ± 1.76	36.21 ± 2.47	39.54 ± 1.84
Hind Foot Length	11.27 ± 0.65	11.09 ± 0.51	11.62 ± 0.70	11.29 ± 0.55
Body Length (Total-Tail)	52.82 ± 1.98	49.93 ± 4.08	57.83 ± 4.73	57.63 ± 4.36
Greatest Length	15.54 ± 0.39	15.37 ± 0.26	16.02 ± 0.64	16.13 ± 0.37
Condylobasal Length	14.98 ± 0.36	14.72 ± 0.22	15.31 ± 0.65	15.49 ± 0.35
Interorbital Breadth	2.82 ± 0.13	2.96 ± 0.18	3.04 ± 0.20	2.91 ± 0.13
Cranial Breadth	7.41 ± 0.09	7.43 ± 0.19	7.66 ± 0.34	7.71 ± 0.17
Molariform Tooth Row	3.67 ± 0.07	3.62 ± 0.08	3.72 ± 0.16	3.73 ± 0.08
Cheek Tooth Row	4.22 ± 0.10	4.16 ± 0.09	4.27 ± 0.19	4.30 ± 0.10
Total Tooth Row	6.49 ± 0.17	6.33 ± 0.14	6.57 ± 0.33	6.57 ± 0.20
Incisor Width	1.24 ± 0.04	1.21 ± 0.05	1.23 ± 0.07	1.27 ± 0.07
Canine Width	1.69 ± 0.06	1.69 ± 0.08	1.74 ± 0.10	1.67 ± 0.06
Molar Width	3.67 ± 0.09	3.75 ± 0.10	3.72 ± 0.20	3.76 ± 0.11
Palate Length	6.40 ± 0.17	6.08 ± 0.14	6.36 ± 0.34	6.43 ± 0.15
Post-palatal Length	6.91 ± 0.22	6.84 ± 0.19	7.11 ± 0.31	7.16 ± 0.14
Mandible Length	8.84 ± 0.33	8.73 ± 0.23	9.08 ± 0.41	9.22 ± 0.27
Mandible Height	3.61 ± 0.25	3.56 ± 0.12	3.68 ± 0.16	3.75 ± 0.16

Franklin, Lancaster and York Cos. (42), (3) *S. cinereus* from northeastern Pennsylvania: Lehigh, Monroe, Northampton, Pike and Schuykill Cos. (17), and (4) *S.c. cinereus* from Otsego and Schoharie Cos., New York (17). The means for each of the 18 variables examined were compared for the four groups and ranked from 1 (smallest) to 4 (largest). The mean ranks for the four groups were: *S.c. fontinalis* non-Pennsylvania (1.77), *S. cinereus* SC and SE Pennsylvania (1.44), *S. cinereus* NE Pennsylvania (3.69) and *S.c. cinereus* New York (3.08). The data indicate that rather than being of intermediate size, specimens of the *S. cinereus* group from southeastern and southcentral Pennsylvania are generally smaller than *S.c. fontinalis* from Maryland, Virginia and Delaware.

A similar size comparison was made for four groups of specimens as determined by the discriminant analysis. The mean ranks for the 18 variables in the four groups were as follows: Non-Pa *S.c. fontinalis* (1.88), Pennsylvania *S.c. fontinalis* (1.57), Pennsylvania *S.c. cinereus* (3.06), and New York *S.c. cinereus* (3.56). In this analysis, the generally smaller size of Pennsylvania *S.c. fontinalis* was evident, as was the intermediate size of Pennsylvania *S.c. cinereus.* An examination of the means in Table 1 reveals that the two *S.c. fontinalis* samples are very similar, while the Pennsylvania *S.c.cinereus* resemble the New York *S.c. cinereus* but to a lesser degree.

The size relationships between the two subspecies as presented in Table 1 are consistent with those presented by earlier workers who compared *S. fontinalis* and *S.c. cinereus* (see 1, 2). Key differences are smaller general size of *S.c. fontinalis* and its shorter tail. Important skull characters are the narrower cranium, and shorter skull length, rostrum and unicuspid tooth row.

An important consideration in the assessment of the taxonomic status of *S.c. fontinalis* and *S.c. cinereus* is the question of sympatry in the two subspecies. During the Mammal Survey of Southeastern Pennsylvania, Roberts and Early (5) assigned all specimens of *S. cinereus* to S.c. fontinalis, although in the mountains, specimens resembled *S.c. cinereus.* In contrast, both *S.c. cinereus* and *S.c. fontinalis* were identified in specimens collected in the Mammal Survey of South Central Pennsylvania (4). In this region, no ecological or geographic segregation of the two subspecies could be illustrated, and in some cases, members of both subspecies were captured in the same traplines.

The results of the discriminant analysis in this study indicated that the two subspecies may occur in sympatry in both the south-central and southeastern regions of Pennsylvania. The potential zone of sympatry was generally south and east of the major mountainous regions of the state and appeared to be dictated by the more limited distribution of *S.c. fontinalis.* With the exception of Cumberland Co., *S.c. fontinalis* were restricted to the southernmost tier of counties in Pennsylvania (Figure 2). On the basis of the discriminant analysis, six localities yielded specimens of both subspecies, as follows: Chester Co., Cedarville, 1.5 m SW; Franklin Co., Mont Alto, 3.5 mi ENE, 1450′; Lancaster Co., Pequea, 1.5 mi NE, 180′, Wrightsdale, 2.5 mi SSE; York Co., Delta, 1.5 mi ENE, 2.5 mi ENE (figure 2).

If *S.c. fontinalis* is a subspecies of *S. cinereus,* then the maintenance of its distinctive morphological characteristics in the zone of sympatry with *S.c. cinereus* represents an exception to the pattern of intergradation which generally prevails along the interface of subspecies ranges. However, the sympatry of *S.c. cinereus* and *S.c. fontinalis* does not appear to be comparable to that of the classic example of *Peromyscus maniculatus gracilis* and *P.m. bairdii* in southern Michigan where these two subspecies form the ends of a Rassenkreis and are ecologically segregated. The two races of *P. maniculatus* have apparently come into sympatry as a result of habitat alterations created by man (6), a possibility that cannot be ruled out in the case of the two subspecies of *S. cinereus* in question.

CONCLUSIONS

The results of this morphological analysis contradict Poole's (3) assessment of the size relationships of members of the *S. cinereus* group in southeastern Pennsylvania. Rather that being intermediate in size between non-Pennsylvania *S.c. fontinalis* and *S.c. cinereus,* specimens from the lowlands east of the Appalachian Mountains are generally smaller, rather than larger, than *S.c. fontinalis* from Maryland, Virginia and Delaware. Likewise, specimens from south-central and southeastern Pennsylvania form two distinct morphotypes, some resembling *S.c. cinereus* and others very similar to *S.c. fontinalis* from Maryland, Virginia and Delaware.

While these results suggest that *S.c. fontinalis* may represent a distinct sibling species, they are not sufficient to warrant any immediate change in the current taxonomy. Successful resolution of the taxonomic

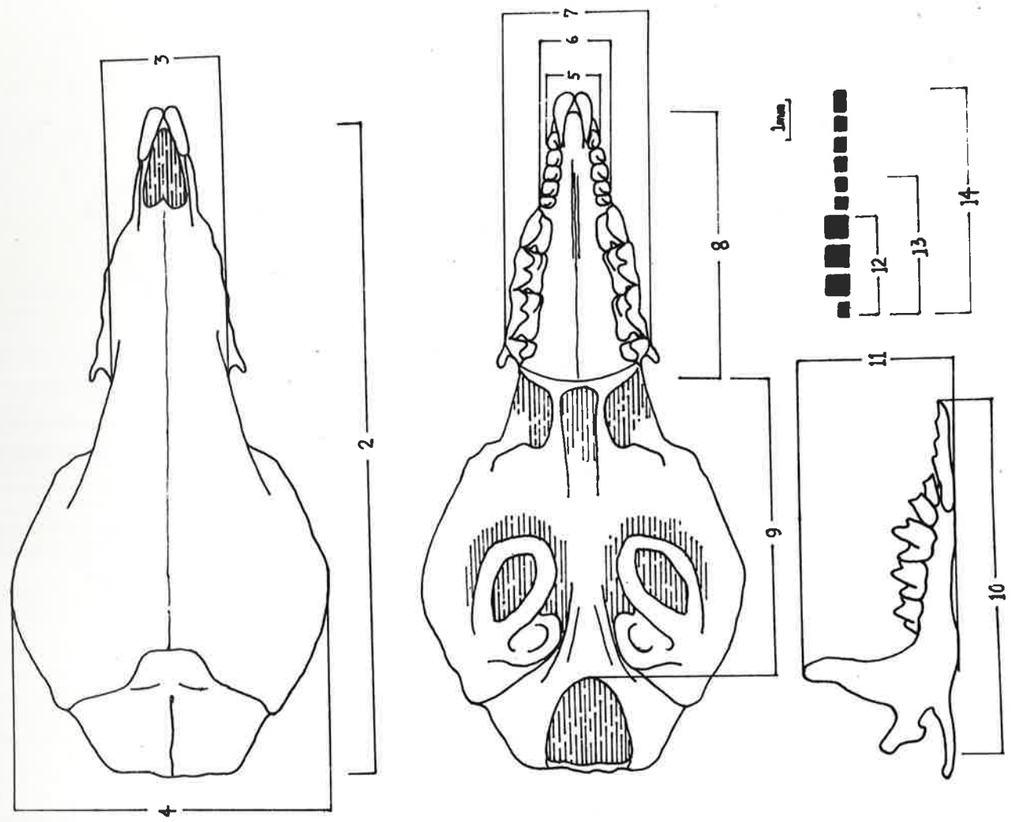


FIGURE 1. Diagramatic views of skull, mandible and upper tooth row of *Sorex cinereus* showing measurements employed. Dorsal view of the skull (#1-4); ventral view of the skull (#5-9); mandible (#10-11); semidiagrammatic view, left side of upper tooth row (#12-14). Definition of measurements: 1. Total length of skull. Anterior surface of incisors to most posterior surface of occipital condyle. 2. Condylo-basal length. Anterior median point between bases of first upper incisors to most posterior surface of occipital condyle. 3. Interorbital breadth. Least measurement across skull between orbits. 4. Cranial breadth. Greatest distance across braincase. 5. Incisor width. Distance between lateral edges of second incisors measured at alveolar border. 6. Canine width. Distance between lateral edges of canines measured at alveolar border. 7. Molar width. Distance between lateral edges of M^2 measured at alveolar border. 8. Palate length. Greatest anterio-posterior measurement of the palate in the median line. 9. Post-palatal length. Distance from posterior margin of palate to anterior border of foramen magnum. 10. Mandible length. Distance from anterior tip of first lower incisor to posterior tip of condyle. 11. Mandible height. Distance from base of mandible to tip of coronoid process. 12. Molariform tooth row. Distance from posterior border of M^3 to anterior edge of P^4 measured at alveolar border. 13. Cheek tooth row. Distance from posterior of M^3 to anterior border of P^2 measured at alveolar border. 14. Total tooth row. Distance from anterior surface of first incisor to posterior surface of last molar.

FIGURE 2. Localities of Pennsylvania specimens examined.

problem of *S.c. fontinalis* will require work in three areas. A substantially larger sample of specimens of *S.c. fonitnalis* and *S.c. cinereus* from more localities in both the zones of sympatry and allopatry must be examined. Qualitative characters such as a difference in tooth cusp pattern which will separate the two forms must be sought. Finally, it must be determined whether the two shrews are segregated by either microhabitat selection or some other niche parameter.

ACKNOWLEDGEMENTS

I wish to thank the curators of the collections previously mentioned who graciously provided access to or loans of specimens described in this paper and Robert S. Hoffmann for his critical review of this paper. Figure 1 was drawn by Joann Kelhart, a student in the Biology Department at Shippensburg State College.

LITERATURE CITED

1. Hollister, N. 1911. Remarks on the long-tailed shrews of the eastern United States, with description of a new subspecies. Proc. U.S. Nat. Mus. 40: 377-381.
2. Jackson, H.H.T. 1928. Taxonomic review of the North American long-tailed shrews (genera *Sorex* and *Microsorex*). N.A. Fauna 51: 1-238.
3. Poole, E.L. 1937. Pennsylvania records of *Sorex cinereus fontinalis*. J. Mammal. 18: 96.
4. Gifford, C.L. and R. Whitebread. 1951. Mammal Survey of South Central Pennsylvania. Pennsylvania Game Commission, Harrisburg. 75 pp.
5. Roberts, H.A. and R.C. Early. 1952. Mammal Survey of Southeastern Pennsylvania. Pennsylvania Game Commission, Harrisburg. 70 pp.
6. Hooper, E.T. 1942. An effect on the *Peromyscus maniculatus* Rassenkreis of land utilization in Michigan. J. Mammal. 23: 193-196.

Proceedings of the Pennsylvania Academy of Science 51:47—50. 1977.

A STUDY OF THE RELATIONSHIP BETWEEN SCARLET OAK (QUERCUS COCCINEA MUENCHH.) AND HILL OAK (QUERCUS ELLIPSOIDALIS E.J. HILL) IN MICHIGAN AND NEARBY STATES[1]

WILLIAM ROY OVERLEASE
Department of Biology
West Chester State College
West Chester, Pa. 19380

ABSTRACT

Field populations of Scarlet Oak and Hill Oak were studied from southern Indiana to northern Michigan with additional populations from northern Illinois and central Wisconsin and their morphological characters compared. Collections of acorns were made from field populations and grown under "common garden" conditions for evidence of genetic similarities or differences. The evidence indicates a continuum of character change between the two species from south to north. Data from the common garden studies appear to support a genetic continuum from south to north. Hill Oak is considered as a northern small-fruited expression of Scarlet Oak.

INTRODUCTION

Hill Oak was described as a new species in 1899 by Rev. E.J. Hill in the Botanical Gazette (1). Following the publication of the description, identifications of this new species were recorded by botanists and foresters in Illinois, Wisconsin, Iowa, Indiana and Michigan. It wasn't long, however, before confusion arose between Hill Oak and such closely related species as Scarlet Oak (*Quercus coccinea* Muenchh.), Black Oak (*Quercus velutina* Lam.), Pin Oak (*Quercus palustris* Muenchh.) and later, Red Oak (*Quercus rubra* L.) and Northern Red Oak (*Quercus rubra* var. *borealis* (Michx. f. Farw.)).

Rev. Hill's species description was so broadly stated that the question arose as to what was a typical Hill Oak. In looking over Rev. Hill's herbarium sheets on deposit at the Chicago Museum of Natural History, it appears, according to the notes on them, that at least five different sheets were used from two localities for the plates of the species description. As far as I can tell from the specimens, his description includes two taxa, one with yellow inner bark and small rounded acorns (later referred to as a variant of Black Oak in this paper), and one with pink to tan inner bark with ellipsoid acorns which is typical of the northern Hill Oak populations in Michigan and Wisconsin.

To give some idea of the confusion that has attended this species, Trelease published a paper on Hill Oak in Illinois (2) in which he eliminated Scarlet Oak as a natural occuring species in Illinois except in the southern part of the state. In this context, it is interesting that even after his published description of the new species, Rev. Hill continued to identify Scarlet Oak in the Chicago region as also did Pepoon in his *Flora of the Chicago Area* (3).

In 1933, Wadmond in Wisconsin published a paper (4) on the relationship between Hill Oak and Scarlet Oak in which he agreed with Trelease in that he felt that Scarlet Oak was primarily a southern species in both Indiana and Illinois and that identifications from the northern parts of these states and Wisconsin were in error. The late Dr. Wendell H. Camp was very interested in the problem of Hill Oak and made many general observations which he gave to the author. He was very certain that Scarlet Oak did occur in southern Wisconsin.

[1]Received October 7, 1976; revised; accepted August 11, 1977.

In their *flora of Kalamazoo County, Michigan* (5) C.R. and F.N Hanes listed both Scarlet Oak and Hill Oak from the county. They noted that the Scarlet Oak was confirmed by E.J. Palmer of Arnold Arboretum, an authority on oaks, but that Charles Deam, one of the midwest's most eminent field botanists thought them to be a form of Hill Oak.

Floyd Swink, in his recent *Plants of the Chicago Region* (6) makes the following statement regarding Scarlet and Hill Oak: "Local in dry soil. Some botanists feel that the populations of *Quercus ellipsoidalis* of our region are not specifically distinct from Scarlet Oak."

The following paper is a presentation of the author's work on the question of Hill Oak and Scarlet Oak with some data on the relationship to small-fruited forms of Black Oak.

METHODS

Ten field populations of Scarlet and Hill Oak were selected for intensive field study. These ranged from unglaciated southern Indiana to the range limits of what has been called Scarlet Oak in Michigan and what has been known as Hill Oak in Michigan. For comparison, three stands of Hill Oak, one at Thornton Woods near Chicago which appears to be the type or near the type locality for Hill Oak, one at Rockford, Illinois near the Wisconsin state line, and a third in central Wisconsin at Wisconsin Rapids, were studied.

Although 13 morphological field characters were studied in detail, six which were the most diagnostic are summarized and reported (Table 1).

Populations were located whenever possible within state parks or preserves. Other criteria used in selecting populations for study were: naturalness of stand conditions, homogeneity of soil type, homogeneity of the population avoiding obvious hybrid swarms, and accessibility of the site for future study.

For each population, a strip transect was laid out on which approximately 100 mature trees were numbered to form an adequate population for a random sample. The length of the transect depended on the number of mature trees available within 15 meters of each side of the transect. The transects averaged about 500 meters in length. The specific trees to be studied intensively on the transect were determined by selecting random numbers between 1 and 100 and then locating and studying the proper numbered trees. The total number of trees sampled from a population depended on the morphological variation observed within the population with more variable populations requiring larger samples. The populations averaged about 20 trees which proved to be an adequate sample to include normal population variation (Table 1).

Whenever possible, 25 mature acorns were collected from each tree studied. Of these, one chosen at random, was measured in detail. See Table 1 for dimensions measured. Analysis of variance was used to compare populations statistically for significant differences.

Acorns from the field populations were collected during two consecutive falls, 1960 and 1961 and grown under "common garden" conditions in the former Bogue Forest Nursery in East Lansing,

TABLE 1

Population means for selected morphological characters of Scarlet and Hill Oak from unglaciated southern Indiana to the northern range limits in Michigan with a comparative south to north transect in Illinois and Wisconsin.

	Population sample size	Acorn size, length + width, mm.	Acorn length, mm.	Acorn shape, width/length x 100	Ratio, acorn cup height total height with cup attached x 100	Winter bud length, mm.	Twig pubescence, 10 absent, 5 intermediate, 1 abundant
Scarlet Oak							
Southern, Unglaciated Indiana (Nashville)	23	35	19	91	57	5.9	10
Northern Indiana (Elkhart)	18	35	19	85	54	5.7	10
Scarlet — Hill Oak							
South-central Mich. (Stockbridge)	11	33	18	81	50	—	9
Central Mich. (East Lansing)	18	32	18	74	48	4.4	8
Hill Oak							
North-central Mich. (Harrison)	14	28	16	78	46	3.8	6
North-central Mich. (Farwell)	26	30	16	80	47	3.8	3
Northern Mich. (Grayling)	29	28	15	78	46	3.7	3
Scarlet-Hill Oak							
Northeastern Ill. (Chicago)	20	33	18	87	52	4.1	—
North-central Ill. (Rockford)	19	33	18	84	51	4.2	5
Hill Oak							
Central Wisconsin (Wisconsin Rapids)	20	28	17	80	48	4.0	5

TABLE 2

*Sum of 13 morphological field characters** in which contrasted pairs of Scarlet Oak and Hill Oak populations did not differ significantly at the 1% level (analysis of variance). Arranged from south to north in Indiana and Michigan with three populstions from Illinois and Wisconsin for comparison.*

	Northern Indiana	South-central Michigan	Central Michigan	North-central Michigan	North-central Michigan	Northern Michigan	Northeastern Illinois	North-central Illinois	Central Wisconsin
Scarlet Oak									
Southern, unglaciated Indiana (Nashville)	6	8	5	2	1	2	4	4	1
Northern Indiana (Elkhart)		9	7	1	1	2	7	6	0
Scarlet-Hill Oak									
South-central Mich. (Stockbridge)			8	4	3	4	8	9	3
Central Michigan (East Lansing)				4	4	4	4	6	3
Hill Oak									
North-central Mich. (Harrison)					8	11	2	5	11
North-central Mich. (Farwell)						10	3	5	8
Northern Michigan (Grayling)							3	5	9

**Thirteen morphological characters studied were: Total acorn height, acorn length, acorn width, acorn size, acorn shape, acorn cup height, ratio of acorn cup height to total acorn height, acorn cup scale shape, acorn cup fringe presence, twig pubescence, inner bark color, twig brittleness, and tree form.

TABLE 3

Population means of selected morphological characters for Scarlet Oak, Hill Oak, and Black Oak grown under "common garden" conditions at East Lansing, Michigan

	Black Oak, Northwestern Michigan (Honor)	Black Oak, Northwestern Michigan (Traverse City)	Black Oak, Northern Michigan (Indian River)	Hill Oak, Northern Michigan (Grayling)	Hill Oak, Central Wisconsin (Wisconsin Rapids)	Significance, Analysis of Variance ns — not sig.
1960 PLANTING						
Number of parent trees sampled	2	6	3	4	5	
Emergence time, days average for population after first nursery germination	13	11	10	9	13	ns
Height, age 1, mm.	50	38	39	26	27	1%
Height, age 2, mm.	457	305	406	305	254	1%
Leaf length, age 1, mm.	70	66	73	62	75	1%
Leaf width, age 1, mm.	40	41	48	40	41	ns
Leaf margin, 2 smooth, 5 wavy, 8 dentate, age 1	4.6	3.8	3.8	5.0	6.0	1%
Leaf angle, age 1, degrees	39°	39°	36°	31°	28°	1%
Percent leaves red, age 2, Oct. 4, 1962	19	26	35	35	54	1%
Percent leaves green, age 1, November 8, 1961	14	19	5	8	1	1%
Percent leaves lost, age 2, November 6, 1962	3	15	24	19	8	5%
Percent leaves frost damaged, October 1961	10	0	4	2	1	5%
Percent trees with red petioles, June 1962, age 2	18	15	41	51	39	5%
Leaf pubescence, age 2, 10 abundant, 50 some, 100 none	24	11	29	64	56	1%
Shoot pubescence, age 2, 10 abundant, 50 some, 100 none	24	12	26	58	52	1%

	Scarlet Oak, northern Indiana (Elkhart)	Scarlet-Hill Oak, northwestern Indiana (Chesterton)	Scarlet-Hill Oak, southcentral Michigan (Stockbridge)	Scarlet-Hill Oak, central Michigan, (East Lansing)	Scarlet-Hill Oak, central Michigan (Rose Lake Experiment Station - East Lansing)	Hill Oak, North-central Michigan (Harrison)	Hill Oak, northern Michigan (Grayling)	Significance, analysis of variance ns - not significant
1961 PLANTING								
Number of parent trees	9	3	2	3	9	6	14	
Height, age 1, mm.	146	133	121	114	102	102	89	1%
Leaf length, age 1, mm.	108	112	113	97	91	84	79	1%
Leaf width, age 1, mm.	69	75	67	67	60	53	50	1%
Leaf margin, 20 entire, 40 wavy, 70 dentate, 90 lobed	85	78	80	74	77	74	77	5%
Leaf angle, age 1, degrees	23°	22°	20°	29°	24°	29°	27°	5%
Percent leaves red, age 1, October 4, 1962	15	11	16	21	16	22	32	1%
Percent leaves with red petioles, age 1, June 1962	80	55	59	89	76	54	43	ns
Leaf pubescence, age 1, 10 abundant, 50 some, 100 none	97	93	96	92	96	93	91	ns

Michigan. The first fall, 24 acorns were planted from each parent tree in a population. The second fall, 32 acorns were planted from each parent. Following planting, the seedbeds were mulched for the winter with ½ inch of sawdust.

The nursery planting was a randomized block design (7) with each row of planted acorns replicated four times. On germination the seedlings were scored for morphological differences and a mean obtained for each replication and each parent tree for each character selected for measurement. This was then tested statistically by analysis of variance to determine significant differences between the populations at the 5% and 1% levels of confidence. Only characters showing significant differences are generally reported.

RESULTS – DISCUSSION

Studies of field morphological characters of populations of Scarlet Oak from Indiana (two populations) and Hill Oak up to its northern range limits in Michigan (five populations) indicated a general continuum of character change from south to north (Table 1). Northern populations as compared to southern populations had smaller and narrower acorns with the acorn less covered by the acorn cup. Also they had smaller winter buds and more twig pubescence.

These same trends were generally evident in comparing populations of Hill Oak in northern Illinois to those of central Wisconsin (Table 1).

No definite break in morphological characters was evident between northern Indiana Scarlet Oak and southern Michigan populations of Hill Oak. Since these southern Michigan populations have characteristics of both Scarlet and Hill Oak and are intermediate between them, they have been referred to as Scarlet Oak by some experienced field botanists, and as Hill Oak by others.

A statistical analysis of thirteen morphological characters by population oriented on a south to north basis is presented in Table 2.

It very clearly summarizes the relationships between the populations. For example, the unglaciated southern Indiana Scarlet Oak population was found most similar to the northern Indiana expression of Scarlet Oak, as expected, but also was similar to a population in south-central Michigan. It was not similar to the northern expressions of Hill Oak.

Northern Indiana Scarlet Oak populations were similar to southern Indiana Scarlet Oak but also similar to southern Michigan populations of Hill Oak and to northern Illinois populations of Hill Oak.

Northern populations of North-central Michigan and Northern Lower Peninsula Michigan Hill Oak were similar to each other and to the central Wisconsin population.

In southern Michigan, central Michigan and northern Illinois an intermediate series of populations were found that were most similar to each other.

From field experience, the general literature, and the data presented in this paper, northern populations of Hill Oak are easily separated from southern Indiana populations of Scarlet Oak. However, there is a broad region in northern Indiana and southern Michigan, and northern Illinois and southern Wisconsin with intermediate populations between both species (Table 2). These form a Scarlet-Hill Oak complex.

In my opinion, these populations as well as the more distinct northern populations would be best understood biologically and taxonomically if regarded as northern small-fruited expressions of Scarlet Oak. I don't feel the field morphological differences are any greater than has been demonstrated for the southern and northern populations of both Black Oak (8) and Red Oak (9).

It is felt that the limited evidence from "common garden" studies made at East Lansing, Michigan lend support for the concept of a genetic continuum of closely related taxa from unglaciated southern Indiana to the northern range limits of Hill Oak in Michigan (Table 3).

Collections made in 1961 from Scarlet and Hill Oak populations showed significant differences between populations for the following characters: tree height, leaf length, leaf width, leaf margin, leaf angle, and percent leaves red in October. The first three characters appear related to acorn size with the larger southern acorns producing more vigorous trees with larger leaves. This was also found to be true among larger and smaller fruited Black Oaks (8). The last three characters do suggest a general genetic gradient of character change from south to north.

The 1960 planting indicated the close genetic relationship between northern populations of Hill Oak from central Wisconisn (Wisconsin Rapids) and northern Michigan (Grayling).

The 1960 planting also indicates the obvious seedling differences between the northern small-fruited Black Oak and Hill Oak. Some botanists have regarded these small-fruited trees with yellow inner bark as expressions of Hill Oak both in the Chicago Region as previously referred to in Rev. Hill's species description, and among northern Michigan oak populations. They are more appropriately part of a Black Oak south to north continuum (8) similar to Scarlet Oak.

ACKNOWLEDGEMENTS

The data for this study was a portion of a Ph.D. dissertation completed by the author at Michigan State University under the direction of Drs. John Cantlon, Jonathan Wright, Philip Clark, and John Beaman.

LITERATURE CITED

1. Hill, E.J. 1899. A new biennial-fruited oak. *Bot. Gaz.* 27: 204-208.
2. Trelease, W. 1919. The jack oak. Trans. Ill. Acad. Sci. 12: 108-118.
3. Pepoon, H.S. 1927. *An Annotated Flora of the Chicago Area.* Chicago Academy of Science. 554 pp.
4. Wadmond, S.C. 1933. The *Quercus ellipsoidalis-Quercus coccinea* complex. *Trans. Wisc. Acad. Sci.* 28: 197-203.
5. Hanes, C.R. & F.N. 1947. *Flora of Kalamazoo County, Michigan.* Vascular Plants. (Authors), Schoolcraft, Michigan. 295 pp.
6. Swink, F. 1974. *Plants of the Chicago Region.* The Morton Arboretum, Lisle, Ill. 474 pp.
7. Wright, J.W. 1976. *Introduction to Forest Genetics.* Academic Press. 388 pp.
8. Overlease, W.R. 1975. A study of variation in Black Oak (*Quercus velutina* Lam.) populations from unglaciated southern Indiana to the range limits in northern Michigan. *Proc. Penna. Acad. Sci.* 49: 141-144.
9. Overlease, W.R. 1975. Population studies of Red Oak (*Quercus rubra* L.) and Northern Red Oak (*Quercus rubra* var. *borealis* (Michx.f. Farw.). *Proc. Penna. Acad. Sci.* 49: 138-140.

Proceedings of the Pennsylvania Academy of Science 51:51–53. 1977.

EFFECTS OF A ZINC MINE GROUND WATER EFFLUENT ON A STREAM DIATOM COMMUNITY[1]

DAVID M. BELL

Department of Biology
Lehigh University
Bethlehem, PA 18015

ABSTRACT

The diatom community of a creek receiving a zinc mine effluent was investigated for changes in community characteristics. Declines in community richness and diversity were observed downstream from the effluent. The changes cannot be attributed solely to addition of dissolved zinc, suspended solids, or ground water, but may be a result of the combination of physical and chemical modification of the habitat due to siltation and heavy metal addition.

INTRODUCTION

Ecological investigations, particularly those concerned with man's effects on the environment, depend heavily on comparison of biological communities in reference and affected areas. This technique offers one conspicuous advantage; comparisons of dynamic biological events are compared in relative fashion, with the anthropogenic influences the major difference in the areas compared. Major seasonal and meteorological influences are assumed to exert equal effects on both control and affected areas, and thus their effects can be minimized in the comparison. For example, this approach has been employed in the study of the effects of organically enriched effluents (Macan and Worthington, 1951), acid mine wastes (Ettinger and Kim, 1975), and in the simulation of heavy metal additions by Williams and Mount (1965). Since a major assumption in this type of study is the similarity of the environments compared, care must be taken to select areas close in proximity and habitat characteristics.

The deep mining operations of the New Jersey Zinc Company (NJZ) in the Saucon Valley, near Bethlehem, Pa., offer a unique opportunity for the study of the influence of a major industrial effluent upon a rural creek. NJZ pumps approximately 36 million gallons per day of ground water into the Saucon Creek, and for much of the creek's length, this effluent is the major anthropogenic influence. The properties of the NJZ effluent, as cited in the EPA fact sheet of 1974, indicate that the effluent has the following composition; 1.55 ppm total zinc, 0.67 dissolved zinc. 25 ppm suspended solids, and 0.006 ppm dissolved cadmium. The ground water is 12-14°C, and has a hardness of 130-160 ppm, as measured in our laboratory.

In a small creek of the Saucon's nature, the two-dimensional characteristics of the lotic habitat are emphasized, and the substrate is characteristics of most of the *in situ* primary production. Production is accomplished by the periphyton community, especially diatoms and filamentous algae. Thus the composition of this sessile, microscopic community is indicative of the properties of the aquatic habitat, and is appropriate for an analysis of the possible changes caused by the NJZ effluent (Patrick, 1951). If the introduction of this large quantity of ground water alters only the distribution and not the nature of the various stream habitats, the periphyton assemblages above and below the effluent should tend toward similarity. If the alterations include some physical and/or chemical changes, then the periphyton communities should show some degree of disparity. This study is an analysis of the diatoms of the periphyton communities above and below the NJZ effluent in this context.

METHODS

The periphyton community was sampled by submersing glass slides just below the water surface in holders constructed of styrofoam and galvanized tin coated with epoxy paint. Slides were immersed for one week periods for three weeks during May and June of 1967, the week permitting abundant colonization while keeping populations low enough for high resolution light microscopy. Sampling stations (Fig. 1) were selected 0.7 km above the effluent (Station A), 0.8 km below the effluent (Station B), and in a tributary 0.5 km before its confluence with the main branch of the Saucon (Station C). The tributary station was chosen to permit examination of a second reference area in the Saucon watershed. The colonized slides were fixed in chromic acid-acid alcohol, and stained with a methylene blue-acid fuchsin counterstain. With this technique, detritus retained the blue color, while cytoplasm stained pink. Large diatoms (*Nitzschia sigmoidea,*

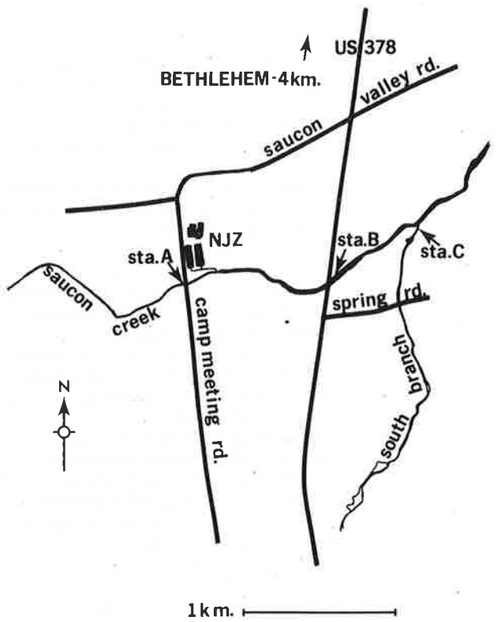


FIGURE 1. Map of Saucon Valley, with two branches of Saucon Creek and sampling stations indicated. Map is traced from USGS SW/4 Allentown 15' quadrangle (1964).

[1]Received January 4, 1977; revised; accepted July 13, 1977.

Fragilaria crotonensis, and *Cymatopleura elliptica)* were totally censused under low power (35x); the numbers of smaller diatoms were estimated from counts of five or more randomly chosen slide coordinates at either 120x or 400x magnification. Total slide populations were estimated by extrapolation from the slide area surveyed to the total slide area (19.4cm²); the extent of extrapolation was a factor of 6 x 10^2 at 120x and 6.7 x 10^3 for the 400x counts. The average number of cells identified and counted was 864 at A, 134 at B, and 621 at C. Identification to species was accomplished by reference to Cleve-Euler (1951), Tiffany and Britton (1952), Prescott (1962), and Patrick and Reimer (1966). Species diversity values in bits (H'_D) were computed from the Shannon-Weaver information equation (Shannon and Weaver, 1949), and similarity values (H'_S) were derived as suggested by Hummon (1974).

RESULTS

Table 1 lists the diatom species identified at each station over the three-week assessment period. Population estimates for each species are averaged number estimates per slide area for the three one-week samples. Listed below are total number of identified species, total estimated numbers per slide area, and Shannon-Weaver diversity values for the three-week averaged diatom populations. Table 2 lists the diversity indices for each of the three one-week samples, followed by the average of the three.

DISCUSSION

Tables 1 and 2 clearly demonstrate that the diatom community downstream from the NJZ effluent sustains substantial reductions in estimated population numbers, species richness, and species diversity, as well as replacement of dominant species. The reduction in both numbers and diversity implies that the benthic habitat is made unsuitable for most diatom species, and no tolerant form shows a compensatory high population growth. The persistence or appearance of several tolerant genera — *Achnanthes, Surirella, Synedra* — implies that the alteration of the downstream habitat is tolerable to some periphytic diatoms, so the possibility of chemical toxicity, if present, is somewhat selective in its activity.

Tables 1 and 2 also demonstrate that the second reference area, the southern tributary of the Saucon, shows a strong similarity to the Saucon above NJZ. Areas A and C share 18 of 21 species in common, whereas areas A and B share only 4 of 21 species. These observations are substantiated by computation of Hummon similarity values. Areas A and C have a similarity value of 2.08, while the values for the A-B and B-C comparisons are 0.57 and 0.52, respectively. Similarity values may vary from zero to the mean H'_D value of the site pairing (Hummon, 1974).

In addition to diversity and similarity analyses, identification of dominant taxa (in numbers) shows that *Cymbella ventricosa, Navicula rhynchocephala, Nitzschia palea,* and *Meridion circulare* are prominent in the reference areas A and C, while *Surirella angusta* and *S. linearis* are most abundant in the perturbed area B. Twenty-one diatom species (78 percent) identified in the reference areas are not seen immediately below the NJZ effluent.

TABLE 1

Taxonomic representation and average population estimates for identified diatom species at upstream (A), downstream (B), and tributary (C) stations. Below are total taxa identified, estimated total diatom numbers per slide (19.4 cm²) and diversity indices for the populations listed.

TAXON	Station A	Station B	Station C
Achnanthes minutissima (Kuetzing) Cleve	6400	1400	1800
Achnanthes lanceolata (Brébisson) Grunow	15200	5800	12200
Caloneis trinodis (Lewis) Boyer	200	—	—
Cocconeis placentula Ehrenberg	28467	—	5000
Cymbella tumida (Brébisson) Van Heurck	7	—	—
Cymbella ventricosa Kuenzing	30067	—	47200
Cyclotella melosiroides (Kirchner) Lemmerman	1062	—	3600
Cymatopleura elliptica (Brébisson) Wm Smith	257	—	579
Diatoma hiemale (Lyngbye) Heiberg	800	—	7457
Fragilaria crotonensis Kitton	6076	600	15400
Fragilaria capucina Desmazieres	3833	—	3467
Gomphonema olivaceum (Lyngbye) Kuenzing	—	—	2400
Gomphonema sphaerophorum Ehrenberg	56	—	400
Melosira varians C. A. Agardh	6433	—	12720
Meridion circulare (Grenville) C. A. Agardh	19293	—	23800
Navicula dicephala (Ehrenberg) Wm Smith	—	—	600
Navicula rhynchocephala Kuenzing	37000	—	15600
Navicula viridula Kuenzing	656	—	2200
Nitzschia dissipata (Kuenzing) Grunow	11000	—	1000
Nitzschia linearis (Agardh) Wm Smith	400	—	—
Nitzschia palea (Kuenzing) Wm Smith	43149	400	12000
Nitzschia sigmoidea (Nitzsch) Wm Smith	17	—	67
Rhoicosphenia curvata (Kuenzing) Grunow	—	—	5000
Surirella angusta Kuenzing	—	15000	—
Surirella linearis Wm Smith	—	21700	20
Synedra incisa Boyer	—	—	1000
Synedra ulna (Nitzsch) Ehrengerg	2400	—	—
Taxa	21	6	22
Estimated numbers/slide (19.4 cm²)	213313	44900	173510
Diversity	3.24	1.72	3.46

TABLE 2

Diversity estimates for consecutive one-week sampling periods for upstream (A), downstream (B), and tributary (C) stations. Included are the averages of the three values.

SAMPLE	A	B	C
May 23	3.09	0.45	2.76
May 30	2.77	1.67	3.06
June 6	2.67	1.50	2.89
Mean Diversity	2.84	1.21	2.90

Three possible causes for the observed declines and alterations may be proposed. The first is the effect of large amounts of suspended solids (66 lbs/day) entering the stream. Most of these particles may wash through the area studied, but some are retained as a fine grey coating on the rocks of the stream bottom. The entrapment of these particles in and on the benthic habitat may physically alter the surface and interstitial microhabitats, discourage the attachment of diatom colonies, and abrade those colonies which do temporarily attach. Detrimental effects of silt from road construction on periphyton and benthic invertebrates have been described by King and Ball (1964).

A second property of the NJZ effluent is an increased concentration of zinc. Total effluent zinc as reported by NJZ is 1.55 ppm; of this, dissolved zinc constitutes 0.67 ppm. Williams and Mount (1965) investigated the effects of increased zinc concentrations on the growth of periphyton in flowing channels. They found that an increase in concentration from 0.13 to 1.1 ppm caused a 48 percent reduction in species representation. Of the diatoms observed, the genera *Cymbella* and *Gomphonema* were noted as zinc-intolerant, while *Nitzschia* and *Synedra* were considered zinc-tolerant.

A third effect of the ground-water effluent is the alteration of the annual temperature regime of the stream. Large additions of constant-temperature ground-water keep the stream temperatures cooler in summer and warmer in winter (Jan., 9.8°C; June, 17.3°C; 1977). The predicted effects of water of relatively constant chemical and physical characteristics should be to reduce the number of species in the diatom community, and encourage large populations of those tolerant species (Patrick, 1964).

No single one of the aforementioned perturbations appears to account for the changes in the diatom community downstream of the NJZ effluent. The slides do not become heaviy silted in their one-week submersion, so colonization by drifting species should be possible. In the control areas, colonization proceeds so quickly that after one week, conspicuous tufts and filaments of diatom colonies are extending from the slide surface. There is a possibility of zinc toxicity; however, at least six diatom species find the heavy metal characteristics of the stream tolerable, if not favorable, for growth. No compensatory population increases are seen in the affected areas, except for the appearance of the two *Surirella* species, *S. angusta* and *S. linearis,* as might be expected in the course of temperature alteration.

At the present, the most reasonable interpretation of the causes of the alterations in the diatom community below the NJZ effluent is a combined effect of suspended and entrapped fine particulates, chemical toxicity of zinc ions, and relatively constant water temperatures. Each of these factors has demonstrable effects on decreasing population numbers and/or species diversity. However, their separate influences cannot be isolated in the natural conditions of the Saucon watershed, and must be simulated under controlled laboratory conditions.

SUMMARY

The hypothesis that the biotic assemblages respond to alteration of the habitat is investigated in the diatom community of Saucon Creek, near Bethlehem, Pa. The creek receives a mine-pumped effluent which increases suspended solids and zinc concentration of the downstream environment, while decreasing temperature variation in the stream water. The alteration in the communities studied is demonstrated by taxonomic lists, Shannon-Weaver diversity values, and Hummon similarity values. The depression in standing crop, species richness, and community diversity cannotn be presently attributed to any single physical or chemical alteration, but may be due to the additive action of siltation, temperature modification, and zinc toxicity. The most tolerant diatom genera seen are *Achnanthes, Surirella,* and *Synedra.*

ACKNOWLEDGMENTS

I am indebted to Dr. Bradford B. Owen for his advice and technical assistance. Parts of this work were supported by a National Science Foundation Undergraduate Research Participation Fellowship.

REFERENCES

Cleve-Euler, A.M. 1951. *Die Diatomeen von Schweden und Finnland.* Svenska ventenskapsakademien, Stockholm. 5 vol.

Ettinger, W.S., and Kim, K.C. 1975. Benthic insect species composition in relation to water quality in Sinking Creek, Centre County, Pennsylvania. *Proc. Pa. Acad. Sci.* 49)2): 150-154.

Hummon, W.D. 1974. S'_H: a similarity index based on shared species. *Oecologica* 17: 203-220.

King, D. L., and Ball, R. C. 1964. The influence of highway construction on a stream. *Res. Rep. Mich. St. agric. Exp. Stn,* 19. 4 pp.

Macan, T. T., and Worthington, E.B. 1951. *Life in Lakes and Rivers.* Praeger, N.Y. 272 pp.

Patrick, R. 1951. Diatoms as indicators of changes in environmental conditions. *Trans. Sem. on Biol. Prob. Water Poll. R. A. Taft San Engr. Center,* Cinn., Ohio. pp. 71-83.

Patrick, R. 1964. A discussion of natural and abnormal diatom communities, p. 191. In D. F. Jackson (ed.), Algae and Man, Plenum Press, N.Y.

Patrick, R., and Reimer, C. W. 1966. *The Diatoms of the United States.* Academy of Natural Sciences of Philadelphia. Monograph, no. 13

Prescott, G. W. 1962. *Algae of the Western Great Lakes Area.* Wm. C. Brown Co., Iowa. 977 pp.

Shannon, C. E., and Weaver, W. 1949. *The Mathematical Theory of Communication.* Univ. Illinois Press, Ill. p. 14.

Tiffany, L. H., and Britton, M. E. 1952. *The Algae of Illinois.* Univ. Chicago Press, Chicago. 407 pp.

Williams, L. G., and Mount, D. I. 1965. Influence of zinc on periphyton communities. *Am. J. Bot.* 52(1): 26-34.

Proceedings of the Pennsylvania Academy of Science 51:54–56. 1977.

FORMED BLOOD ELEMENTS OF THE MUSSEL ELLIPTIO COMPLANATUM[1]

BONNI J. HAZLETON[2] and GEORGE R. ISENBERG

Department of Biology
State University College
Potsdam, N.Y. 13676

ABSTRACT

Three types of formed elements, viz. small basophils, large basophils and acidophils occur in the blood of the freshwater mussel, *E. complanatum*. The distribution of these three types of cells in the blood is 6.04% for small basophils, 52.44% for large basophils and 42.04% for the acidophils. All three types of elements can be differentiated by their degree of cytoplsamic granulation (acidophils > large basophils > small basophils). However, large basophils usually contain large vacuoles as compared to the other two types of elements. Small basophils appeared to have a larger nuclear-cytoplasmic ratio.

INTRODUCTION

Blood cells characteristically found in the circulatory systems of molluscs are called amoebocytes because of their ability to move independently (Wagge (1), Takatsuki (2)). These blood cells have been classified into three cell types: (1) small basophils; (2) large basophils; and (3) acidophils by Wagge (1), Ceunot (3), Narain (4), George and Ferguson (5) and Dundee (6). The main criteria used by these authors were the nature of cytoplasmic granulation, staining properties of cytoplasm and its granules, and the volume of cells possessed by their nuclei. The large basophil is described as possessing a hyaline or very finely granular cytoplasm interspersed with vacuoles and extensive filipoddial processes. In comparison, the acidophil has extremely coarse granular cytoplasm and more restricted processes. Both of the above cell types exhibit phagocytic activity (Wagge (1), Takatsuki (2), Narain (4)). In addition, the third cell type, the small basophil is described as a relatively small cell with no observable cytoplasm, or a minimal amount of hyaline cytoplasm.

Moore and Eble (7) reproted three cell types in the hard clam, *Mercenaria mercenaria;* an agranulocyte and small and large granulocytes. Their classification was based on cell size, nuclear size, number of cytoplsamic granules, endoplasmic/ectoplasmic ratio, and motility.

Research has previously been done on a variety of freshwater mussels of various genera. In particular, the studies by Narain (4) and Dundee (6) investigated the formed blood elements with regard to cell type, differential distribution, and total cell number. Fluctuations in cell number from different time periods were noted by these investigators. Feng (8) and Narain (4, 9) proposed that, because of their relationship to the feeding process, these fluctuations in cell number were indicative of cardiac rhythm or the feeding state of the individual at the time of cell extraction. Dundee (6) suggests that the number of blood cells is likely to vary during blood extraction, since mussels shed their blood cells under abnormal conditions.

E. complanatum is a fresh water mussel common to the Atlantic drainage basin, from the St. Lawrence River south to Georgia and west in the British provinces to Manitoba (Baker (10)). The present study attempts to compare blood cell types and their distribution in *E. complanatum* with the freshwater mussels reported by Dundee (6) and Narain (4).

MATERIALS AND METHODS

Mussels were collected from the Racquette River in the Village of Potsdam, N.Y. and maintained in an aquarium in the laboratory. The aquarium containing river sediment and water was constantly aerated by means of an aquarium pump. River water was added to the aquarium occasionally to maintain the desired water level. The mortality rate under these conditions was minimal with many specimens lasting for periods of to several months.

Blood samples were removed from the specimens by means of a 2.5 cc syringe. The needle was inserted into the ventricle of a freshly-opened animal and small quantity of blood withdrawn.

Cell sizing and total cell counts were determined using unstained blood samples. The length of 50 randomly selected blood cells of each type and their nuclei was measured with an ocular micrometer. Total cell counts of five samples from each of five specimens were determined by using a Neubauer counting chamber.

Differential cell counts were made from blood smears stained with Wright's stain. To obtain an acceptable blood smear all slides were pre-treated with a slide adhesive (Tissue-Tac, Dade Co.) and exposed to formalin vapors for ten minutes (Liebman (11)). A fresh sample of blood was smeared on the slide in the same manner as that used in making human blood smears. The slide was placed on a slide dryer and then stained. Samples taken from five mussels were prepared in the preceding manner. Each slide was divided into eight sections of 3mm squares and all cells were counted within five randomly selected sections.

RESULTS AND DISCUSSION

The length of each blood cell type and their nuclei found in *E. complanatum* are found in Table 1. The three cell types were found to be larger than those reported by Narain (4) and Dundee (6). The nuclear-cytoplsamic cell body ratios observed in *E. complanatum* are comparable to those found by Dundee (6) and Narain (4) (Figure 1). The macronucleocyte described by Dundee (6) had the largest cell body whereas the comparable small basophil reported by Narain (4) was the smallest of the three cell types. This was found to be the same in *E. complanatum*.

The mean total count of blood cells per cubic millimeter of blood reported by Dundee (6) ranged from 1913 to 648 cells for the eleven species she studied. The author noted that within each species and within each individual the total blood cell count varied considerably. Narain's (4) results were similar with the mean average of 758 cells per cubic millimeter for *Lamellidens corianus*. Again the counts varied greatly. Total blood cell counts for *E. complanatum* (Table 2) support the fact that the number of blood cells present varies a great deal even in the same specimen at different times.

The blood cell count variability may be explained by the fact that the open circulatory system of the mussel allows for free movement of the amoebocytes. Because of their digestive function, (Wagge (1), Takatsuki (2), Owen (12)) the amoebocyte number may vary in a specimen depending on the stage of feeding and/or the cardiac rhythm (Feng(8), Narain (9)). The problem of cell clumping also restricts and caused great variation in cell counts (Narain (4)), but with careful handling clumping can be held to a minimum.

Dundee (6) presented statistics on eleven mussel species noting that the acidophils comprised 85.2% of the total blood cell count, large basophils 7.3% and small basophils 7.5%. Results reported by Narain (4) state that the large basophil represented 60.2% of the total count, acidophils 26.3% and small basophils 13.5%.

Differential cell counts obtained in the studies of *E. complanatum* are reported in Table 3. The findings are more comparable to the data presented by Narain (4) (see Figure 2). It can be seen from Table 3 that not only do the total cell counts vary but the percentages of cell types varies appreciably in samples drawn from different specimens or from the same specimen.

The interference that can be made with respect to differential cell counts may possibly be attributed to the function of the various blood cell types. Variability in percentages may be due to the fact that blood cells with a particular function in a certain stage of metabolism are in other areas of the mussel body fulfilling an excretory or digestive function, therefore lowering percentages of that cell type in the area of extraction.

In our studies we found that the large basophils, perhaps because of their extensive filipodia, were more susceptible to clumping than were other cell types. This may be a factor in the variability of the differential cell counts.

[1]Received April 18, 1977; revised; accepted August 2, 1977.
[2]Present Address: Department of Biology, Syracuse Univeristy, Syracuse, N.Y. 13210.

TABLE 1

Measurements of the blood cells of E. complanatum

Type of Blood Cell	Cell Length (μ)	Nucleus Length (μ)
Acidophils		
Mean	15.9 (± .61)*	5.3 (± .07)
Range	12-31.2	4.8-7.2
S.D.	± 4.28	± .50
Basophils		
Mean	17.3 (± .42)*	6.0 (± .11)
Range	12.24	4.8-7.2
S.D.	± 2.94	± .77
Small Basophils		
Mean	9.2 (± .16)*	6.7 (± .09)
Range	7.2-12	4.8-7.2
S.D.	± 1.11	± .67

* Standard error of the mean.

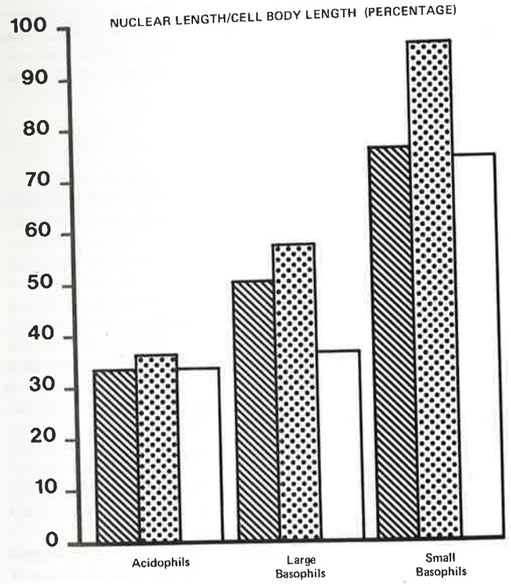


Figure 1. Nuclear-cell body length ratios as indicated by Dundee (6), Narain (4) and present results with E.complanatum.

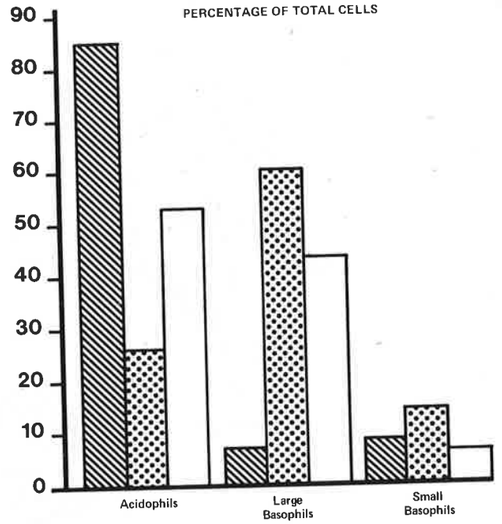


Figure 2. Cell distribution of formed elements as reported by Dundee (6), Narain (4) and present results from E.complanatum.

TABLE 2

Total blood cell counts of E. complanatum

Mussel	Sample Counts (cells/cu. mm. blood) 1	2	3	4	5	Mean	Standard Deviation
I	1700	1550	900	1300	1350	1360 (± 135.2)*	± 302.9
II	650	800	650	500	750	670 (± 51.4)*	± 115.1
III	950	950	1150	550	750	850 (± 101.8)*	± 228.0
IV	750	950	650	650	550	710 (± 67.7)*	± 151.7
V	1500	500	600	900	1100	920 (± 179.7)*	± 402.5

Standard error of the mean.

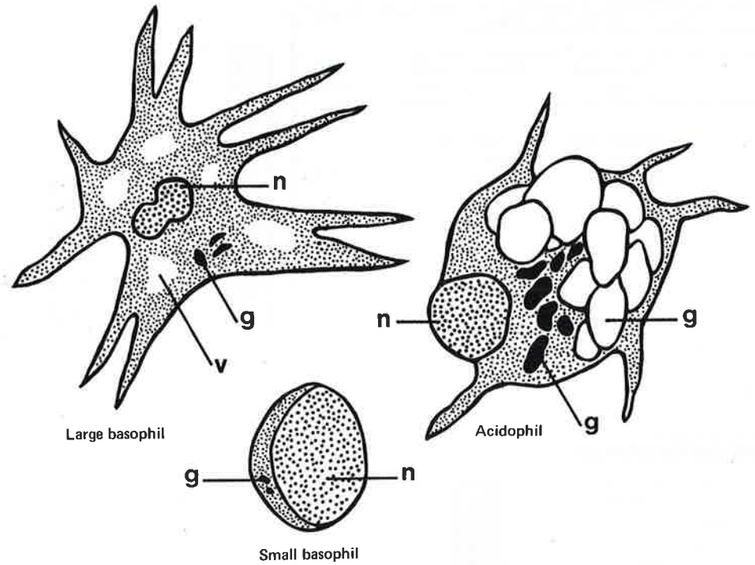


Figure 3. Diagrammatic sketches of relative size, degree of granulation, representative nuclear-cell body ratio and extent of filipodial extensions (n - nucleus ; g - granule ; v - vacuole) .

TABLE 3

Results of differential counts of blood cells of E. complanatum. *Wright's Stain.*

	Small Basophil	Large Basophil	Acidophil
Mussel I			
cell count	161	722	880
% Cell Type	9.1%	41.0%	49.9%
Mussel II			
cell count	91	621	856
% Cell Type	5.8%	39.6%	54.6%
Mussel III			
cell count	46	400	782
% Cell Type	3.7%	32.6%	63.7%
Mussel IV			
cell count	63	487	800
% Cell Type	4.6%	36.1%	59.3%
Mussel V			
cell count	45	376	224
% Cell Type	7.0%	58.3%	34.7%

The selection of parameters for identification of the blood cells of *E. complanatum* has been based mainly upon the descriptions and drawings by Dundee (6) and Narain (4) for other bivalve blood cells. The diagrammatic sketch of the three blood cell types in *E. complanatum* (Figure 3) points out some characteristic features useful in determining differential counts. In the large basophil, filipodial processes are much more extensive than in the acidophil. The same processes appear to be lacking in the small basophil. Both the acidophil and small basophil have regular, oval or spherical nuclei. In many instances, large basophils have bi-lobed, kidney shaped or irregularly shaped nuclei. The large basophil unlike the other two cell types has cytoplasmic vacuolation.

ACKNOWLEDGEMENTS

Thanks are extended to Dr. Robert H. Cerwonka for assistance in classification of *E. complanatum* and Dr. Pei-show Juo for suggestions and manuscript review. Special thanks to Mr. Leroy Madison and Miss Susanne Langelier for the illustrative materials.

LITERATURE CITED

1. Wagge, L.E. 1955. Amoebocytes. *Int. Rev. Cytol.* 4: 31-78.
2. Takatsuki, S. 1934. On the nature and functions of amoebocytes of *Ostrea edulis. Quart. J. Microsc. Sci.*, 76: 379-431.
3. Cuenot, L. 1891. Etudes sur le sang et les glandes lymphatiques dans la serie animale (2 Portie: Invertebres). *Arch. Z. Exper.* 9: 19-54.
4. Narain, A.S. 1972. Formed elements of the blood of the freshwater mussel. *Lamellidens corrianus. J. Morph.* 137: 63-70.
5. George, W.C. and Ferguson, J.H. 1950. The blood of gastropod molluscs. *J. Morph.* 86: 315-324.
6. Dundee, D.S. 1953. Formed elements of the blood of certain fresh-water mussels. *Trans Amer. Microsc. Soc.* 72: 254-264.
7. Moore, C.A. and Eble, Albert F. 1977. Cytochemical aspects of *Mercenaria mercenaria* hemocytes. *Biol. Bull.* 152 (1): 105-119.
8. Feng, S.Y. 1965. Heart rate and leucocyte circulation in *Crassostrea virginica* (Gmelin). Biol. Bull. 128: 198-210.
9. Narain, A.S. 1973. The amoebocytes of Lamellibranch molluscs, with special reference to the circulating amoebocytes. Mal. Rev. 6: 1-12.
10. Baker, F.C. 1928. The Fresh Water Mollusca of Wisconsin. Part II, Pelecypoda, Univ. of Wisconsin Geolgocial Nat. Hist. Survey. 70: 30.
11. Liebman, E. 1945. Preparation of blood smears with the formalin vapor method. *Stain Technology.* 20: 83-84.
12. Owen, G. 1966. In: Physiology of Mollusca. K.M. Wilbur and C.M. Yonge, eds. Academic Press, New York and London. 11: 53-96.

Proceedings of the Pennsylvania Academy of Science 51:57—58. 1977.

OBSERVATIONS ON THE NOCTURNAL BEHAVIOR OF FERAL PONIES[1]

DR. RONALD R. KEIPER

Pennsylvania State University
Mont Alto, Pennsylvania 17237

ABSTRACT

The nocturnal behavior of feral ponies was recorded during 68 hours of direct field observation during the summer of 1976. Observations were made between 1900-0500 EST. Data was recorded at 1 minute intervals for each hour of darkness for five different kinds of behavior: grazing, resting, grooming, drinking and walking behavior. Grazing occurred intensely for several hours after dark and just before dawn. Resting was seen at all hours, but occurred most frequently during the early morning hours. Walking and drinking occurred primarily just after dark when the animals moved to water holes for water. Grooming behaviors occurred at constant low levels throughout the night.

INTRODUCTION

In the last decade a number of field studies have investigated the behavior of feral mustangs (1), ponies (2), and burros (3) and considerable insight has been gained concerning the daily and seasonal activity patterns. However, essentially all this information describes behavior during the daylight hours, and virtually nothing is known of equine nocturnal behavior. This dearth of knowledge results from a variety of factors including the lack of tolerance on the part of the animals to the nocturnal presence of man, the size and topography of the study area, and the lack of proper equipment for carrying out observations in the dark.

In the present study observations were made on the nocturnal behavior of feral ponies that live on Assateague Island, a 37 mile long barrier island that parallels the Atlantic coast of Maryland and Virginia. The primary objective was to determine the activity patterns displayed by the ponies during the hours of darkness. This research was possible because the animals are acclimated to the presence of man and could be observed, using flashlights and a night vision scope, from short distances without affecting the normal behavior. The topography of Assateague Island also facilitated observation, for the land is mostly flat and consists primarily of saltmarsh.

MATERIALS AND METHODS

The study was conducted in an area of about 1800 acres within the Chincoteague National Wildlife Refuge on the southern (Virginia) portion of Assateague Island. Approximately 100 ponies occupy this acreage and lead a relatively wild existence in that they roam freely and obtain their own food throughout the year. Each pony could be individually recognized on the basis of sex, size, color and markings, and each was assigned a code letter, indicating herd membership, as well as a code number.

Observations were conducted from 1900-0500 EST on seven evenings during the summer of 1976 (2 evenings in June, 3 evenings in July, and 2 evenings in August) for a total of 68 hours of direct field observation. During each observation period the behavior of the ponies was monitored using a Starlight Image Intensifier Scope. Battery powered lanterns were also used to check behavior and did not disturb the animals as long as illumination was limited to periods of about 10 seconds. Data were collected on the behavior of individual animals as well as on the entire herd using check sheets on which various activities were recorded at 1 minute intervals for each hour of darkness. Seven different kinds of maintenance behavior were recognized: Grazing, Standing (a resting behavior), Lying Down, Walking, Drinking, Rubbing-Rolling (forms of auto-grooming), and Mutual Grooming.

[1]Received April 27, 1977; revised; accepted August 4, 1977.

RESULTS AND DISCUSSION

Observations of the nocturnal behavior of the Assateague ponies revealed that the animals spent almost half (49.7%) of the 10 hours between 1900-0500 EST engaged in grazing behavior. The ponies also spent 42.2% of the time engaged in resting behaviors.

These results are quite different from those obtained from studies on domestic cattle, where the animals grazed only 10-15% of the time at night (4,5,6) and on domestic sheep, where grazing occurred approximately 33% of the time (7).

Detailed study (Table 1) of the activities of the ponies showed that the animals tended to have a definite behavioral pattern over the course of the night. Following the onset of darkness the ponies moved to water, for walking behavior was significantly higher in the first hour after dark than in any other hour (one factor analysis of variance, $P < 0.01$). Likewise drinking behavior was recorded only during the first two hours after darkness. Movement to water just before and following sunset (1900) has also been noted in zebras (8), although observations were terminated at 2000 hours. On the other hand Blakeslee (9) reported that free-ranging Appaloosa horses were never observed drinking at night.

Although grazing behavior occured to some extent in every hour of darkness, some primary grazing periods, where grazing took place at significantly higher levels ($P < 0.01$), can be noted. The first period began at sunset and continued until about 2400. The second period occurred between 0100 and 0300, followed by a significant decrease in grazing from 0300-0400. The final grazing period began about 0400 and continued after sunrise. Cows also displayed primary feeding periods from 2030-2300 and from 0100-0330 (4).

As night progressed grazing activity decreased and resting behaviors increased. This transistion often involved a gradual movement while grazing from feeding areas in the marsh to resting sites located on "islands" (elevations of sand covered with stands of pine and oak) scattered throughout the marsh. Although lying down was the predominate form of resting behavior seen in cattle (5), "standing" behavior was more commonly seen in the ponies. This resting activity occupied 26.6% of the hours of darkness and was most frequent at 2200 (Table 1).

In standing behavior the animal usually lowered the head so as to bring the neck horizontal to the ground, pointed the ears out or slightly back, partially or fully closed the eyes, and took the weight off one of the hind legs. The bones were locked in place to provide a rigid framework and many of the body muscles were relaxed.

Another resting activity, lying down, was also observed in the ponies and occupied approximately 15.5% of the total study time. Lying down occured at low levels in early evening and reached a peak in the early morning hours (Table 1). A similar pattern has been noted by Blakeslee (9) who found that many of her horses lay down in lateral recumbency during the middle of the night (from about 0200-0300).

Lying down was accomplished via either lateral or sternal recumbency.

TABLE 1

Nocturnal Behavior of Feral Ponies

Hours	# of Animals	Frequency of Behaviors G	S	D	W	R	Dr.	MG
1900-2000 EST	65	37.4	10.7	0.60	9.91	0.46	0.18	0.12
2000-2100 EST	93	37.5	11.2	4.20	5.81*	0.29	0.37	0.34
2100-2200 EST	73	34.2	12.9	8.50	3.20*	0.07	0.00*	0.43
2200-2300 EST	75	25.1	25.5*	7.60	0.80*	0.21	0.00*	0.16
2300-2400 EST	77	28.2	21.5	9.20	0.41*	0.05	0.00*	0.08
2400-0100 EST	85	23.1*	21.0	14.7*	0.40*	0.09	0.00*	0.09
0100-0200 EST	44	28.7	17.8	12.2	0.75*	0.00	0.00*	0.09
0200-0300 EST	71	35.7	10.6	12.8*	0.54*	0.06	0.00*	0.06
0300-0400 EST	55	21.5*	19.1	19.3*	0.29*	0.00	0.00*	0.00
0400-0500 EST	40	36.0	14.8	8.3	0.41*	0.00	0.00*	0.00

*The frequencies are expressed as the mean of the repeated observations for each hour. Statistical analysis utilized one way analysis of variance. Significant differences between hours are indicated by one star. ($P < 0.01$)

G = Grazing; S = Stand; D = Lying Down; W = Running or Walking; R = Rubbing or Rolling; Dr. = Drinking; MG = Mutual Grooming.

In lateral recumbency the animal lay on its side with its head upon the ground and its legs stretched outward. In sternal recumbency the animal rested with its weight on its sternum, its head upright, and its legs partially folded under the body.

Although foals spent large amounts of time in these positions, mature ponies only occasionally slept lying down. Likewise adults never lay down for as long as 60 minutes whereas that time period was common for younger animals. Despite the high frequency of lying down in the early morning (between 0100 and 0400) no observations were made of the entire herd lying down. However, daytime observations of free-ranging Appaloosa horses have revealed times when entire herds were recumbent at one time (10).

The other behaviors for which data were collected occured at low frequencies throughout the night (Table 1) and there was no significant difference in their frequency with respect to time of night.

In conclusion, nocturnal observation of feral ponies does suggest that a definite activity pattern occurs over the course of the night. The animals move to water holes and drink following the onset of darkness, then display a high level of grazing behavior.

As the evening passes, there is a transition from grazing to resting behavior, with lying down increasing in frequency during the early morning hours. Often this transition involves a movement from grazing to resting sites. Just before dawn, grazing behavior increases in frequency and resting activities decrease.

Grooming behaviors occur at relatively low frequencies throughout the night and the levels are constant regardless of time.

Additional data will be collected in the future on the nocturnal activities of feral ponies both during the summer and at other seasons of the year so that further insight can be gained on this aspect of equine behavior.

ACKNOWLEDGEMENTS

This research was funded by Earthwatch and the Center for Field Research of Belmont, Massachusetts. The author also wishes to express his thanks to the National Park Service, the Chincoteague Wildlife Refuge, and the Chincoteague Volunteer Fire Company for granting me access to their lands and permission to observe the Assateague ponies. I also thank the Chincoteague National Wildlife Refuge for allowing me to use the Starlight Image Intensifier Scope.

REFERENCES

1. Feist, J.D. 1971. Behavior of Feral Horses in The Pryor Mountain Wild Horse Range. Unpublished M.S. thesis. University of Michigan, Ann Arbor.
2. Tyler, S.J. 1972. The Behavior and Social Organization of the New Forest Ponies. *Animal Behav. Mono.* 5(2): 87-196.
3. Moehlman, P.D. 1974. Behavior and Ecology of Feral Asses (*Equus asinus*) Unpublished Ph.D. thesis. University of Wisconsin, Madison.
4. Atkeson, F.W., et al. Grazing Habits of Dairy Cattle. *J. Dairy Sci.* 25: 779-784.
5. Castle, M.E. and R.J. Halley. 1953. The Grazing Behavior of Dairy Cattle at the National Institute for Research in Dairying. *Brit. J. of Anim. Behav.* 1:139-143.
6. roubicek, C.B. 1961. Nocturnal Behavior of Beef Cattle in the feedlot during summer. *J. Anim. Sci.* 20:665.
7. Tribe, D.E. 1949. Some Seasonal Observations on the Grazing Habits of Sheep. *Empire J. Exp. Agri.* 17:105-115.
8. Joubert, E. 1972. Activity Patterns shown by Mountain Zebra in Southwest Africa with Reference to Climatic Factors. *Zoologica Africana* 7(1):309-331.
9. Blakeslee, J.K. 1974. Mother-young Relationships and Related Behavior Among Free-Ranging Appaloosa Horses. Unpublished M.S. thesis. Idaho State University, Pocatello.
10. Stebbins, M.C. 1974. Social Organization in Free-Ranging Appaloosa Horses. Unpublished M.S. thesis. Idaho State University, Pocatello.

Proceedings of the Pennsylvania Academy of Science 51:59—66. 1977.

FISHES OF THE CONEWAGO CREEK DRAINAGE, YORK AND ADAMS COUNTIES, PENNSYLVANIA[1] [2]

PHILIP C. RITSON, JANET L. POLK and ROBERT W. MALICK, JR.

Ichthyological Associates, Inc.
Three Mile Island Aquatic Study
P.O. Box 223
Etters, PA 17319

ABSTRACT

An ichthyofaunal survey of Conewago Creek, a tributary of the lower Susquehanna River, was conducted May through November, 1976. Forty-seven species of fish and one hybrid combination were taken in 75 collections at 49 stations. Most abundant species were the bluntnose minnow, blacknose dace, spotfin shiner, and white sucker. Most cold-water fishes were restricted to the upper reaches; holdover and natural reproduction of stocked trout were confined to the headwaters of the main branch. Breeding populations of the silverjaw minnow and banded darter, recently common in the lower Susquehanna, were found in several subdrainages. The silvery minnow, a new record for the Susquehanna River above Conowingo Dam, was found in Beaverdam Creek, a small tributary.

Shannon-Weaver ($\bar{d}$) and Probability of Interspecific Encounter (PIE) diversity indices at individual stations ranged from 0.92 to 4.08 and 0.29 to 0.93, respectively. comparisons using Kendall's coefficient of rank correlation test indicated low to moderate similarity in rankings of species among subdrainages.

INTRODUCTION

Conewago Creek and its tributaries (Figure 1) drain 1,320 km² of the Gettysburg Plain of the Piedmont Province in York and Adams counties, Pennsylvania and 13.5 km² in Carroll County, Maryland (Shaw and Busch 1970). The main stream heads in Buchanan Valley within South Mountain and encompasses about one-half of the Adams County watershed (Stose 1932). South Branch of Conewago Creek arises in the slate hills of southwestern York County and Carroll County, Maryland, flows north across Adams County, and joins the main stream near New Chester (Stose and Jonas 1939). The Conewago then flows northeasterly through York County and enters the Susquehanna River at York Haven. The stream at one time divided at the flood plain of the river; one branch flowed north to York Haven and the other south along the west side of Brunner Island to enter the river at Saginaw. All flow is now directed north to York Haven.

Dams and impoundments for recreation and water power have been created throughout the drainage. Recreational lakes include Pinchot Lake on Beaver Creek, Silver Lake on Bennett Run, and Lake Meade on Mud Run. Dams capable of prohibiting fish movement exist at Detters Mill, East Berlin, and New Chester.

The Pennsylvania Fish Commission (PFC) began an extensive stocking program in 1932. Warm-water fishes stocked throughout the drainage included eels, minnows, suckers, catfish, sunfish, bass, and yellow perch. Recently, stocking programs were largely restricted to Pinchot Lake and the Upper Conewago. Pinchot Lake was periodically stocked with northern pike, muskellunge, largemouth bass, and walleye. Trout were annually stocked in Adams County in the Conewago Creek headwaters, Latimore Creek, and Opossum Creek.

Previous investigators (Fowler 1925, Tsai 1971, Conover 1972, Wallace 1973) have collected fishes in sections of the Conewago drainage. The PFC has conducted numerous surveys to evaluate the feasability of trout stocking and assess the impact of localized fish kills in the orchard district of Adams County. However, there has never been a survey of the entire drainage, or consolidation of published literature.

MATERIALS AND METHODS

Fishes were collected at 49 stations; 22 in York and 27 in Adams county from May through November, 1976. Approximately 100 m of stream were sampled at each station. All stations were sampled with a 3.05 m X 1.22 m seine (0.32 cm mesh). Additional samples were taken using a Sears 1250 watt, 3.5 hp AC generator (115 V, 10.8A) at stations where we expected electrofishing to yield other species. A representative sample of fishes from each station was preserved in 10% formalin, rinsed in water, and stored in 40% isopropanol. Other specimens, including most game fishes, were enumerated and released.

Air and water temperatures were recorded with each collection and the following water chemistry survey of 21 selected stations was made on 25 September: air and water temperatures with standard field thermometers, pH with a Photovolt 126 pH indicator, dissolved oxygen with a YS 54 oxygen analyzer, and dissolved carbon dioxide with an A10/CA-10WR Hach Kit.

Stations, chosen on the basis of accessability and location in the drainage, were numbered from headwaters to mouth for the main branch and tributaries. They were grouped and discussed by subdrainage: Stations 1-7, 15-17, Upper Conewago; 18-24, Beaverdam Creek; 25-29, South Branch Conewago; 8-11, 30, Middle Conewago; 31-40, Bermudian Creek; 41-44, Pinchot Park; 45-49, Little Conewago; 12-14, Lower Conewago (Figure 1).

Locations of stations are as follows: (1) Lippencott Spring Creek at bridge on Pennsylvania traffic route (PTR) 234, 2.4 km SW of Trust; (2) Conewago Creek at bridge on Legislative Route (LR) 01035, 0.8 km S of Trust; (3) Conewago Creek on PTR 234, 3.2 km NW of Arendtsville; (4) Conewago Creek at bridge on LR 01018, 1.6 km SE of Arendtsville; (5) Conewago Creek at bridge on PTR 394, 2.8 km SE of Biglerville; (6) Conewago Creek at bridge on LR 01005, 3.6 km N of Hunterstown; (7) Conewago Creek at bridge on LR 01004, 0.8 km N of New Chester; (8) Conewago Creek at bridge on PTR 234, 1.2 km W of East Berlin; (9) Conewago Creek at bridge on LR 66034, 1.6 km NW of Harmony Grove; (10) Conewago Creek at bridge on PTR 74, 2.8 km S of Rossville; (11) Conewago Creek at bridge on LR 66003, 1.6 km S of Erney; (12) Conewago Creek at bridge on PTR 181, 3.2 km N of Manchester; (13) Conewago Creek at Brunner Island off LR 66153, 1.6 km N of the mouth of the Conewago; (14) Mouth of Conewago Creek at bridge on LR 66153 in York Haven; (15) Opossum Creek at bridge on LR 01010, 1.6 km NW of Bendersville;; (16) Opossum Creek at bridge on PTR 34, 1.6 km E of Bendersville; (17) Opossum Creek at bridge on PTR 234, 3.2 km E of Biglerville; (18) Unnamed creek at culvert on US traffic route 15, 1.6 km N of the PTR 394 interchange; (19) Unnamed creek at bridge on LR 01005, 3.6 km N of Hunterstown; (20) Beaverdam Creek at bridge on PTR 394, 0.4 km W of Hunterstown; (21) Beaverdam Creek at bridge on LR 01005, 2.0 km N of Hunterstown;

[1]Received April 18, 1977; revised; accepted August 12, 1977.
[2]The study was supported by Metropolitan Edison Company.

(22) Beaverdam Creek on township road extension of LR 01067, 1.2 km NW of The Pines; (23) Beaverdam Creek at its confluence with Conewago Creek, 1.6 km upstream from the dam at New Chester; (24) Swift Run at bridge on LR 01067, 4.8 km NW of New Oxford; (25) Sterners Creek at bridge on PTR 194, 4.0 km E of Littlestown; (26) South Branch Conewago Creek at bridge on Sheppards Lane off LR 01005, 1.2 km SW of Mount Pleasant; (27) Plum Creek at the bridge on LR 66080, 2.8 km S of Hanover; (28) South Branch Conewago Creek at bridge on Stormstore Rd, 0.4 km downstream of confluence of Shovelsburg Creek and South Branch, and 2.4 km W of Irishtown; (29) South Branch Conewago Creek at bridge on LR 01004, 2.4 km N of New Oxford; (30) Beaver Creek at bridge on Profectory Rd., off PTR 194, 1.6 km N of Abbottstown; (31) Bermudian Creek at bridge on PTR 34, 0.4 km S of Idaville; (32) Bermudian Creek at bridge on Mill Rd. off LR 01011, 0.8 km N of Limerock Mill; (33) Latimore Creek at bridge on township road off LR 01009, 1.2 km S of Latimore; (34) Latimore Creek at bridge on township road off LR 01009, 2.0 km SE of Deardorffs Mills; (35) Bermudian Creek at Bridge on 01009, 0.4 km downstream of confluence with Latimore Creek and 3.2 km SE of Deardorffs Mills; (36) North Branch Bermudian Creek at bridge on spur E of LR 66022, 0.4 km SE of Clear Spring; (37) North Branch Bermudian Creek at bridge on LR 66022, 0.8 km E of Big Dam; (38) Bermudian Creek at bridge on LR 190 at confluence with North Branch, 1.6 km SW of Kralltown; (39) Doe Run at bridge on LR 190, 0.8 km SE of Kralltown; (40) Bermudian Creek at bridge on Bermudian Church Rd off LR 66035, 5.6 km W of Davidsburg; (41) Beaver Creek at bridge #212 on Squire Gratz Rd off LR 66006, 1.6 km N of Rossville; (42) Stony Run at bridge on Bull Rd at Confluence with Beaver Creek, 2.4 km NW of Alpine; (43) Stony Run at bridge on PTR 177, 2.4 km S of Lewisberry; (44) Bennett Run at bridge on LR 66087, 2.4 km N of Erney; (45) Paradise Creek at bridge on LR 66143, 2.0 km W of Taxville; (46) Little Conewago Creek at bridge on PTR 74, 0.4 km E of Weigelstown; (47) Fox Run at intersection of Bull Rd and Magnus Rd, 3.2 km E of Dover; (48) Little Conewago Creek at bridge on LR 66003, 7.2 km NE of Dover; (49) Little Conewago Creek at confluence with Conewago Creek off LR 66002, 4.0 km N of Manchester.

Diversity indices were calculated for each station using the machine formula of the Shannon-Weaver function presented by Lloyd et al. (1968):

$$\bar{d} = C/N\,(N\,Log_{10}N - \Sigma\, n_i Log_{10} n_i)$$

where $\bar{d}$ = the information per individual; c = 3.321928 (converts Log_{10} to Log_2); N = the total number of individuals; and n_i = the total number of individuals in the ith species. This index summarized information concerning the number of species present and the distribution of individuals among the species. Low $\bar{d}$ values result from a small number of species and an uneven distribution of individuals. Large numbers of species and an even distribution of individuals result in high $\bar{d}$ values.

The probability of interspecific encounter index (PIE) was also computed (Hulbert 1971):

$$PIE = \left(\frac{N}{N-1}\right)\left[1 - \sum_{i=1}^{s}\left(\frac{N_i}{N}\right)^2\right]$$

where PIE = the probability that two specimens encountered at random in a community belong to different species; $N = \Sigma_i n_i$ = the total number of individuals in the community; and s = the number of species in the community. The PIE index was included in an attempt to find a more descriptive index for fish communities. To our knowledge it has never been applied to fishes. A correlation coefficient was computed between the Shannon-Weaver and PIE indices.

Catch data were combined by subdrainage in using Kendall's coefficient of rank correlation test (Dixon 1975). This non-parametric statistical test analyzed the association in rankings of species between subdrainages.

RESULTS AND DISCUSSION

A total of 15,102 fish representing 9 families, 29 genera, 47 species, and 1 hybrid combination was taken in 75 collections at 49 stations (Table 1). Common names were taken from Bailey et al. (1970). The most abundant species were the bluntnose minnow, blacknose dace, spotfin shiner, and white sucker. No one species was collected at all stations. The blacknose dace and white sucker were the most widely distributed; collected at 43 stations. The bluntnose minnow was collected at 38 stations and green sunfish at 37 stations. Five species, recorded in PFC stocking records, but not collected in this study were the American eel *(Anguilla rostrata)*, rainbow trout *(Salmo gairdneri)*, northern pike (*Esox lucius*), muskellunge (*E. masquinongy*), and white catfish (*Ictalurus catus*).

Upper Conewago. - Sixteen collections at 10 stations yielded 2,588 fish of 31 species (Table 1). Most fish (589) and most species (26) were taken at Stations 17 and 7, respectively. The blacknose dace ranked first in abundance (648 spmn.) and was taken at all stations. Young brown trout were abundant at Station 3 indicating good survival and natural reproduction of stocked adults. Juvenile and adult brook trout were restricted to Stations 1 and 2 near the headwaters of the Main Branch. The silverjaw minnow was most abundant in the Upper Conewago (144 spmn.) but was present in other subdrainages (Figure 2). It probably gained access to Conewago Creek via a crossover from the Monocacy River (Potomac drainage) to Conewago Creek during Pleistocene or post-Pleistocene times (Wallace 1973). The mottled sculpin was restricted to headwater stations and was most abundant (56 spmn.) at Station 4 (Figure 3). To our knowledge, this represents the southernmost record of the mottled sculpin in the Susquehanna watershed.

Beaverdam Creek. - The bluntnose minnow predominated in Beaverdam Creek and comprised more than 42% of the catch. A total of 2,623 fish of 27 species was taken at 7 stations. Other common fishes included the comely shiner (207 spmn.), banded killifish (198), and stoneroller (165). Seven silvery minnow were collected at Stations 20 and 21 which represents a new record for the Susquehanna drainage in Pennsylvania (Malick et al., manuscript) Figure 3.

South Branch Conewago. - Ten collections at five stations yielded 1,545 fish of 26 species. The white sucker (268 spmn.), tessellated darter (229) and bluntnose minnow (209) were most abundant. The goldfish was the only species restricted to this subdrainage; two adults were taken at Station 29. The fathead minnow (81 spmn.) and bluntnose minnow (150) were most abundant at Station 27. Tsai (1971) reported only one fathead minnow from this location in 1970 and considered its scarcity due to competition with the bluntnose minnow. We collected substantial breeding populations of both species.

Middle Conewago. - Some 1,387 fish of 36 species were collected at 5 stations. The swallowtail shiner (173 spmn.), spotfin shiner (135), and green sunfish (130) were most abundant. The shorthead redhorse, walleye, and *Leopmis* hybrid were most common at Station 9, located just downstream of the Detters Mill dam. During normal flow this dam may have prohibited upstream movement of redhorse and walleye. It may also contribute to increased opportunity for hybridization by concentrating sunfishes.

Bermudian Creek. - Collections from ten stations yielded 3,309 fish of 31 species. Most fish (758) and most species (27) were taken at Station 40. The blacknose dace ranked first in abundance (733 spmn.) and was taken at all stations. The bluntnose minnow (388 spmn.), stoneroller (328), and white sucker (322) were also common. Large collections of the satinfin shiner and banded killifish were taken at Stations 40 and 39, respectively.

Pinchot Park. - Seven collections yielded 471 fish of 26 species. The creek chub (110 spmn.) and blacknose dace (100) were common. The green sunfish was the only species taken at all four stations. The chain pickerel and creek chubsucker were taken only in this subdrainage and were collected by the PFC in a survey of Beaver Creek before the impoundment of Pinchot Lake. Thus they were considered native (Figure 3). The yellow perch, taken in a post-survey collection of Bennett Run on 26 March 1977, was not collected during the 1976 survey. PFC records indicated that yellow perch were extensively stocked throughout the Conewago until 1961.

Little Conewago. - Nine collections at five stations yielded 1,287 fish of 28 species. Most fish (465) and most species (19) were recorded at

TABLE 1

Numbers of fish, species, and species diversity indices at stations in Conewago Creek.

Subdrainage	Upper Conewago											Beaverdam Creek								South Branch Conewago						Middle Conewago					
Station	1	2	3	4	5	15	16	17	6	7	Total	18	19	20	21	22	23	24	Total	25	26	27	28	29	Total	8	30	9	10	11	Total
No. of Collections																															
Seine	1	1	1	1	1	1	1	1	1	1	10	1	1	1	1	1	1	1	7	1	1	1	1	1	5	1	1	1	1	1	5
Electrofisher	-	-	1	1	1	-	1	1	-	1	6	-	-	1	1	-	-	-	2	1	1	1	1	1	5	2	-	1	1	1	5
No. of Species	3	5	12	10	17	8	12	19	18	26	31	14	15	9	22	17	14	16	27	17	14	10	11	21	26	22	16	23	27	23	36
No. of Specimens	32	18	250	277	435	260	337	589	164	226	2588	151	516	238	299	1023	197	199	2623	265	78	777	94	331	1545	450	195	163	401	178	1387
Species Diversity ($\bar{d}$)	1.41	1.68	2.59	2.21	3.20	2.04	3.07	3.28	3.11	4.08		2.89	2.64	2.12	3.53	1.89	2.67	3.20		2.83	3.16	3.04	1.78	3.41		3.61	2.96	3.95	3.84	3.27	
Species Diversity (PIE)	0.61	0.61	0.79	0.73	0.85	0.64	0.87	0.87	0.83	0.93		0.83	0.81	0.69	0.88	0.51	0.77	0.85		0.80	0.86	0.86	0.51	0.88		0.88	0.82	0.92	0.91	0.83	
Brown trout	-	3	60	-	-	3	4	4	-	1	75	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Brook trout	12	2	-	-	-	-	-	-	-	-	14	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Chain pickerel	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Stoneroller	-	-	-	1	53	21	51	76	1	14	217	15	-	54	57	2	-	37	165	1	6	80	-	75	162	7	11	1	-	-	19
Goldfish	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	2	-	-	-	-	-	-
Carp	-	-	-	-	-	-	-	-	-	3	3	-	-	-	5	3	-	-	8	-	-	-	7	-	7	-	-	5	13	-	18
Silverjaw minnow	-	-	-	-	47	-	41	33	23	-	144	3	1	-	4	-	-	3	11	-	-	-	-	-	-	-	8	-	-	-	8
Cutlips minnow	-	-	8	7	-	1	4	-	1	1	22	-	-	-	-	-	-	-	-	-	4	-	-	5	9	-	1	-	-	-	1
Silvery minnow	-	-	-	-	-	-	-	-	-	-	-	-	-	3	4	-	-	-	7	-	-	-	-	-	-	-	-	-	-	-	-
River chub	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	5	-	17	22
Golden shiner	-	-	-	-	-	-	-	-	-	2	2	1	12	-	16	81	5	-	115	-	-	-	-	-	-	-	-	-	-	-	-
Comely shiner	-	-	-	-	-	-	-	1	3	6	10	26	112	-	14	38	16	1	207	-	-	-	-	-	-	2	-	2	2	1	7
Satinfin shiner	-	-	-	-	1	-	-	-	3	27	31	5	63	-	-	-	-	-	68	1	5	-	1	22	29	28	-	4	2	12	46
Common shiner	-	-	1	1	20	21	50	17	2	15	127	31	70	-	22	15	2	12	152	1	-	-	-	4	5	5	3	3	39	1	51
Spottail shiner	-	-	-	-	7	-	6	33	2	6	54	1	78	-	11	36	4	5	135	1	-	-	1	21	23	46	-	-	21	-	67
Swallowtail shiner	-	-	-	-	19	-	13	95	9	20	156	9	12	-	2	12	16	9	60	-	-	-	-	33	33	122	1	7	29	14	173
Rosyface shiner	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	11	-	11
Spotfin shiner	-	-	-	-	5	-	-	6	3	7	21	-	-	-	1	16	49	-	66	-	1	-	-	6	7	25	-	17	29	64	135
Bluntnose minnow	-	-	1	-	7	-	1	14	58	10	91	45	155	7	68	710	77	59	1121	7	-	150	7	45	209	5	12	1	57	16	91
Fathead minnow	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	23	-	-	24	1	-	81	-	1	83	-	1	-	-	-	1
Blacknose dace	16	11	85	118	121	149	46	52	20	30	648	1	1	5	2	-	2	9	20	98	23	41	1	1	164	1	45	1	-	1	48
Longnose dace	-	-	13	22	19	18	17	25	-	25	139	-	-	-	-	-	5	-	5	-	1	-	-	22	23	15	60	-	-	-	75
Creek chub	4	1	45	6	31	26	36	102	1	10	262	3	1	14	-	5	-	12	35	15	-	87	-	-	102	-	28	-	2	-	30
Fallfish	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
White sucker	-	-	15	60	77	21	68	114	14	8	377	2	1	1	10	11	-	5	30	54	1	104	65	44	268	29	5	11	7	1	53
Creek chubsucker	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Northern hog sucker	-	-	-	-	-	-	-	-	-	1	1	-	-	-	-	-	-	-	-	1	5	-	-	1	7	-	3	-	2	1	6
Shorthead redhorse	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	16	1	1	18
Yellow bullhead	-	-	1	-	-	-	-	1	-	-	2	-	-	-	1	-	-	-	1	-	1	-	2	-	3	2	-	2	6	1	11
Brown bullhead	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	15	-	-	17	-	-	-	-	-	-	1	-	1	1	-	3
Channel catfish	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	2
Margined madtom	-	-	-	-	1	-	-	-	-	1	2	-	-	-	-	-	1	-	1	-	3	-	-	-	3	3	-	-	-	1	4
Banded killifish	-	-	-	-	13	-	-	-	11	9	33	1	5	117	7	50	10	8	198	-	-	-	-	-	-	-	-	-	-	-	-
Rock bass	-	-	-	-	1	-	-	-	1	1	3	-	-	-	-	-	-	-	-	8	-	-	1	2	11	16	-	5	9	12	42
Redbreast sunfish	-	-	-	-	-	-	-	-	-	1	1	-	-	-	6	-	-	-	6	-	-	-	-	8	8	14	-	7	6	9	36
Green sunfish	-	-	1	5	3	-	-	10	4	11	34	8	3	6	6	2	1	15	41	4	-	40	3	1	48	46	10	2	70	2	130
Pumpkinseed	-	-	-	1	-	-	-	1	-	8	10	-	1	31	42	3	2	1	80	23	2	29	5	4	63	24	2	30	14	2	72
Bluegill	-	-	-	-	-	-	-	2	7	5	14	-	-	-	14	-	-	1	15	17	10	9	-	1	37	5	1	19	29	2	56
Lepomis hybrid	-	-	-	-	-	-	-	1	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	8	2	-	10
Smallmouth bass	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	3	-	-	-	5	35	-	2	3	11	51
Largemouth bass	-	-	-	-	-	-	-	-	-	1	1	-	-	-	3	1	-	2	6	3	-	-	1	1	5	3	-	-	2	1	6
White crappie	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Black crappie	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Tessellated darter	-	-	8	-	10	-	-	2	1	3	24	-	-	-	2	-	7	20	29	28	13	156	-	32	229	16	4	-	39	3	62
Banded darter	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	8	1	4	13
Shield darter	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	1	3
Walleye	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	6	-	-	6
Mottled sculpin	-	1	12	56	-	-	-	-	-	-	69	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

TABLE 1 Continued

Subdrainage	Pinchot Park					Little Conewago					Lower Conewago					
Station	41	42	43	44	Total	45	46	47	48	49	Total	12	13	14	Total	TOTAL
No. of Collections																
Seine	1	1	1	1	4	1	1	1	1	1	5	1	2	2	5	50
Electrofisher	-	-	-	1	1	-	1	-	1	-	1	-	1	2	3	33
No. of Species	1	1	-	1	3	1	1	-	1	1	4	1	1	2	4	48
No. of Specimens	11	-	5	3	8	2	22	-	-	-	24	-	2	-	2	925
Species Diversity ($\bar{d}$)	-	-	-	-	-	-	-	-	-	2	2	3	2	-	5	47
Species Diversity (PIE)	-	3	-	-	3	-	-	-	-	-	-	-	-	-	-	2
	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	201
	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	56
	-	-	-	5	5	-	-	5	-	1	6	-	1	-	1	7
	-	-	-	2	2	-	-	-	-	-	-	1	39	3	43	67
	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	117
	-	-	-	-	-	-	-	-	-	-	-	-	3	5	8	246
	-	-	-	3	3	-	-	-	2	49	51	2	8	-	10	333
	-	-	-	5	5	1	-	-	-	-	1	-	-	1	1	458
	-	-	-	-	-	7	11	-	2	-	20	1	27	24	52	386
	-	-	-	-	-	8	-	7	3	6	24	1	15	5	21	662
	-	-	-	-	-	-	-	-	-	1	1	-	19	1	20	34
	-	-	-	29	29	-	-	1	22	300	323	55	504	371	930	1679
	-	-	-	11	11	28	19	48	56	29	180	2	60	29	91	2182
	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	118
	-	-	99	1	100	60	74	1	19	4	158	-	1	-	1	1872
	-	-	-	12	12	40	186	-	-	1	227	12	64	2	78	777
	-	-	109	1	110	15	-	-	-	-	15	-	-	1	1	766
	-	-	-	-	-	-	-	-	-	-	-	-	9	3	12	12
1	-	-	-	14	15	31	12	3	13	34	93	1	14	2	17	1175
1	-	-	30	-	31	-	-	-	-	-	-	-	-	-	-	31
-	-	-	-	-	-	5	2	-	-	1	9	10	6	1	17	64
-	-	-	-	1	2	-	-	-	-	3	3	2	14	-	16	42
1	-	-	-	1	2	-	1	-	-	-	1	-	-	1	1	28
4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	24
-	-	-	-	-	-	-	-	-	-	-	-	-	9	4	13	15
-	-	-	-	1	1	3	-	-	1	-	4	2	8	1	11	35
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	400
1	-	-	-	7	8	-	2	-	-	3	5	3	2	9	14	97
-	-	-	-	-	-	-	3	-	-	2	5	-	9	10	19	90
6	16	6	1	29	-	-	2	-	-	-	2	-	3	3	6	336
10	3	-	1	14	-	-	-	-	2	2	4	-	1	3	4	259
14	14	2	-	30	1	-	-	-	-	-	1	-	6	7	13	177
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	11
-	1	-	2	3	-	-	-	-	-	1	1	3	16	20	39	108
4	3	-	-	7	-	-	-	-	-	-	-	-	-	-	-	29
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4
2	7	-	1	10	-	-	-	-	-	-	-	-	1	-	1	11
12	-	-	3	15	38	15	10	4	-	67	58	58	306	5	369	587
-	-	-	3	3	-	1	-	33	24	58	1	1	7	-	8	443
-	-	-	-	-	-	-	-	-	1	1	1	-	-	-	-	12
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	7
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	69

Subdrainage	Bermudian Creek															
Station	31	32	33	34	35	36	37	38	39	40	Total	41	42	43	44	TOTAL
No. of Collections																
Seine	1	1	1	1	1	1	1	1	1	1	10	1	1	1	1	15
Electrofisher	-	-	-	1	1	-	1	-	-	1	4	-	-	-	-	1
No. of Species	6	12	4	12	22	15	20	19	14	27	31	12	7	6	20	72
No. of Specimens	162	355	228	161	280	284	361	460	260	758	3309	67	47	251	106	3471
Species Diversity ($\bar{d}$)	1.90	2.45	0.82	2.61	3.08	2.84	3.59	2.77	2.12	3.35		3.06	2.34	1.72	3.51	
Species Diversity (PIE)	0.69	0.76	0.29	0.77	0.82	0.78	0.89	0.81	0.59	0.86		0.87	0.78	0.64	0.88	
	-	-	-	-	1	-	-	-	-	-	1	-	-	-	-	76
	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	14
	-	-	-	-	-	-	-	-	-	-	-	11	-	-	-	11
	28	44	-	18	35	29	24	134	10	6	328	-	-	-	-	925
	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2
	-	-	-	-	1	-	-	-	-	-	1	-	-	-	-	47
	-	-	-	-	2	16	6	4	1	9	38	-	-	-	-	201
	-	2	-	1	5	-	-	1	1	2	12	-	-	-	-	56
	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	7
	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	67
	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	117
	-	-	-	-	-	-	-	-	13	-	14	-	-	-	-	246
	-	-	-	-	-	-	-	4	-	91	95	-	-	-	-	333
	-	9	-	12	53	4	13	7	13	-	116	-	-	-	-	458
	-	3	-	-	5	2	18	2	-	5	35	-	-	-	-	386
	-	1	-	-	4	7	32	2	-	149	195	-	-	-	-	662
	-	-	-	-	-	-	-	2	-	-	2	-	-	-	-	34
	-	-	-	-	-	-	21	25	12	106	168	-	-	-	-	1679
	-	13	-	13	-	10	93	69	16	174	388	-	-	-	-	2182
	-	-	-	-	-	-	-	-	9	1	10	-	-	-	-	118
	47	56	190	68	92	123	10	114	19	14	733	-	-	-	-	1872
	1	7	1	22	30	27	46	69	-	15	218	-	-	-	-	777
	72	66	10	4	13	29	1	6	2	8	211	-	-	-	-	766
	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	12
	10	146	27	17	18	10	30	12	-	52	322	1	-	-	-	1175
	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	31
	-	-	-	-	1	-	12	1	-	10	24	-	-	-	-	64
	-	-	-	2	1	-	1	-	1	2	7	1	-	-	-	42
	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	28
	-	-	-	-	-	-	-	-	-	-	-	4	-	-	-	24
	-	-	-	2	4	-	-	1	-	2	9	-	-	-	-	15
	-	-	-	-	-	-	-	-	164	4	169	-	-	-	-	35
	-	-	-	-	4	-	4	-	-	6	14	1	-	-	-	400
	-	-	-	-	1	2	9	-	1	3	15	-	-	-	-	97
	-	1	-	-	2	9	22	1	8	2	46	6	16	6	1	90
	-	7	-	-	-	1	-	-	-	4	12	10	3	-	-	336
	4	-	-	1	2	-	2	-	-	2	11	14	14	2	-	259
	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	177
	-	-	-	-	-	-	6	-	-	3	9	-	-	-	-	11
	-	-	-	-	-	-	-	-	-	-	-	2	-	-	-	108
	-	-	-	-	-	2	2	-	-	-	4	4	3	-	-	29
	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4
	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	11
	-	-	-	-	1	14	9	5	3	65	97	12	-	-	-	587
	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	443
	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	12
	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	7
	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	69

TABLE 2

Results of Kendall's coefficient of rank correlation test between subdrainages of Conewago Creek.

	Upper Conewago	Beaverdam Creek	South Branch Conewago	Middle Conewago	Bermudian Creek	Pinchot Park	Little Conewago
Beaverdam Creek	0.46						
South Branch Conewago	0.50	0.43					
Middle Conewago	0.41	0.42	0.57				
Bermudian Creek	0.66	0.52	0.62	0.54			
Pinchot Park	0.28	0.21	0.48	0.39	0.32		
Little Conewago	0.45	0.31	0.68	0.62	0.66	0.41	
Lower Conewago	0.19	0.20	0.23	0.41	0.30	0.11	0.47

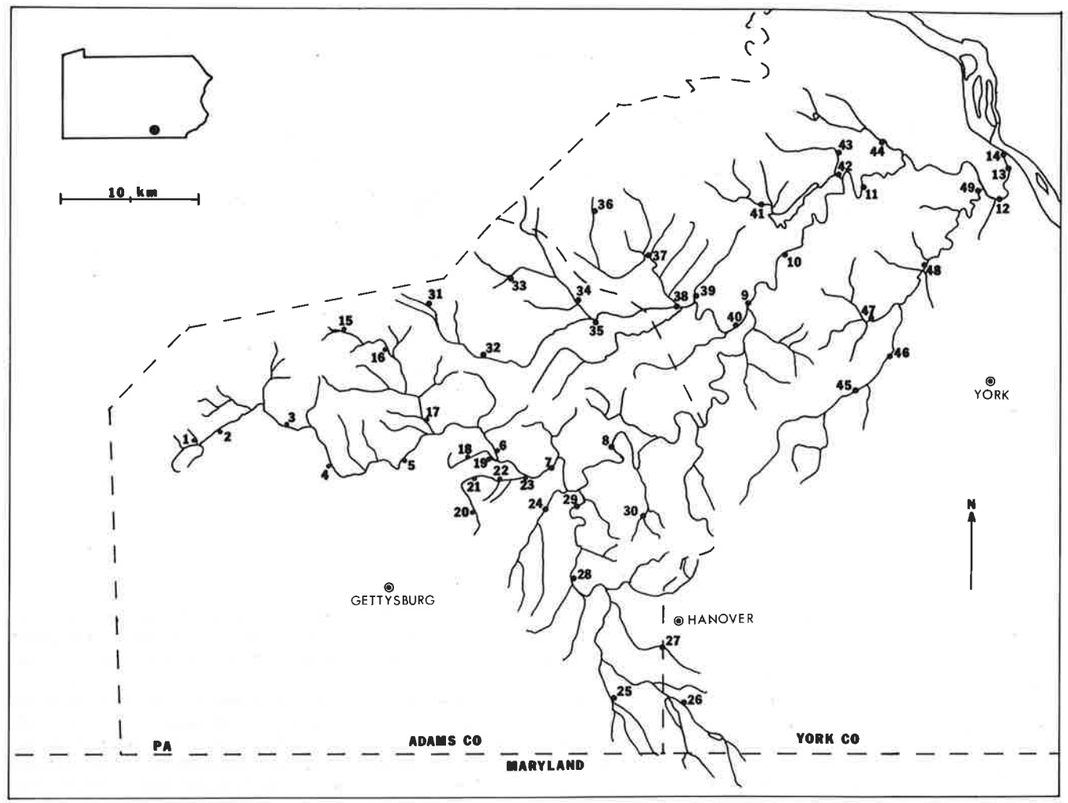


FIGURE 1. Location of stations in the Conewago Creek drainage.

Station 49. Common fishes included the spotfin shiner (323 spmn.), longnose dace (227), and bluntnose minnow (180). The bluntnose minnow, blacknose dace, and white sucker were the only species taken at all five stations. Large collections of the spotfin shiner and longnose dace were taken at stations 49 and 46, respectively.

Lower Conewago. - A total of 1,892 fish of 33 species was collected at 3 stations. Most fish (1,208) and most species (30) occurred at Station 13 due to a wide range of habitats and proximity to the river. The spotfin shiner comprised almost half of the catch. It was also abundant in the York Haven Pond of the Susquehanna River, an impoundment just upstream from the mouth of the Conewago (Malick 1977). The banded darter ranked second in abundance (369 spmn.); most taken in a riffle at Station 13 (Figure 2). Kneib (1972) was the first to report the banded darter from the Susquehanna drainage; it has dispersed downstream rapidly and is now well established in the lower Susquehanna (Denoncourt et at. 1975). In general, the Lower Conewago ichthyofauna was more typical of the river than the other subdrainages.

Species Diversity. - Shannon-Weaver ($\bar{d}$) and PIE diversity indices were generally moderate to high (Table 1). Most $\bar{d}$ values ranged from 2.00 to 3.50 and most PIE from 0.60 to 0.90. Highest diversities for the drainage ($\bar{d} = 4.08$, PIE = 0.93) were recorded at Station 7 located just downstream from the dam at New Chester. Stream alteration caused by the dam produced a wide variety of habitats not observed at other stations, thereby increasing diversity. Electrofishing usually increased

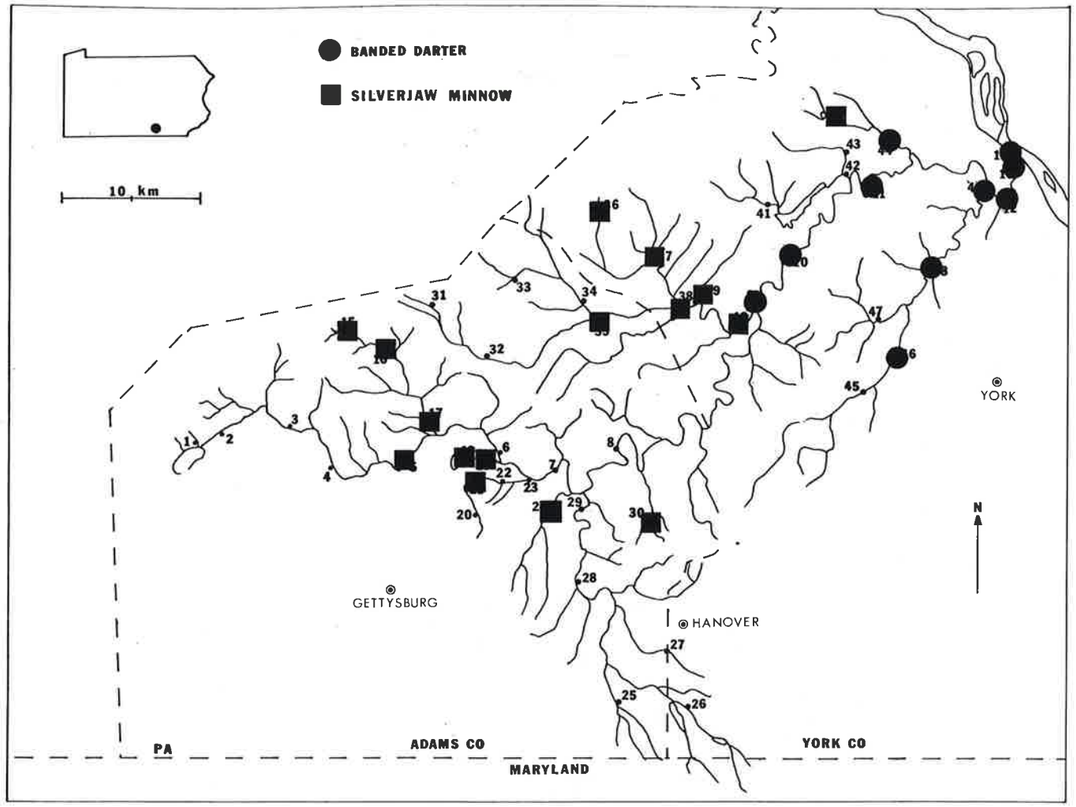


FIGURE 2. The distribution of the silverjaw minnow and banded darter in the Conewago Creek drainage.

diversity because it was more efficient at capturing large species not vulnerable to the seine. However, electrofishing was so efficient at capturing certain species, especially the stoneroller and white sucker, that it decreased diversity at some stations. Lowest diversities ($\bar{d}$ = 0.82, PIE = 0.29) occurred at Station 33 on Latimore Creek and resulted from dominance by the blacknose dace which comprised more than 83% of the catch. Station 33 was subject to frequent fishkills caused by pesticide runoff from surrounding orchards. Shannon-Weaver and PIE values were plotted (Figure 4) and found to be highly correlated (0.91).

Kendall's Correlation. - Results of the Kendall's coefficient of rank correlation tests are presented in Table 2. Bermudian Creek, South Branch, and Little Conewago were the most closely correlated subdrainages (0.62-0.68); the Middle Conewago was correlated to these subdrainages (0.54-0.62) but to a lesser degree. These subdrainages formed the middle portion of the watershed, each drained chiefly agricultural areas, and all had comparable flow. The Upper Conewago was most closely correlated (0.66) with Bermudian Creek. This may have resulted from the proximity of the two subdrainages; both drained the northwestern portion of the watershed, and each had relatively similar headwaters. Beaverdam Creek showed a moderate degree of correlation with Bermudian Creek (0.52). Large collections taken at stations of this subdrainage close to the main Conewago may have been responsible for this correlation. The Pinchot Park area and Lower Conewago were not similar to any other subdrainage (<0.50). The Pinchot Park area was comprised of high gradient streams and a large impoundment, both unique for the lower portion of the watershed. The Lower Conewago was more representative of fishes in the river due to the proximity of these areas.

Physicochemical. - Water temperatures varied from headwater stations to the mouth. Temperatures for all sample dates were generally lower at headwater stations of the Upper Conewago and Bermudian Creek. Water temperatures in Beaverdam Creek, the Middle Conewago, and Lower Conewago were generally higher. Results of September water chemistry tests showed higher dissolved oxygen concentrations in the Upper Conewago (8.4 ppm) and Pinchot Park (8.4) subdrainages. Lowest dissolved oxygen concentrations were recorded in the South Branch (4.0 ppm) and Bermudian Creek (4.2). The pH in the drainage ranged from 7.4 in Bermudian Creek to 8.6 in the Middle Conewago. Carbon dioxide levels were low at most stations; highest measurements were recorded from the South Branch (20 mgl) and Bermudian Creek (35 mgl).

CONCLUSIONS

The composition and distribution of fishes in Conewago Creek was typical of the Susquehanna watershed in southcentral Pennsylvania. Fishes unique to the drainage or with unusual distributions included the chain pickerel, silverjaw minnow, silvery minnow, creek chubsucker,

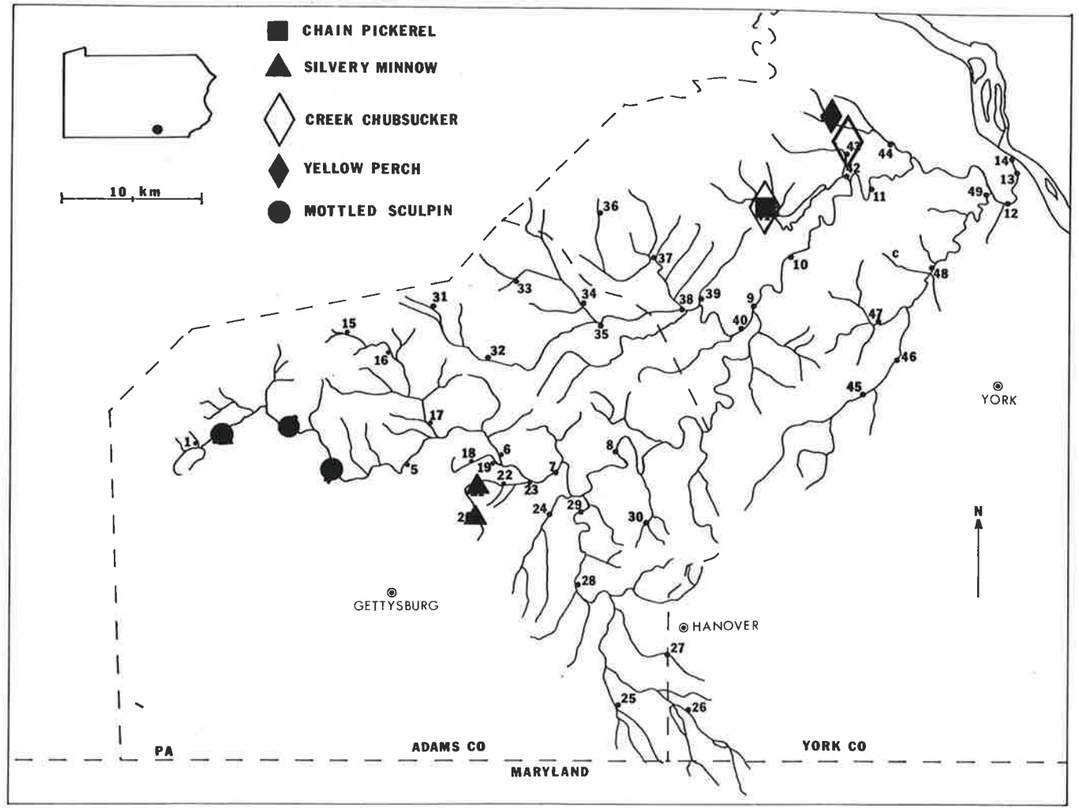


FIGURE 3. The distribution of the chain pickerel, silvery minnow, creek chubsucker, yellow perch, and mottled sculpin in the Conewago Creek drainage.

and mottled sculpin. Shannon-Weaver and PIE indices were highly correlated and appeared to be of equal value. However, they were of limited use in descibing the fishes of this drainage beyond providing baseline data. Kendall's correlation test provided a quantitative measure of the similarity between subdrainage which was useful in defining areas unique with respect to fish composition.

ACKNOWLEDGEMENTS

We sincerely thank Dr. Robert F. Denoncourt of York College of Pennsylvania for his constant encouragement and critical review of this manuscript. The cooperation of the Pennsylvania Fish Commission and Department of Environmental Resources is greatly appreciated.

LITERATURE CITED

Bailey, R.M., J.E. Fitch, E.S. Herald, E.A. Lachner, C.C. Lindsey, C.R. Robins, and W.B. Scott. 1970. A list of common and scientific names of fishes from the United States and Canada. Amer. Fish. Soc. Special Publ. No. 6. 150 p.

Conover, T.C. 1972. A morphological and distributional description of the spotfin shiner *Notropis spilopterus,* and the satinfin shiner *Notropis analostanus.* M.S. Thesis. Pa. State Univ., Univ. Park, Pa. 74 p.

Denoncourt, R.F., C.H. Hocutt, and J.R. Stauffer, Jr. 1975. Extensions of the known ranges of *Ericymba buccata* Cope and *Etheostoma zonale* (Cope) in the Susquehanna River drainage. *Proc. Pa. Acad. Sci.* 49: 45-46.

Dixon, W.J. (ed.). 1975. Biomedical computer programs. Univ. of Calif. Press, Berkeley. 792 p.

Fowler, H.W. 1925. Records of fishes in Pennsylvania. *Copeia* 140: 23-24.

Hurlbert, S.H. 1971. The nonconcept of species diversity: a critique and alternative parameters. *Ecology* 52(4): 577-586.

Kneib, R.T. 1972. The effects of man's activity on the distribution of five stream fishes in Little Pine Creek, Pennsylvania. *Proc. Pa. Acad. Sci.* 46: 49-51.

Lloyd, M., J.H. Zar, and J.R. Karr. 1968. On the calculation of information-theoretical measures of diversity. *Amer. Midl. Nat.* 79(2): 257-272.

Malick, R.W., Jr. 1977. Fish. pp. 6-85. *In* G.A. Nardacci and Associates. An ecological study of the Susquehanna River in the vicinity of the Three Mile Island Nuclear Station. Annual Report for 1976. Ichthyological Assoc. Inc., Etters, Pa. 231 p.

Shaw, L.C. and W.F. Busch. 1970. Pennsylvania gazetteer of streams, part 1. Comm. of Pa., D.E.R., Harrisburg, PA. 280 p.

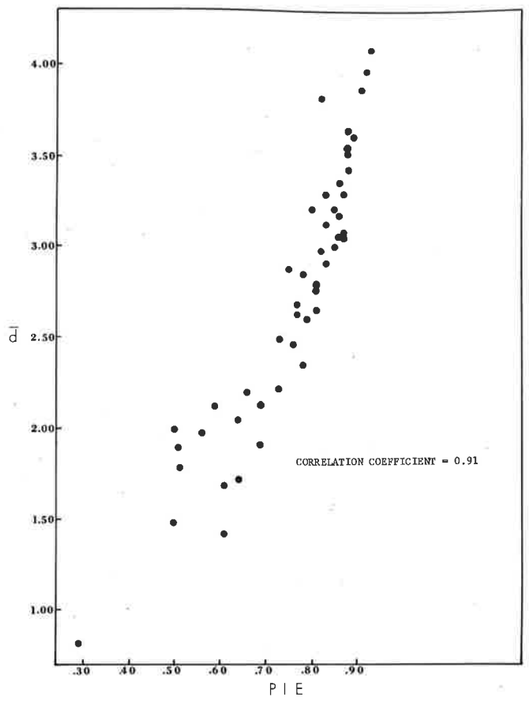


FIGURE 4. Correlation of Shannon-Weaver diversity indices ($\bar{d}$) and PIE values.

Stose, G.W. 1932. Geology and mineral resources of Adams County, Pennsylvania. Pa. Geol. Surv., Bull. C1. 153 p.

Stose, G.W. and A.I Jonas. 1939. Geology and mineral resources of York County, Pennsylvania. Pa. Geol. Surv., Bull. C67. 199 p.

Tsai, C. 1971. Occurrence of the fathead minnow, *Pimephales promelas* (Pisces: Cyprinidae), in the Chesapeake Atlantic Slope drainages. *Chesapeake Sci.* 12(4): 274-275.

Wallace, D.C. 1973. The distribution and dispersal of the silverjaw minnow *Ericymba buccata* Cope. *Amer. Midl. Nat.* 89(1): 145-155.

Proceedings of the Pennsylvania Academy of Science 51:67—69. 1977.

INITIAL SURVEY OF THE PLANKTON OF TWENTY-SEVEN LAKES NEAR WILKES-BARRE, PENNSYLVANIA, 1976[1]

CHARLES B. REIF

Wilkes College
Wilkes-Barre, Pennsylvania 18703

ABSTRACT

Seven collections of net plankton from each of twenty-seven lakes were made throughout 1976. Values for the frequency of appearance and abundance of one hundred genera are presented.

INTRODUCTION

Of the thirty lakes for which morphometric and chemical characteristics have been reported (1), twenty-seven have easily accessible outlets and so were selected for this initial survey of the genera of planktonic organisms present in those lakes. Although a few restricted observations of plankton have been made in several of the twenty-seven lakes, no systematic survey of the plankton has previously been undertaken.

MATERIALS AND METHODS

Seven sets of collections were made during hours of daylight at the outlets of the twenty-seven lakes in 1976 on: I-1, IV-30, VI-15, VII-15, VIII-20, X-20, and XII-30. Certain vertically migratory plankters might have been captured in greater numbers at night but for this study the diurnal effluent plankton was deemed sufficient. For each sample, sixty liters of lake water were put through a standard nylon plankton net and reduced to sixty milliliters of sample, to which three milliliters of formalin were added. One milliliter of each thoroughly mixed sample was placed in a plankton counting chamber and under the microscope the organisms were identified and enumerated. Within several genera the organisms were identified to species. A second microscopic examination was made of the settled plankton in each sample to assure that no kind of organism had been overlooked.

RESULTS AND DISCUSSION

All of the data of the plankton counts for all of the lakes were tabulated and from that total set two values were selected for presentation in Table 1. The first value shown for each genus (if present) in Table 1 is the number of samples, of the seven for each lake, in which any of the genera was represented. The second value shown in Table 1 is the greatest number of individuals present in any of the samples in which any genus was represented in the plankton, expressed as the number of individuals per liter of lake water.

The positioning of the lakes in Table 1 was done primarily on the basis of the lakes' being natural or artifical, and, secondarily, geographically, following the pattern set in the reference cited (1).

In general one may note that all of the lakes included in this survey are relatively poor producers in terms of the number of genera represented and in the number of individuals present. Analysis of the total set of information as tabulated, as well as the condensed information in Table 1, revealed no pattern of distribution of the planktonic organisms, nevertheless, publication of this information was deemed advisable so that the information may serve in some way for future studies of the lakes involved.

ACKNOWLEDGEMENTS

Several friends of Wilkes College, despite their desire for anonymity, did make possible the 1800 miles of travel necessary in the collecting of the plankton as well as the 1400 hours of microscopic examination of the plankton. The author is beholden to Tanya April Hallez and Mary Lynn Krisza for their very substantial assisatance.

REFERENCE

Reif, C.B. 1975. THIRTY LAKES IN THE VICINITY OF WYOMING VALLEY, PENNSYLVANIA. *Proceedings and Collections of the Wyoming Historical and Geological Society*, Volume XXIV, 1-36.

[1]Received April 18, 1977; reviewed; accepted August 12, 1977.

TABLE I

Genera present in the plankton of twenty-seven lakes near Wilkes-Barre, Pennsylvania, as found in seven collections taken during 1976. The first value indicates the number of samples in which the kind of organism was present. The second value indicates the greatest number of individuals per liter of lake water in any one of the samples.

	NATURAL LAKES														ARTIFICIAL LAKES											
	Lake Carey	Oxbow Lake	Lake Winola	Cummings Pond	Harveys Lake	Moon Lake	North Lake	Lake Silkworth	Sylvan Lake	Lily Lake	Lake Liberty	Lake Nuangola	Bear Lake	Indian Lake	Lake Catalpa	Harris Pond	Huntsville Reservoir	Lake Louise	Pike's Creek Reservoir	Shady Side Lake	Blytheburn Lake	Fenner's Pond	Bear Creek Lake	Meadow Run Lake	Mountain Lake	Penn Lake	Fairchild Pond
CHLOROPHYTA																											
Ankistrodeamus												3-9															
Arthrodesmus														1-11							1-1			1-120	1-2		
Bambusina																						1-4					
Cerasterias																											
Chaetophora		1-5			1-1			1-1												1-2						1-7	
Closteriopsis							1-4				1-6	1-92		1-8		2-17		1-28								3-126	
Closterium		4-15	2-2	1-1	1-1		2-16	1-7		1-2	1-17	2-4	1-1	5-27	3-270	4-5		1-45		2-4	2-26	3-4	3-6	1-6	2-3	1-15	2-2
Coelastrum				1-57																							
Cosmarium			2-25																	1-2		1-1					
Crucigenia	1-1		1-3									1-1		1-3											1-400		
Desmidium					1-3											1-1		1-4	1-1			1-3				1-2	
Dictosphaerium			1-217									1-63								1-370				1-1			
Dispora				1-12800	1-46										1-54												
Docidium																				1-1							
Elaktothrix												1-1												1-66		1-4	1-14
Eudorina	3-2600	2-10	5-480		3-81	3-450	1-8	3-180		2-9	2-160	2-59			2-270	2-17	3-90	4-400	2-440	3-68	4-35	1-6					
Geminella																	1-29							1-44			
Gloeocystis	1-69		1-90		1-3		1-20000	2-42				1-27		1-27	1-480	2-20	1-16	1-400	1-1000			1-25					2-530
Glosocystopsis	1-4		1-22																								
Golenkinia											1-10																
Gonatozygon							1-2									2-2						6-5	1-3				
Hyalotheca			1-1																								
Hydrodictyon								1-12				1-10															
Kirchneriella												1-1															
Micrasterias		1-5	1-1	1-1			1-6				1-5	2-1	1-1	3-11	2-54		1-1			1-1	1-1	1-4	1-1		1-4		
Mougeotia	1-6	1-7	2-23	1-33					1-1		1-15					1-1		1-3			1-33				1-4		
Netrium				1-3																							
Oedogonium																											
Pandorina	2-1																										
Pediastrum	3-100	1-3	2-29	3-3000	1-3	2-1500	3-9	2-11		1-2	3-180	2-12		1-5	5-2400	4-130	1-2	4-900	1-5	3-6	3-39	2-2	1-1	1-19			1-2
Quadrigula								1-11				1-16		1-3											1-2		
Scenedesmus	1-69			1-1	2-34		1-4	1-10		2-4		1-22			1-54	2-28					2-3	1-28		1-2			1-41
Selsnastrum	2-7	1-3	3-23		2-16	3-2	4-1000	3-4	3-4		5-19	3-6		1-290	2-100			1-9		3-6	3-26	2-29			1-16	1-1	3-6
Spondylosium plamum					1-6	2-126	1-1			2-2								1-28				2-29					
Spondylosium pulchrum					1-2			1-51														1-8					
Staurastrum furcigerum		1-1					2-50																				
Staurastrum leptocladium		1-413							1-17			1-150															
Staurastrum paradoxum	5-50000	4-150	3-170	3-1400	3-71	2-79	2-53	2-49	2-2000	3-150	2-83	2-89	1-1	3-110	3-163	3-84	4-1200	4-4000	2-23	3-71	4-2100	2-44	2-88	3-150	2-880	1-350	1-128
Staurastrum pentacerum							1-8			1-46		1-74										1-4			1-15		
Staurastrum setigerum		1-100					2-12					1-39				1-4											
Tetradesmus										1-19																	
Tetraedrom gracile						2-46										1-40											1-51
Tetraspora																											
Ulothrix	1-1300	1-190		1-1900	1-3	1-22000			1-245	1-550	1-16	1-1000			2-216	1-8		1-3000			2-267					
Volvox	3-230	3-44	2-14	3-200	3-5	4-105	5-36	2-53	3-7800	2-2	5-250	1-31		1-5	3-1950	2-4	1-7	4-12000	1-11	3-97	1-19		1-1				2-6
Xanthidium			1-2		1-81							1-1				1-16											
Zynema				2-7						1-3																1-1	
Zygnemopsis							1-1																				
EUGLENOPHYTA																											
Phacus																	1-24					2-466			1-7		
CHRYSOPHYTA																											
Actinella								1-11									1-3									1-15	
Asterionella	2-92	3-160	2-900	3-5500	6-194	4-8900	4-140	3-210	3-240	4-720	5-1100	5-136	3-5100	3-270	5-1200	4-65	5-1050	5-11000	3-520	5-110	2-64	3-23	3-39	5-5100	3-3120	4-20	1-13
Chrysosphaerella	2-92					1-21				2-190						1-4					2-67	2-700	1-22		2-1280	1-34	
Cymbella		1-6	1-1											1-1	2-5												
Denticula																							1-12				
Diatoma						2-63			2-35		2-74	2-18	1-27	1-2	1-5	1-8		1-18			2-12	2-9	2-98	2-13	1-2	2-4	1-18

Table 1 – Continued.

	NATURAL LAKES														ARTIFICIAL LAKES											
	Lake Carey	Oxbow Lake	Lake Winola	Cummings Pond	Harveys Lake	Moon Lake	North Lake	Lake Silkworth	Sylvan Lake	Lily Lake	Lake Liberty	Lake Nuangola	Bear Lake	Indian Lake	Lake Catalpa	Harris Pond	Huntsville Reservoir	Lake Louise	Pike's Creek Reservoir	Shady Side Lake	Blytheburn Lake	Fenner's Pond	Bear Creek Lake	Meadow Run Lake	Mountain Lake	Penn Lake	Fairchild Pond
CHRYSOPHYTA (Cont'd.)																											
Diatomella																									1-7		
Dinobryon		2-24	1-3	1-1100	3-900	2-1000	2-390	3-210	1-1400	3-1300	2-1000	4-5000	3-63	3-5000	1-1100	2-270	2-21	1-17		2-1000	4-2200	3-3700	4-210	3-1000	3-1400	3-490	2-560
Eunotia															2-1900	1-9											
Fragilaria	3-9100	4-27	4-45	2-82	3-69	2-710	2-180	3-630	3-12000	2-170	3-600	3-1000	2-190	2-250	4-3000	2-86	4-4000	3-940	2-1000	3-190	2-460	2-190	3-95	3-100	2-78	3-25	1-70
Frustulia																					1-5						
Gomphoneis								1-2																			
Mallomonas					1-9	2-42	1-11000	1-1470	2-350	2-490	1-10	1-45	1-720			2-29	1-140	2-28		1-22	1-3	1-6		1-52	2-750	1-6	1-4
Opephora																										1-54	
Pinnularia																									1-7		
Stauroneis																						1-6	1-3			1-1	
Surirella																							1-23				
Synura	2-390	1-53	1-1	3-42000	1-4	2-310		2-700	1-1000	1-6	2-360	2-43	2-410		1-43	2-9	2-360	3-20500		2-9	1-2	2-900	2-110	3-1000	2-30	2-220	1-4
Tabellaria		5-400	1-5		2-90	3-1530	2-1	4-2000	3-280	4-2400	4-57	7-1000	3-68	4-16	3-380	2-13	1-7	1-4	3-92	2-2	3-580	6-108	5-72	3-20	3-19	7-100	3-11
Tetracyclus	2-2				1-1											1-1							1-3				
Uroglenopsis					1-69											2-65						1-96					
PYRROPHYTA																											
Ceratium	3-54	4-700	3-69		3-550	2-1000	2-190	1-40	2-870	3-70	2-65	2-87			2-320	3-37		3-270		2-790	2-15					1-9	2-220
Cystodinium		1-42																									
Peridinium	1-10	2-10	1-2	1-195	3-4	2-100	2-180	1-92	2-2200	3-650	3-54	3-47	3-160	2-16	1-82	1-95	1-5	2-85		1-19	3-450	3-350	1-120	1-17	2-64	2-60	1-41
CYANOPHYTA																											
Anabaena	4-1000	4-100	3-43	3-1000	4-1000	4-3100	1-10	3-150	3-1000	3-200	2-440	2-105	1-6	2-14	1-100	3-18	2-65	3-14800	1-6	4-110	3-230	1-10	3-6	2-8	1-3		
Aphanizomenon		2-2100	1-4		2-25			3-18700						1-1	2-1900			2-630	1-23								
Aphanocapsa					1-3		1-23	2-210		2-9	3-54	1-12			2-1200	1-46	1-23	1-3000	1-250	2-73	1-100	2-8			1-19	1-8	
Coelosphaerium				1-6				1-17	1-1	1-6					1-160	1-3	2-33									1-2	
Gloeotrichium			1-1																								
Gomphospaeria														1-19													
Marismopedia		1-22	1-8		1-4					1-2										1-6							
Microcystis	4-1000	3-370	2-26	3-1000	2-18	2-190	1-35	1-51	3-1000		2-37	1-6			5-1800	2-56	2-56	3-8900		2-11	2-27		1-18	1-1			1-1
Spirulina			1-1										1-13													1-4	
PROTOZOA																											
Centropyxis							1-4	1-21		1-6	1-3			2-11	1-2												
Difflugia	1-37	1-30		1-29		2-4100		2-21	1-230		1-138			1-10	1-840			2-2800	1-23	2-41	1-1000				2-4		
Peranema				1-21											1-9												
ROTIFERA																											
Asplanchna	1-110	5-270	2-11	5-59	4-23	3-460	2-5	4-170	3-200	3-47	6-26	5-200	2-10	4-66	3-180	4-48	3-115	5-56	1-200	16-1300	6-27	3-49	2-53	5-300	1-23	2-170	5-170
Brachionus	1-4	2-11	2-1	2-95	1-4	1-4	1-24		2-19						3-100			1-28				2-4					1-8
Euchianis		1-14	2-9		2-1	1-21	1-1	1-10		1-6			1-1	1-3	1-6	1-40	1-1		1-1	1-1	2-3	1-6		1-7		1-1	
Kellicottia longispina	2-3	2-10	2-1	1-140	4-19	4-120	4-14	2-3	2-37	1-6	2-4	3-67	4-28	2-11	3-54	3-10	2-69	2-34	1-92		3-22	2-5	1-1		1-15	2-1	
Keratella cochlearis	4-640	4-85	4-43	3-300	4-59	3-1500	3-120	3-90	4-1000	4-160	4-81	4-64	2-21	4-800	5-2500	5-150	4-360	4-220	2-23	4-180	4-700	4-57	2-19	3-180	2-125	3-48	1-24
Keratella quadrata								1-6								2-18	1-340			2-170							
Keratella serrulata															1-3												
Monomata											2-7																
Polyarthra	3-25	3-42	2-12	3-10	3-41	3-350	3-20	3-27	1-5	2-61	3-38	2-18		4-180	3-210	3-73	3-33	2-40	1-68	3-270	2-440	3-19	2-8	3-19	2-120	2-29	2-10
Pseudoploesma formosum										1-27						1-14						1-2					
Tetramastix opoliensis		1-85		2-166		2-21									2-54	1-96	1-5		1-4								
Trichocerca	1-18	2-26		1-7	1-2	3-41	1-14	2-7	1-79	3-15	1-44	2-75		2-66	3-100	1-40	1-12	1-135	1-3	2-61	2-46	1-29			1-11	2-1	1-8
Trochosphaera														1-320					1-210								
ARTHROPODA																											
Alona	2-3			2-39		1-1			1-1					3-16	1-2	1-30		1-2		1-39							
Bosmina	3-10	3-118	1-13	6-200	1-2	4-300	4-153	1-4	2-41	1-1	4-64	1-20		3-16	5-160	2-19		4-91	4	2-51	4-5		1-6	2-100		4-3	3-47
Chydorus	3-6		1-1	4-130		2-7	1-3		2-24	1-3	3-7	1-20	1-7	2-2	4-2	1-52		5-30		3-3	1-2	2-3			1-1	1-2	2-9
Cyclops	4-12	2-5	4-15	4-17	2-3	2-8	4-4	4-16	3-26	3-45	4-180	5-12	2-7	5-38	3-77	2-16	2-3	4-42	3-3	4-28	3-10	4-25	1-6	2-1	1-2	2-11	1-1
Daphnia	1-35	2-1	1-11	4-10	1-4	2-21	3-10				2-11	2-4	2-6	3-60	3-4	2-13	1-2	2-26	1-2	2-13	1-30	2-1	1-6	2-6	1-4	1-2	1-29
Diaptomus	2-2	1-1	1-11	4-13	4-3	3-15	3-30	3-4	4-18	4-5	3-6	3-4	6-19	3-110	3-54	4-18	4-4	4-48	1-1	3-7	4-37			1-12	4-22	1-7	3-75
Holopedium															1-380	1-4											
Nauplii	3-26	4-7	3-35	2-140	2-28	3-260	3-68	2-70	3-210	4-72	3-68	2-60	1-3	3-150	4-500	3-52	3-19	3-120	1-5	4-50	3-50	3-120	2-18	3-32	2-79	2-5	2-65

Proceedings of the Pennsylvania Academy of Science 51:70—74. 1977.

FERTILITY AND LEVELS OF DEVELOPMENT IN MID-NINETEENTH CENTURY PENNSYLVANIA[1]

GEORGE A. SCHNELL

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

ABSTRACT

Fertility is related spatially to development among Pennsylvania's counties in 1850. General fertility rates are rank-order correlated with indexes of urban-industrial status and agricultural production at a moment in the Commonwealth's history when development was well underway but had not as yet spread to some of the eventually important centers of population and production. Whereas results portray fertility associating inversely with development, questions remain concerning the manner in which specific manufacturing and mining operations relate to industrial status, as well as the influence of foreign born and nonwhite populations as they contribute to both development and reproductive behavior.

INTRODUCTION

Reductions in mortality and the eventual lowering of fertility by populations experiencing development, especially urban-industrial growth, have been described and analyzed by a variety of social scientists and demographers over a relatively long period (1). However, the demographic transition, so-called, has been studied at the national level, with little concern for intra-national variations. It seems reasonable, therefore, to expect that examination of these processes at a larger scale would reveal significant spatial patterns and associations unlikely to emerge at a smaller scale. Also, beyond the fact that the geographic study of demographic response to development would be better served by adopting such a distributive approach, it seems that the regional variations in social and economic status and demographic characteristics which certainly exist within sub-national populations demand it.

This paper is concerned with the degree to which spatial variations in demographic behavior, namely fertility, might have been influenced by level and type of development among Pennsylvania's counties in 1850. It should be stated at the outset that, as important as it might have been in contributing to rapid growth through its reduction, mortality is not considered because its registration was incomplete in 1850. Questions remain concerning the validity of the natality estimates used but, with a few exceptions, they seem to be far more nearly accurate than the death statistics available. The selection of 1850 seems appropriate because it represents a moment in the commonwealth's economic history when agricultural pursuits were generally established throughout, and urban-industrial development was well underway but had not as yet spread to some of the eventually important centers of population and production. Of equal importance in selecting this particular year is the quality of the Census itself; the Census of 1850 was the most sophisticated to that time amassing, as it did, a wide array of information on the population and its institutions.

DATA AND METHODS

It seems appropriate to begin with a brief discussion of the relevant, published data available in the 1850 Census (2), and then proceed to the manner in which these statistics were fashioned into demographic rates and indexes of development. First, the count of births in 1850 represents, in reality, population under one year of age at the time of enumeration. The figures given are thus births recorded during the year ending 1 June, 1850 and include those surviving plus an unknown number of infant in-migrants. Despite the difficulties which accrue from any inaccuracies in birth registration compounded by what appears to be underregistration of mortality in general (3) and infant deaths in particular, it is believed that the natality information is useful (especially since it seems to be all that was available by county in 1850). Moreover, both vital rates as well as rates of natural increase must be employed, were the stages of demographic transition to be determined; however, the woeful underestimation of mortality frustrates any such attempt (4). By comparison, data descriptive of number of inhabitants, agricultural and industrial activities, as well as a number of population characteristics were touted as being generally accurate, and should present few problems as used here.

Given the rather wide range in sex ratios and age composition among those resident in Pennsylvania's counties in 1850, general fertility rates (births divided by females 15-49, multiplied by 1,000 and hereafter referred to as G.F.R.) were used in place of crude rates because of their (G.F.R.'s) greater sensitivity to such variations. In addition to birth information, data are available at the county level on population by color (white and "free colored"), nativity, and illiteracy, each of which seems to bear on the subject at hand.

Defining development in an operational sense presents some problems when considering the subject at the county level in 1850. Since counties are rather large areal units and because *all* counties in Pennsylvania in 1850 had both industrial and agricultural sectors (of different proportions and relative importance), it seems unreasonable to treat development in terms of urban-industrial status alone. Therefore, it was decided to incorporate into the indexes both industrial and agricultural indicators as well as population size and urbanization. Industrial status can be crudely estimated, at best, since only the most general employment counts, capital, and product values are available for manufacturing and mining combined at the county level; and just as importantly, urban population estimates must be aggregated upward from minor civil division enumerations by county. An urban-industrial index was calculated by summing each county's rank in number of inhabitants, percentage of urban population, and employment in manufacturing-mining as a percentage of total population, and re-ranking them (the counties) on the basis of this sum of ranks. An agricultural index was defined by summing each county's rank in grain production (wheat, rye, oats, and Indian corn), value of animals slaughtered, and number of milk cows. As before, each county's sum was used to establish an overall rank or index. The development index was derived by summing the ranks on all six urban-industrial and agricultural indicators and re-ranking each county on that basis.

The study proceeds from a series of related assumptions based upon the demographic responses made in western countries during industrialization which concern development level and reproduction. Specifically, it is expected that counties with a greater proportion of inhabitants residing in urban places and engaged in industrial activities will have had lower fertility than agricultural populations which, in turn, will have had lower fertility than counties in which neither urban-industrialization nor agricultural pursuits were well defined. Additionally, one might expect that specific industrial or agricultural activities might have had equally specific influences upon social-economic status and natality, given the characteristics of the respective populations with regard to race, nativity, and illiteracy. Although the latter expectation seems to be as appropriate as the former, Census data to support such analysis are not available, and its treatment must be highly speculative, at best. Finally, rank-order correlation coefficients are used to measure the influence of these indexes on natality, and rank-order residuals are identified and discussed concerning the factors which might have contributed to their fertility being over- or under-predicted by level of development.

[1]Received April 18, 1977; reviewed; accepted July 15, 1977.

RESULTS AND DISCUSSION

It is abundantly clear that Pennsylvania occupied a position of great importance in the United States and the world during the mid-nineteenth century. Its population of more than 2.3 million in 1850 was second only to New York's, and its density of more than 50 per square mile was almost equal to today's national density. Industrially, it produced more pig and wrought iron than any other state, practically all of the nation's anthracite and almost half of its bituminous coal, and was among the leaders in manufacture of cotton and wool. Agriculturally, its position was equally impressive on scales of magnitude and value in its production of a variety of crops and animal products. In addition, its population was already quite varied as the Commonwealth housed more than 13 percent of the nation's foreign born and over 12 percent of its free nonwhites. As impressive as these aggregations may seem, it is clear that significant regional differences existed within Pennsylvania in 1850, as they do today, in various demographic elements as well as in specific economic activities. It is to this latter point that this paper speaks in its attempt to deal with the geographic aspects of development and fertility at the county level.

As was stated in the previous section, both an agricultural index and an uban-industrial index were defined and calculated to accomodate the relatively large areas and often diverse populations which compose and are encompassed within many of Pennsylvania's counties. The agricultural index, as constituted, seems to approximate rather well the strength of that economic sector in each county. Table 1, which lists rank-order correlation coefficients between this index and selected rural-agricultural indicators, presents a series of results which are not expected. The coefficient between the index and an estimate of the percentage of farm families portrays little relationship. Combine this with the coefficients for farm size (0.287) and the indexes of agricultural and urban-industrial status (0.689), and they suggest that counties which were strong agriculturally were often also strong uban-industrially; that is, counties with important agricultural economies were not necessarily those in which farm size was great and in which large proportions of inhabitants lived on farms. As shown on Table 1, the coefficient descriptive of the relationship between the agricultural index and farm value per improved acre (0.391) seems not to be as high as might be expected. It is noteworthy that farm value related very directly to population density (0.828) and percentage of urban population (0.740), which indicate its sensitivity to urban pressures for land. Therefore, since farm value correlates more closely to things urban-industrial than to agrarian pursuits, it was not used as an agricultural indicator, given the intention of separating as much as possible the two sectors (agricultural and industrial) in the indexes.

TABLE 1

Rank-Order Correlations, Agricultural Index and Selected Indicators, Pennsylvania Counties, 1850

Agricultural Index[a] and:	
% Farm Families[b]	0.041
Farm Value Per Improved Acre[c]	0.391
Average Number of Improved Acres Per Farm	0.287
Urban-Industrial Index[d]	0.689

Source: Computed by author.

[a]The agricultural index is a rank-order based upon the sum of ranks of grain production (wheat, rye, oats, and Indian corn), number of milk cows, and value of animals slaughtered.

[b]Percentage of farm families was estimated by dividing each county's number of farms by the total number of families and multiplying by 100.

[c]This includes value of farmland, improvement, and implements.

[d]The urban-industrial index is a rank-order based upon the sum of ranks of population size, percentage of urban population, and percentage employed in manufacturing and mining.

The urban-industrial index (composed of the rank of each county's population size, percentage of urban population, and percentage of the population employed in manufacturing and mining) was plotted along the vertical axis of Figure 1, and the agricultural index along the horizontal axis. To provide a simple method of establishing class limits, the median of each index was illustrated on Figure 1. The diagram permits the identification of four general categories of development: Counties in the lower-left quadrant are classified as developed since their ranks both agriculturally and urban-industrially exceed the median, those in the upper right are identified as underdeveloped, agriculturally developed counties with urban-industrial ranks below the median occupy the upper left, and those categorized as urban-industrial but relatively weak in agriculture are situated in the lower-right quadrant (Figure 1).

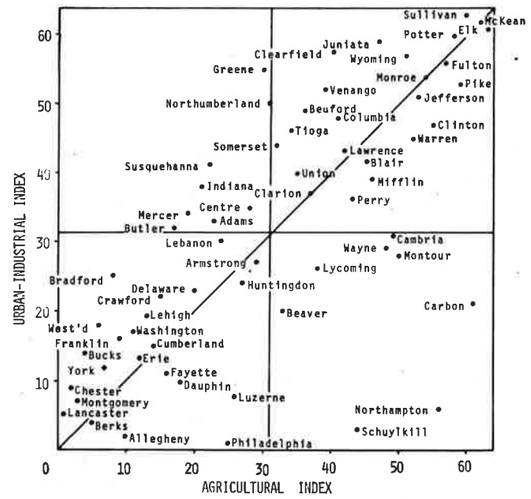


FIGURE 1. The urban-industrial index plotted on the agricultural index permits the identification of four categories of development. In this context, developed counties are located in the lower-left quadrant, having ranks above the median both urban-industrially and agriculturally, underdeveloped counties fall within the upper-right quadrant, agricultural in the upper left, and urban-industrial in the lower right.

The four categories, defined on Figure 1, yield the development levels listed in the legend on Figure 2, which illustrates their distribution (5). The majority of developed counties are concentrated throughout much of the southeast quadrant of the Commonwealth, with other areas appearing in the southwest, the northwest, and northeast. By contrast, those shown as underdeveloped occupy a ten-county area in the north-central section and are joined in the category by less

extensive nodes in the south-central, east-central, and northeastern regions of the state. With a few exceptions, the pattern clearly separates the developed south and periphery from the less-developed north and interior.

Table 2 lists the coefficiens of rank-order correlation for the development index (the sum of ranks of the constituents of both the

TABLE 2

Rank-Order Correlations, Development Index and Selected Characteristics and Indicators, Pennsylvania Counties, 1850.

Development Index[a] and:	
% Foreign Born	0.080
% Illiterate Population[b]	−0.118
% Farm Families	−0.231
% Black Population	0.427

Source: Computed by author.

[a]The development index is the sum of the agricultural and industrial indexes, rank ordered.

[b]Illiterate population over 20 years of age as a percentage of the total population.

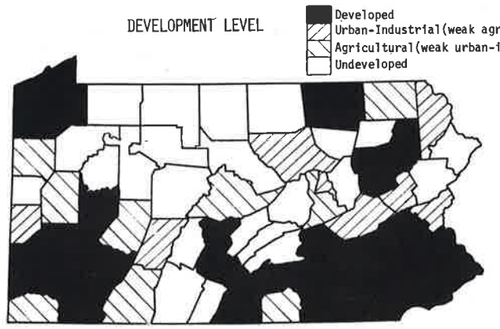


FIGURE 2. Development categories of counties shown are those determined on Figure 1.

agricultural and urban-industrial indexes, which was then re-ranked accordingly) and selected population characteristics. As expected the incidence of illiteracy and percentage of farm families associate negatively with development. The rather weak positive relationship between development and percentage of foreign born population is no doubt related to this group's somewhat greater presence in urban areas as well as their range of skills. The positive relationship between percentage of foreign born and the urban-industrial index (0.240) and its (the foreign born's) negative correlation with the agricultural index (−0.080) support the notion that the foreign born were found frequently in urban circumstances. The relationship between development and the percentage of black inhabitants is positive and stronger than might be expected (Table 2). However, this group was heavily concentrated in and around Philadelphia (54 percent of the "free-colored" resided in the five-county area of the southeast) and Pittsburgh (12 percent lived in the counties of Allegheny, Washington and Fayette), both of which were important centers of population and production in 1850.

Turning to fertility, Figure 3 depicts the distribution of the general fertility rate in 1850. The patterns are generally reversed from those portraying levels of development on Figure 2; that is, the higher fertility rates generally appear in the counties which are defined as underdeveloped, with a few in those identified as agricultural or industrial. The most notable exceptions revealed by comparing figures 2 and 3 are Luzerne County, which had a G.F.R. of more than 140 per thousand but was classified as developed, and Juniata County, which

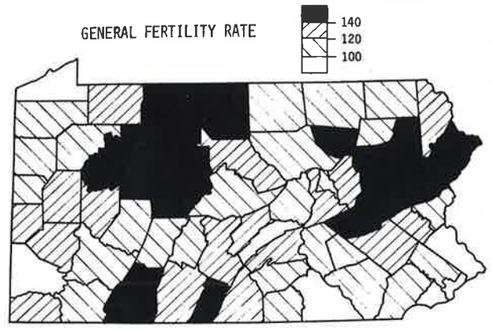


FIGURE 3.

had a fertility rate of less than 100 and was categorized as underdeveloped. Table 3 lists, among other relationships, the rank-order coefficients between fertility and each of the development indexes. Aside from the obvious comment that fertility relates to development in a significant, negative manner, it is worth noting that fertility and the agricultural index are associated more emphatically than natality and urban-industrial status. (Contributing to this difference is the fact that, in relating G.F.R. to the urban-industrial index, there were several more rank-order residuals than in the association between natality and agriculture.) In order to better identify such deviance from expected geographic associations, G.F.R. was plotted on the development index (Figure 4) and all counties whose locations in the diagram were beyond plus or minus one average rank difference were identified. The counties for which fertility was underestimated include Allegheny, Berks, Butler, Luzerne, and Schuylkill; those overestimated were Juniata, Wyoming, and Venango. Table 4 details, in addition to fertility and indicators of development, a series of other characteristics for these eight counties. First, taking those for which fertility was overestimated by the development index, few inconsistencies are apparent in Table 4 except for the very low G.F.R. itself and a low incidence of illiteracy. Since there is little evidence to support an argument in defense of such low fertility given their underdeveloped status, perhaps the placement in Figure 4 of Juniata, Wyoming, and Venango counties represents little more than the effects of woefully underregistered births.

TABLE 3

Rank-Order Correlations, Fertility and Selected Social-Economic Indicators, Pennsylvania Counties, 1850.

General Fertility Rate[a] and:	
Development Index	−0.517
Urban-Industrial Index	−0.441
Agricultural Index	−0.548
% Black Population[b]	−0.372
% Farm Families	0.024
% Foreign Born	0.299
% Illiterate Population	0.166

Source: Computed by author.

[a]Since the number of births is not available for 1850, the general fertility rate was estimated as follows: population under one year of age was divided by the number of females 15-49 and then multiplied by 1,000.

[b]The 1850 Census refers to these inhabitants as "Free Colored" in Pennsylvania and, in those states which had slave populations, disaggregated the free nonwhites from slaves in all counts in which race was considered.

TABLE 4

General Fertility Rates & Development Indicators, Selected Counties in 1850

	G.F.R.		Urban Ind.	Population		Urban Pop.[a]		Employment in Mfg. & Mining			Agr. Index	Farm Families		Black Pop.		Illiterate Population		Foreign Born	
	Rate	Rank	Index Rank	No.	Rank	%	Rank	No.	%[b]	Rank	Rank	%	Rank	%	Rank	%	Rank	%	Rank
Counties in which Fertility was Underestimated[c]																			
Allegheny	121	28	2	138,290	2	60	2	14,653	10.6	5	10	15	61	2.5	13	3.2	27	31	2
Berks	125	27	4	77,129	4	23	7	3,920	5.1	14	5	34	40	0.7	33	1.7	45	4	48
Butler	137	15	32	30,346	23	7	39	769	2.5	42	17	55	8	0.3	55	2.0	40	13	12
Luzerne	158	5	8	56,072	10	15	20	2,087	3.7	25	26	20	60	0.6	37	4.1	19	22	7
Schuylkill	156	6	3	60,713	6	27	4	9,329	15.4	1	44	11	62	0.7	36	9.7	3	30	3
Counties in which Fertility was Overestimated[c]																			
Juniata	97	61	59	13,029	54	0	63	182	1.4	56	47	38	33	1.0	25	1.1	55	1	62
Venango	112	44	52	18,310	45	5	49	483	2.6	41	39	56	7	0.2	57	1.5	50	5	43
Wyoming	107	49	57	10,655	57	5	47	108	1.0	61	51	47	15	0.1	63	1.8	44	9	20
The State	113	—	—	2,311,786	—	28	—	146,766	6.3	—	—	31	—	2.3	—	3.3	—	13	—

Source: Computed by author.

[a]Urban population, as estimated here, is the sum of each county's inhabitants residing in cities and boroughs without reference to size.

[b]Employment in manufacturing, mining, and "the mechanic arts" as a percentage of the total population.

[c]The counties included in this table are residuals of more than one average rank difference, shown on Figure 4.

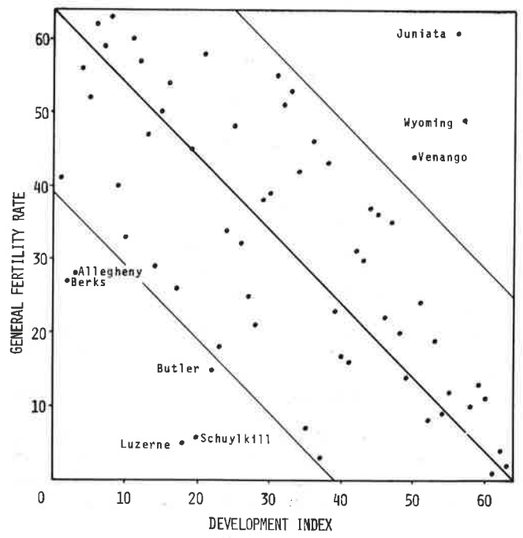


FIGURE 4. Relationship between fertility and development. The center diagonal is suggestive of the expected relationship. The upper and lower diagonals are drawn at plus and minus one average rank difference, and serve to segregate counties for which fertility was substantially underestimated (the five identified in the lower left) or overestimated (those in the upper right) by development level.

Before the counties for which fertility was underestimated are dealt with, it might be worthwhile to review the remainder of Table 3. As shown, natality relates positively to the percentages of foreign born and illiterate inhabitants, only very slightly to the proportion of farm families, and negatively to the percentage of resident blacks. Applying these relationships to the counties identified as underpredicted rank-order residuals on Table 4, perhaps their status might be better understood. Allegheny County, ranked very highly on the development index but listed as having relatively high fertility, had almost 3,500 nonwhites in residence in 1850. Since errors in reporting births occurred through non-registration, it seems reasonable to assume that Allegheny's birth reports were probably among the more accurate, considering the rather large number recorded and its other qualities of development. Therefore, it could be argued that the negative relationship between fertility of the total population and percentage of black inhabitants was generally the result of widespread underregistration of this sub-population's births, especially if one accepts more recent statistics on differential fertility, which identifies nonwhite reproduction as greater than white (6). In addition to numerous nonwhites, Allegheny County had a very large number of foreign-born inhabitants, as did Luzerne and Schuylkill, and this group seems to have displayed a somewhat higher fertility than the native-born population judging by the positive rank-order coefficient shown on Table 3 (7).

As stated previously, only the most general information is available in the 1850 Census descriptive of employment, capital investment, and value of product for manufacturing and mining at the county level. However, it is rather well established from statewide data that Pennsylvania's industries varied significantly in terms of wages, employment and wages by sex, productivity, and capital invested (8). Although figures are for all industries, value of annual product per worker was quite low in coal mining centers such as Luzerne and Schuylkill counties, and Allegheny's was somewhat higher but modest nonetheless (9). Thus, mining seems to have been labor intensive but not especially productive; and Luzerne and Schuylkill, which ranked well urban-industrially, appear to have had fertility levels which were distinct from those similarly classified but with manufacturing and not mining as the activity of importance.

CONCLUDING REMARKS

It is thus generally established that Pennsylvania's developed counties, described here as those with relatively large numbers of inhabitants,

significant proportions of their populations resident in urban places, labor forces engaged in industrial pursuits, and agricultural sectors defined as productive in terms of crop and animal output and value, were found to have generally low fertility. These overall findings notwithstanding, it seems that this paper has raised at least as many questions as it has answered. Moreover, much of what has been stated regarding the role of the foreign born and nonwhite as well as the effect of specific industries on the spatial relationships between development and fertility has been speculative. Therefore, the need exists to study the minorities in more detail, especially their origins, occupations, and socioeconomic characteristics in general; perhaps then, the impact of development upon fertility will be better defined.

REFERENCES AND NOTES

1. See, for example, Davis, K. 1945. The world demographic transition. *Annals Am. Acad. Pol. Soc. Sci.* 237:1-11; Stolnitz, G.J. 1964. The demographic transition. In Freedman, R. (ed). *Population: The Vital Revolution.* Doubleday and Co., Garden City, N.Y., 30-46; Chung, R. 1970. Space-time diffusion of the transition model: the twentieth century patterns. In Demko, G.J., H.M. Rose, and G.A. Schnell. *Population Geography: A Reader.* McGraw-Hill, New York, 220-239; Schnell, G.A. 1970. Demographic transition: threat to developing nations. *J. Geog.* 69:164-171; and Beaver, S.E. 1975. *Demographic Transition Theory Reinterpreted.* Lexington Books, D.C. Heath and Co., Lexington, Mass.
2. All data used in this study are from DeBow, J.D.B., Superintendent of the U.S. Census. 1853. *The Seventh Census of the United States: 1850.* Robert Armstrong, Public Printer, Washington, D.C.; and DeBow, J.D.B., Superintendent of the U.S. Census. 1854. *Compendium of the Seventh Census.* Beverly Tucker, Senate Printer, Washington, D.C.
3. Apparently, Pennsylvania's underregistered mortality was not restricted to that Commonwealth since, in discussing historical aspects of Massachusetts' mortality, Florin cites the number of registered deaths in 1850 as 12,806, which produces a crude death rate of 12.9 per thousand inhabitants, not unlike the rate of 12.4 per thousand registered in Pennsylvania. By contrast, using Boston's crude death rates, ". . .because they are available and reliable," Florin shows a crude death rate for that city in 1850 of about 27 per thousand. See Florin, J.W. 1971. *Death in New England: Regional Variations in Mortality.* University of North Carolina, Department of Geography, Studies in Geography, No. 3, Chapel Hill, 16 and 49.
4. In discussing the faulty registration of mortality, the straightforward language used in the Census is worthy of repetition. It states, in part, "Upon the subject of the deaths, no one can be deceived by the figures of the census, since any attempt to reason from them would demonstrate a degree of vitality and healthfulness in the United States unparalleled in the annals of mankind. . . .The truth is, but a part of the deaths have been recorded. . ." and ". . .in the form these deaths are published, they are of no value. . ." DeBow, *o. cit.*, xl.
5. Boundaries are but approximate for the following counties on Figs. 2 and 3: Clinton, Elk, and McKean, all of which later contributed areas to form Cameron County; Jefferson and Venango, from which Forest was later formed; and union, which eventually was divided to form Snyder County. In addition, all of Lackawanna was formed from the northeastern area of Luzerne, which is shown on the maps as occupying its present territory plus all of Lackawanna's.
6. Although births are not disaggregated at any scale for the "free colored," there are sufficient references concerning other statistics which indicate that data are "reliable, so far as the whites are concerned," which obviously implies that nonwhite figures are suspect. In the case of slave populations, birth counts are available in 1850 for the states which had such populations, and their rates are noteworthy. For example, in 12 of the 15 states for which slave births are available, the G.F.R. of the white and "free colored" *exceeded* the rate for slaves. Moreover, in most of these states, the ratio of whites to "free colored" was large and the G.F.R. for white and "free colored" represented mostly white natality, which renders the disparity even more surprising. Further, in the U.S. in 1850, the G.F.R. for slaves was lower than the rate for the white and free colored (107.7 and 112.6, respectively). Finally, as Bogue has shown, nonwhite fertility has been higher than white in the U.S. as long ago as 1905, when comparable, refined data were first available. Thus, it is highly probable that nonwhite fertility in Pennsylvania was generally underregistered in 1850. See Bogue, D.J. 1969. *Principles of Demography.* John Wiley, New York, 679-680 (Table 18-7).
7. Although no attempt has been made to further investigate Pennsylvania's foreign born by origin in 1850, it is rather well established that, in later years, fertility differentials existed between native whites and foreign-born whites in the U.S., with the latter group exhibiting a significantly greater performance. See, for example, Thompson, W.S. and D.T. Lewis. 1965. *Population Problems.* McGraw-Hill, New York 280.
8. Two industries for which data are available in the Census, and which illustrate the differences mentioned in the text, are wrought iron and cotton manufacture. Average-annual wages per worker were $339 for wrought iron and $163 for cotton. Only seven women worked in the wrought iron industry and their annual wages averaged $79; by contrast, of the 7,663 persons employed in cotton manufacture, more than 4,000 were females, and they averaged $119 in wages annually. Wrought iron was quite productive and capital intensive, with $1,398 in annual product per worker and $1,186 invested per worker. Cotton, by comparison, recorded $695 and $591 for value of annual product and capital invested per worker, respectively.
9. Although 1850 mining employment figures are not available except at the state level, it is practically a certainty that Luzerne, Schuylkill, and Allegheny counties were important coal production areas. Indeed, if 1840 Census data are used, almost 25 percent of the Commonwealth's miners were employed in Schuylkill County: Luzerne and Allegheny employed more than 13 percent each, and outranked all other counties for which mining employment was reported. Taking the 1850 state mining employment total of 11,700 and comparing it to the 4,600 so occupied in 1840, chances are good that Schuylkill County's mining labor force had at least doubled, and Luzerne's had grown well beyond the 600 reported a decade earlier.

Proceedings of the Pennsylvania Academy of Science 51:75—78. 1977.

GEOGRAPHIC VARIATIONS OF INFANT MORTALITY IN PENNSYLVANIA: 1960 AND 1970[1]

MARK S. MONMONIER

Department of Geography
Syracuse University
Syracuse, New York 13210

ABSTRACT

Infant mortality rates for the counties of Pennsylvania are mapped for 1960 and 1970 and for change over the decade. No significant spatial patterns are evident, despite the use of three-year averages to dampen year-to-year fluctuations. Although counties with high 1960 rates had experienced generally greater reductions by 1970 than did places with lower 1960 rates, the pattern of decline is not related to a similar leveling trend for general mortality. Variations in infant mortality exhibit no obvious relationships with selected socio-economic and health-care indicators. Counties with extremely high or low 1970 rates are selected for more detailed study, but no definitive explanations of the geography of infant death emerge.

INTRODUCTION

This paper investigates the spatial variation of infant mortality in Pennsylvania by county unit for the years 1960 to 1970. Of equal concern is the change in the infant mortality rate over this decade. Cartographic and statistical analyses are used to compare infant mortality with general mortality. An attempt is made to relate spatial-temporal trends in infant mortality to socio-economic and health-care indicators. Specific attention is given areas with exceptionally high or low rates in an effort to discover additional factors that might account for place-to-place differences in infant mortality.

Pennsylvania followed the nation with a significant decline in infant mortality through the 1940s. After about 1950 the reduction in deaths of persons under one year of age had slowed appreciably (1). For the United States the ratio of infant deaths to live births had fallen from 85.8 per 1,000 in 1920 to 47.0 in 1940, 29.2 in 1950, 26.0 in 1960, and 20.0 in 1970. Pennsylvania's infant mortality rate declined from 69.0 per 1,000 in 1927 to 44.4 in 1940, 27.3 in 1950, 24.7 in 1960, and 20.3 in 1970 (2). The Commonwealth's lower rates through 1960 can be attributed, in part, to proportions of nonwhites smaller than those of the nation; the infant mortality of nonwhites has consistently been higher than that of whites (3). This difference between racial groups still obtains and has doubtlessly contributed to the convergence around 1950 of metropolitan infant mortality as blacks moved, in increasing numbers, from rural sections of the American south to cities in the Northeast and Midwest (4). The lowering of infant mortality from infectious and parasitic diseases has been largely responsible for the substantial nationwide decline in which, for the white population at least, the gaps among all geographic regions of the country were narrowed as well (5).

SPATIAL PATTERNS OF INFANT MORTALITY

Infant mortality is still far from uniform throughout Pennsylvania. In order to dampen fluctuations promoted by small numbers of births in less populous counties, numbers of live births and infant deaths by place of residence for the years 1959, 1960, 1961, 1969, 1970, and 1971 were used to compute three-year average infant mortality rates for the middle years 1960 and 1970. The resulting rates ranged from 32.9 per 1,000 for Union County to 13.6 for Pike County in 1960 and from 27.8 for Sullivan County to 12.6 for Cumberland County in 1970. Although the statewide three-year mean declined from 24.3 per 1,000 in 1960 to 19.9 in 1970, Greene County's rate rose from 17.1 per 1,000 to 27.6 over the decade. All but six counties registered declines, however; Montour County's drop from 30.7 per 1,000 to 14.9 was the most impressive reduction. Thus, despite a national leveling in the rate of infant deaths, noteworthy variations persist within the Commonwealth.

The geographic patterns of infant mortality for both 1960 and 1970 and of its change over the 1960s exhibit no significant spatial trends. Differences between metropolitan and nonmetropolitan counties, for instance, are not apparent in Figure 1. Appalachia does not emerge as a region with uniformly high infant death rates, even though many high-rate counties are located there. This is somewhat surprising since an earlier study noted that the general death rate, at least for 1960, was appreciably greater in the Anthracite Belt, the region which also experienced the greatest decline in general mortality during the 1960s (6). A more recent investigation demonstrated further that the Anthracite Belt was a distinct region where the mortality rates for most of the 21 more common causes of death differed significantly from the rates for the remainder of the state (7). Yet, for infant mortality the high-rate counties were scattered throughout the Commonwealth in 1970 and formed a few weak clusters in 1960. The only evidence for a distinct region is the northern tier of counties which had relatively high rates in 1960 and exhibited appreciable improvement between 1960 and 1970. Low-rate counties formed some minor clusters for both years, but the distribution of places with low infant mortality, as mapped here, cannot be readily interpreted.

Correlations between standardized mortality ratios and infant mortality rates were computed in order to supplement the visual association between general and infant mortality as illustrated in Figure 1 (8). The absence of strong cartographic associations among the mapped patterns for the 1960 and 1970 three-year averages and for the change over the decade is supported by the correlations in rows five through eight in Table 1. The highest correlation, a weak 0.41, is between general and infant mortality for 1969-71, yet the maps of these two distributions do not suggest even a moderate geographic association. For county units there is little or no similarity between infant deaths and mortality for all age groups.

Modest relationships exist in Figure 1 among the maps concerned solely with infant deaths; these associations suggest that convergence persisted through the 1960s. Despite the low (0.30) correlation between the 1960 and 1970 rates, the change in the infant mortality rate has modest negative (−0.63; see Figure 2) and positive (0.55) correlations with the infant mortality rates for the earlier and later years, respectively. These associations indicate that infant mortality tended to decline in counties with relatively high rates in 1960 and that smaller declines were more common for counties with comparatively low rates in 1970. A similar amelioration has been noted for general mortality within the state in an earlier paper (9). Yet, as measured by the 0.07 correlation in Table 1 between the patterns of change for the mean infant mortality rate and the mean standardized mortality ratio, this similarity between infant and general mortality is temporal but not spatial.

[1]Received April 18, 1977; reviewed; accepted June 30, 1977.

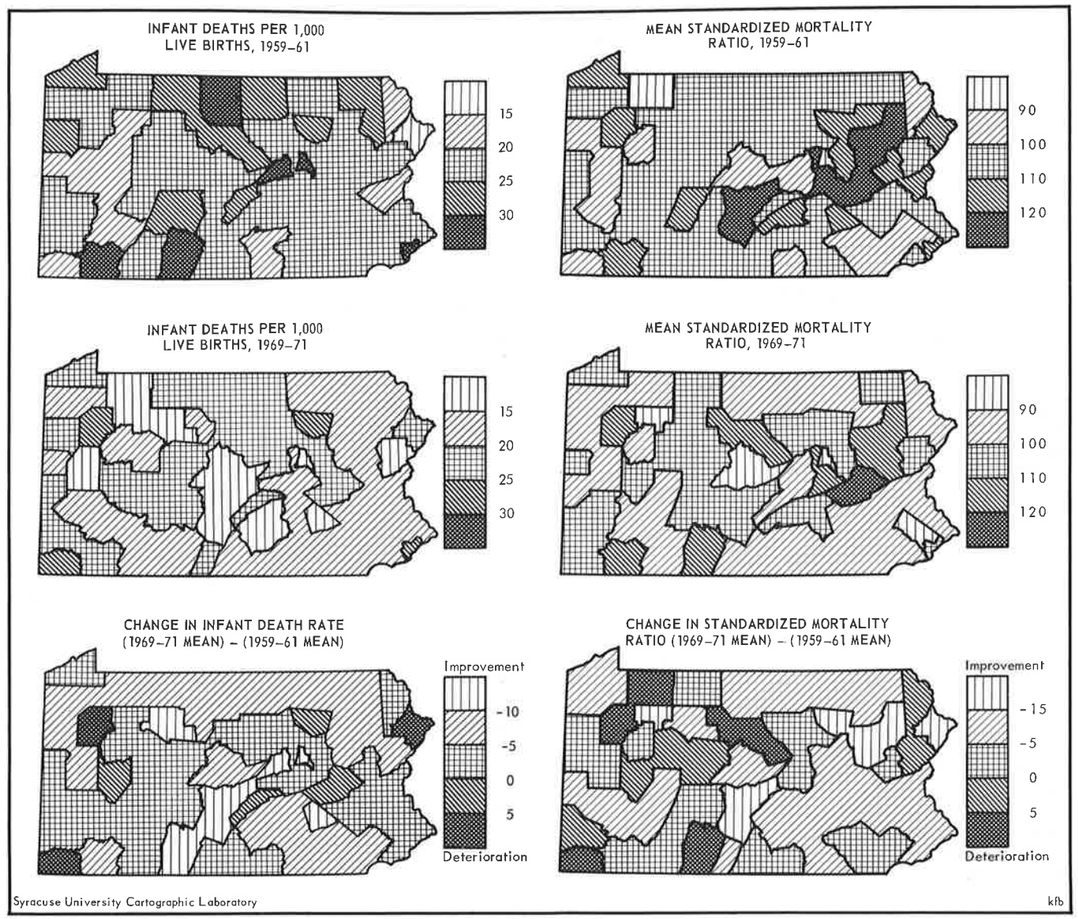


FIGURE 1. Patterns of infant and general mortality for 1960 and 1970 and for change, 1960-1970.

ASSOCIATIONS WITH SOCIO-ECONOMIC AND HEALTH-CARE MEASURES

The puzzling absence of a readily discernable explanation for the geographic patterns of either infant mortality or its decline occurs again in the lower part of Table 1. Here the rates for both time periods and for change over the decade are correlated with four socio-economic variables and three measures of health-care availability. The highest absolute correlation, 0.35, is between 1960's three-year average infant death rate and hospital beds per capita in 1967; here the direction of the correlation is contrary to the reasonable hypothesis that a greater availability of hospital beds — and, by inference, a more favorable supply of hospital services — might tend to lower a place's infant mortality rate. (Yet a generous supply of hospital beds might well be an indicator of excess capacity and, possibly, inefficiency.) Also surprising are the low levels of association with median family income and the percentage of the adult population with a high-school education. A study based on a sample of 2,160 deaths of legitimate infants and 10,395 legitimate births — about 1 out of every 110 for the years 1964-66 — demonstrated a significant negative relationship in the United States between infant mortality and socioeconomic status as measured by the education of either parent and by family income (10). Another study noted a similar influence of socioeconomic status on infant mortality in Chicago for the period 1930-1960 (11). Those results and the present findings clearly demonstrate the differences between individual correlation and ecological correlation for a phenomenon — childbearing — that involves a small, age-specific segment of society.

COUNTIES WITH EXTREME RATES

Ten counties with the five highest and five lowest infant mortality rates for 1970 were chosen for more detailed study (Table 2). Identification of these places on the scatter diagram relating 1960 infant death rates to change over the decade shows that regression underestimated the declines in mortality for all five counties with extremely low 1970 rates (Figure 2). In comparison, the counties with the five highest 1970 rates either experienced increases or registered declines less than those expected on the basis of their high 1960 rates and the statewide relationship for county units between 1960 and 1970. Among these five counties, however, Fayette and Philadelphia had mortality rate reductions below the mean decline of 4.4 per 1,000 for the entire Commonwealth (Table 2).

Are these extremely high and low rates the result of low numbers of live births in their denominators? This question can be addressed by computing the numbers of excess (or deficit) infant deaths. A county's actual number of deaths minus the product of its live births and the infant mortality rate for the state yields a useful measure of excess mortality. Philadelphia's excess of 645 deaths is unlikely to have resulted merely from the selection of the years 1969 through 1971 (Table 2). Indeed, its third highest rate (26.3 per 1,000) is not unexpected insofar as the 1970 population of Pennsylvania's largest city was 51 percent black. Yet, by these calculations the highest 1970 rate of 27.8 per 1,000 in Sullivan County can be attributed to only two extra infant deaths! This excessive rate might, therefore, be ascribed to chance, but the excesses or deficits in infant deaths for the other extreme counties are sufficiently large so that their higher-than-average rates cannot be dismissed as aberrations peculiar to this particular three-year period.

Additional factors, possibly related to infant mortality, are considered in Table 2. Pennsylvania's neonatal mortality rate of 15.4 per 1,000 indicates that 77 percent of all infant deaths in the state occurred within 28 days of birth. Except for Sullivan, all high-rate counties had lower neonatal rates. Nevertheless, neonatal deaths as proportions of all infant deaths did not differ significantly between the two groups. Thus, post-neonatal mortality would appear to be an important, but not dominant factor in the spatial variation of infant mortality.

The relative dominance of neonatal deaths suggests that certain characteristics of a county's live births might be useful in explaining geographic patterns of infant mortality, but a preliminary analysis was not illuminating. Studies of hospital records have shown that immature

TABLE 1

Product-moment Correlations Between the Four Infant Mortality Indexes and the General Mortality, Socio-economic, and Health Care Variables

	Infant Mortality Rates			
	Means		Change, 1960 to 1970	
	1959-61	1969-71	Difference	Percentage
Intercorrelation Matrix				
1959-61 Mean Infant Mortality Rate	1.00	0.30	−0.63	−0.51
1969-71 Mean Infant Mortality Rate	0.30	1.00	0.55	0.64
Difference Between Means	−0.63	0.55	1.00	0.96
Percentage Change	−0.51	0.64	0.96	1.00
Correlations with Independent Variables				
1959-61 Mean Standardized Mortality Ratio	0.02	0.20	0.14	0.14
1969-71 Mean Standardized Mortality Ratio	0.12	0.41	0.23	0.23
Difference Between Mean SMR's	0.11	0.20	0.07	0.08
Percentage Change in SMR's	0.11	0.22	0.09	0.10
Urban Percentage of Population, 1970	0.07	−0.05	−0.10	−0.16
Median Family Income, 1969	−0.12	−0.33	−0.16	−0.22
Percentage of Housing Units with more than 1.01 Persons per Room, 1970	0.10	0.15	0.03	0.04
Percentage of Population over 25 Years Old Complete High School, 1970	0.02	−0.21	−0.19	−0.22
Physicians in Patient Care Per 1000 Persons, 1967	0.28	−0.12	−0.34	−0.25
General Practicioners Per 1000 Persons, 1967	−0.15	−0.19	−0.02	−0.01
Hospital Beds Per Capita, 1967	0.35	−0.01	−0.32	−0.25

TABLE 2

Selected Characteristics of Counties with the Five Highest and Five Lowest Three-year-average Infant Mortality Rates, 1970. (All values are three-year averages for 1969-71 unless otherwise indicated.)

	Deaths per 1,000 Live Births			Excess (Deficit) Infant Deaths	Percentages of All Live Births			
	All Infants	Change, 1960 to 1970	Neo-natal		Weight < 2500 Grams	Birth-Order, 1970-71		Illegitimate
						First	Over Four	
Highest Counties:								
Sullivan (57)	27.8	2.4	13.9	2	5.9	32.6	15.2	5.6
Greene (30)	27.6	10.5	16.7	13	7.2	35.0	14.1	7.2
Philadelphia (51)	26.3	−4.6	19.8	645	11.0	38.2	8.7	21.2
Venango (61)	25.8	5.1	20.8	18	7.0	37.5	9.6	5.9
Fayette (26)	24.8	−5.4	18.9	38	8.0	35.3	14.2	9.2
Lowest Counties:								
Huntingdon (31)	12.6	−10.2	7.5	(16)	6.1	38.3	8.7	8.7
Cumberland (21)	12.6	−6.6	9.9	(53)	6.5	40.1	5.7	5.5
Elk (24)	13.2	−10.3	11.3	(14)	6.7	32.1	15.6	5.5
Butler (10)	13.3	−6.3	11.1	(42)	6.9	34.5	10.0	4.2
Lebanon (38)	13.6	−11.0	11.7	(30)	6.6	39.3	9.2	6.9
Pennsylvania	19.9	−4.4	15.4	0	7.8	37.4	10.1	9.6

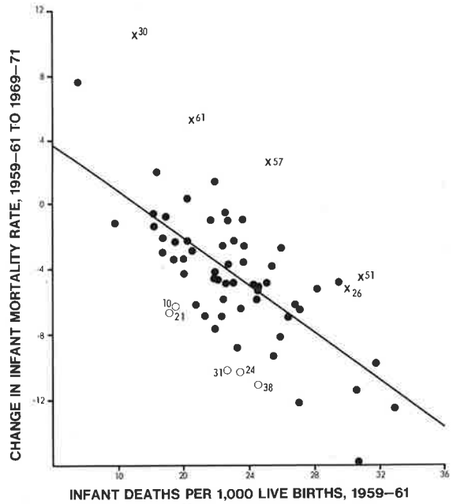


FIGURE 2. Relationship between 1960 infant mortality and change, 1960-1970. Coefficient of determination for the regression line is 0.40. Numbers for high-rate counties correspond to those used in Table 2.

births (infants weighing less than 2,500 grams), births to very young mothers (likely to be first births), births to older mothers (likely to be beyond the fourth birth in birth-order), and illegitimate births all have higher-than-average neonatal mortality rates (12). Although all five low-rate counties had smaller-than-average percentages of immature births, there is no consistent trend among the high-rate counties. The proportions of immature births in Greene and Venango Counties were below that of the state, whereas the percentages for Philadelphia and Fayette were above Pennsylvania's 7.8-percent average. With the exception of Philadelphia, all extreme counties had lower rates of illegitimacy than the state and, again, no trends are evident. Birth-order data for 1970-71 appear to be even less relevant, although it should be noted that birth-order is not a reliable surrogate for the age of the mother.

The firmest conclusion that might be extracted from these analyses is that, by 1960, infant mortality in Pennsylvania had declined to the point where simplistic ecological relationships with socio-economic and health-care-delivery factors are not readily discernible. Consideration of variables more closely related to the hazards of infant death did not, for county-unit spatial aggregations, produce a marked improvement in the level of explanation. Although the geographic variations appear to be more than statistical curosities, they either are unsuitable for study at this scale of analysis or are the products of complex interactions for which needed data, particularly those related to the parents, are lacking.

REFERENCES AND NOTES

1. Shapiro, S., E. R. Schlesinger, and R. E. Nesbitt, Jr., 1968. *Infant, Perinatal, Maternal, and Childhood Mortality in the United States.* Harvard University Press, Cambridge, 133.
2. Data for this study are from *Vital Statistics of the United States,* various years, and from Pennsylvania Department of Health, *Natality and Mortality Statistics Annual report,* various years.
3. Shapiro et al., *op. cit.* [footnote 1], 23-24. The infant mortality rate for nonwhites is about twice that of whites.
4. Shapiro et al., *op. cit.* [footnote 1], 32-33. Between 1950 and 1955 the infant mortality rate for urban areas began to exceed that for rural places. In 1971 the infant mortality rate for urban places in the United States was 19.6 per 1,000 live births; the rate for the remainder of the nation was 18.5. The lowest rate was 16.4 per 1,000 for the balance of metropolitan counties, whereas urban places in metropolitan counties, urban places in nonmetropolitan counties, and the balance of nonmetropolitan counties had rates of 19.4, 20.5, and 20.3, respectively. Thus, the lower rates for nonurban, metropolitan places would appear to be influenced by the socio-economic and health-care amenities of nearby urban centers. Remote, rural areas would, therefore, have a higher infant mortality than would large urban centers.
5. See, for example, MacMahon, B., M.G. Kovar, and J.J. Feldman, *Infant Mortality Rates: Socioeconomic Factors.* 1972. DHEW Publication No. (HSM) 72-1045, National Center for Health Statistics, Rockville, Md., 5 and Shapiro et. al., *op cit.* [footnote 1], 133. In 1971, for instance, infant mortality rates for census divisions ranged from 16.8 per 1,000 for the New England and Pacific states to 22.1 for the East South Central states. The lowest and highest rates by state were 13.8 per 1,000 for Utah and 24.5 for Wyoming; however, the District of Columbia's infant mortality was an even higher 28.1.
6. Monmonier, M. S. 1974. Spatial-temporal trends in mortality in Pennsylvania: 1960 and 1970. *Proc. Pa. Acad. Sci.* 48:13-15.
7. Monmonier, M. S. 1975. A regionalization of Pennsylvania by cause of death, 1969-1971. *Proc. Pa. Acad. Sci.* 49:15-17.
8. Standardized mortality ratios were computed as

$$\frac{D}{\sum_{i=1}^{m} d_i p_i} \times 100,$$

where D is the actual number of deaths for the areal unit, d_i is the mortality rate for age-sex cohort i in the reference population, and p_i is the number of persons in the ith age-sex cohort for the county. The reference population for the maps on the righthand side of Figure 1 was the United States in 1965. Seventy-two age-sex cohorts were used; male-female and white-nonwhite dichotomies were used to subdivide 18 five-year age cohorts (0 - 4, 5 - 9, 75 - 79, 80 - 84, and 85 and older). For additional discussion of these three maps see Monmonier, *op. cit.* [footnote 6].
9. Monmonier, *op. cit.* [footnote 6].
10. MacMahon et al., *op. cit.* [footnote 5], 4 and 13-14. Their findings for the relationship between infant mortality and family income suggest that, for more-highly-educated parents, infant mortality is greater for higher-income families than for middle-income families. This might be the result of child-bearing by older females who have deferred raising a family or of repeated attempts at child-bearing by women who have had one or more miscarriages.
11. Kitagawa, E. M. and P. M. Hauser. 1973. *Differential Mortality in the United States.* Harvard University Press, Cambridge, 66-68.
12. Shapiro et al., *op. cit.* [footnote 1], 51-67.

Proceedings of the Pennsylvania Academy of Science 51:79—84. 1977.

RESIDENTIAL PATTERNS OF BLACKS IN BATTLE CREEK, MICHIGAN, 1850-1930[1]

JUANITA GASTON, Ph.D
Assistant Professor
Department of Geography
Tennessee State University
Nashville, Tennessee 37217
and
WALTER C. FARRELL, JR., Ph.D.
Associate Professor and Chairman
Department of Urban Studies
Cheyney State College
Cheyney, Pennsylvania 19319

ABSTRACT

Little is known about the spatial development and formation of black communities in small cities (population less than 50,000). This study examined changing residential patterns of blacks in Battle Creek, Michigan, over a ninety year period. It was hypothesized that there is a greater dispersion in residential patterns when the black population is small; furthermore, the more concentrated a black residential area, the greater the influx of black migrants. An analysis of manuscript census schedules, city directories, records of deeds, and local newspapers, revealed that black residential patterns were dispersed between 1850 and 1918, and that between 1918 and 1930, concomitant with heavy black in-migration, black residential patterns showed an increasing tendency towards clustering.

INTRODUCTION

In recent years, the number of geographical studies on black Americans has increased tremendously. The studies, in brief, have centered on: ghetto formation (1), residential quality (2), and residential mobility in metropolitan areas (3).

Nevertheless, in spite of the increase of research on black Americans, few studies have focused on the spatial development and formation of black communities in cities with populations of less than 50,000 people. While the knowledge of blacks in the large metropolitan areas is important, detailed case studies on blacks in small cities are needed for future city planning and development and to fill gaps in our knowledge on how and why black communities form and how they change over time. Furthermore, studies of black communities in the nineteenth century are needed if we are to understand the complexity of the urban black experience today.

The objective of this paper is to extend knowledge on the spatial dynamics of black residential patterns in small cities. The residential patterns of blacks in Battle Creek, Michigan — a town of 38,000 in 1970 — is examined over a ninety year period. The guiding research questions are: What was the original settlement pattern of blacks in Battle Creek? What changes have taken place in the residential patterns from 1850 to 1930? What factors influenced the pattern of development?

METHODOLOGY

The "Dagwood Sandwich" (4) approach in historical geography is utilized in an attempt to describe and explain the spatial distribution of the black population. The first step in the approach was to establish a history of change by mapping the residential location of black families for selected cross sections in time between 1850 and 1930. The second step was to describe the patterns and analyze the processes creating them.

Four cross sections in time, 1870, 1900, 1918, and 1930 were selected to depict the phases of black community growth as reflected in the changing residential patterns in Battle Creek. Choice of these specific dates was based on relatively large fluctuations in the black population. The study relied heavily upon manuscript censuses, city directories, tax and assessment rolls, newspapers, records of deeds, and unstructured interviews to identify black households. It was hypothesized that there was a greater dispersion in residential patterns when the black population was small, and that black residential patterns became concentrated as the influx of black migrants increased.

BLACK SETTLEMENT IN BATTLE CREEK

The exact date when the first black settler appeared in Battle Creek is unknown. Nevertheless, by 1840, two black families had been identified in the city. By 1850, the black population numbered thirty-four out of 1,064 (5). Forming 3.9% of the total population, the percentage of the black population was unusually high as compared to 0.6% for the state (6). The high concentration of blacks in Battle Creek was probably the result of antislavery advocates, especially Quakers, who had actively encouraged black settlement in the city.

During the 1860's and 1870's, the small black colony attracted an increasing number of Afro-Americans. The black population increased from thirty-four in 1850, to 155 in 1860, and to 315 to 1870 (7). An important factor in explaining the growth of the black population was the increasing hostility of whites toward blacks, especially in the border states and the midwest, in the years prior to the Civil War. Coinciding with the arrival of blacks, the city was experiencing modest growth. Blacks were able to find jobs as laborers and skilled workers at the Nicholas and Shepard Thresher Works and other burgeoning factories.

During the 1880's and 1890's,Battle Creek (with its established black community) continued to attract other blacks, although at a slower rate than in previous years. The black population increased from a low of 270 in 1880, to 355 in 1890, and to 525 in 1900 (Table 1). The severe economic depressions of the 1870's and 1890's may have contributed to the slower growth rate.

At the beginning of the new century, Battle Creek entered the period of its most rapid growth and development. The population of Battle Creek jumped from 18,565 in 1900 to 43,573 in 1930, while the black population jumped from 525 in 1900 to 1,795 in 1930 (8). The major factors affecting growth were the cereal factories' boom and wartime mobilization. Most of the migrants after 1910 came from the Deep South — Alabama, Georgia, Mississippi, Tennessee, Arkansas, and Louisiana (8,9).

[1]Received June 6, 1977; revised; accepted August 12, 1977.

TABLE 1

Growth of black population of Battle Creek 1850 - 1930

Year	Total Pop.	Increase No.	Increase %	Black Pop.	Increase No.	Increase %	% Black
1850	1,064	—	—	34	—	—	3.3
1860	3,359	1,295	121.7	155	121	355.9	4.5
1870	5,838	2,478	73.8	315	160	103.2	5.2
1880	7,063	1,225	21.0	270	-45	-14.3	3.8
1890	13,197	6,134	86.8	355	85	31.5	2.7
1900	18,563	5,366	40.7	525	170	47.9	2.8
1910	25,267	6,704	36.1	575	50	9.5	2.3
1920	36,164	10,897	43.1	1,055	480	83.5	2.9
1930	43,573	7,409	20.1	1,795	740	70.1	4.0

Source: U.S. Census of Population: 1850-1930.

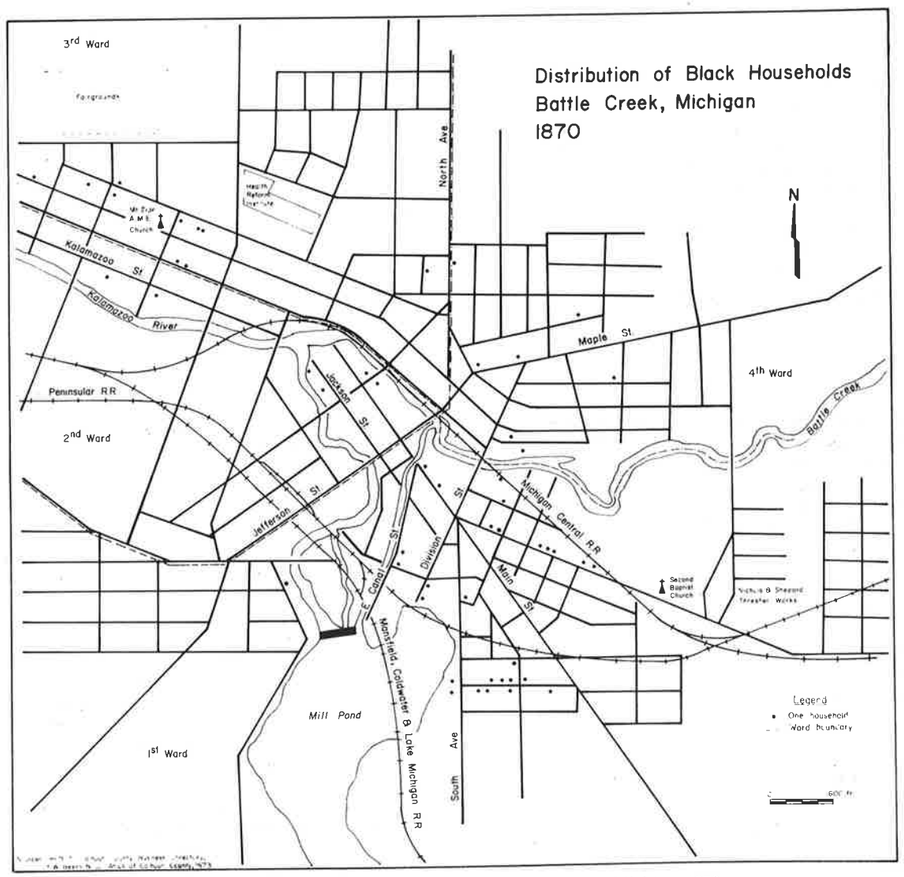


FIGURE 1. Distribution of Black Households, Battle Creek, Michigan 1870.

THE 1870 CROSS SECTION

Few in number, the 1870 black households were dispersed throughout the city (Figure 1) with hints of clustering emerging in the First and Third Wards (10). The largest percentage of black population (64%) was found in the First Ward — a lower class area. A nucleus of black settlement emerged around Warren Street in South Battle Creek — a working class area in which most residents worked as laborers at the Nicholas and Shepard Thresher Works. The remainder of the black households in the First Ward were spread throughout its poorer sections. This generalization is based on evidence of a large number of lodger and boarder residences intermingled with factories which polluted the air; a lower percentage of households reporting real estate than in any other section of the city; and the presence of more day laborers in this area. The location of the industrial and commercial core which provided blacks with easy accessibility to jobs, along with the low cost housing because of the nearby unattractive river lowlands, largely explains the high concentration of Afro-Americans in the First Ward.

A second cluster was emerging in the Third Ward around the African Methodist Episcopal Zion Church. An examination of the manuscript census indicated that this area was apparently developing as an upper class black neighborhood. Jobs held by the heads of households were mainly skilled and semi-skilled (e.g., white-washers, barbers, and stonemasons); one-half of the residents owned property valued from $600 to $1,200; and renters and boarders — so pervasive in the First Ward — were uncommon here. Few households, black or white, were located in the Second Ward, and the Afro-Americans lived near the commercial core. The most fashionable residences in the city were located in the Fourth Ward, and the blacks who lived there were mainly live-in servants and caretakers.

This dispersal in black households reflects the level and extent of the economic differentiation within the black community. No area in the city existed where blacks were systematically excluded.

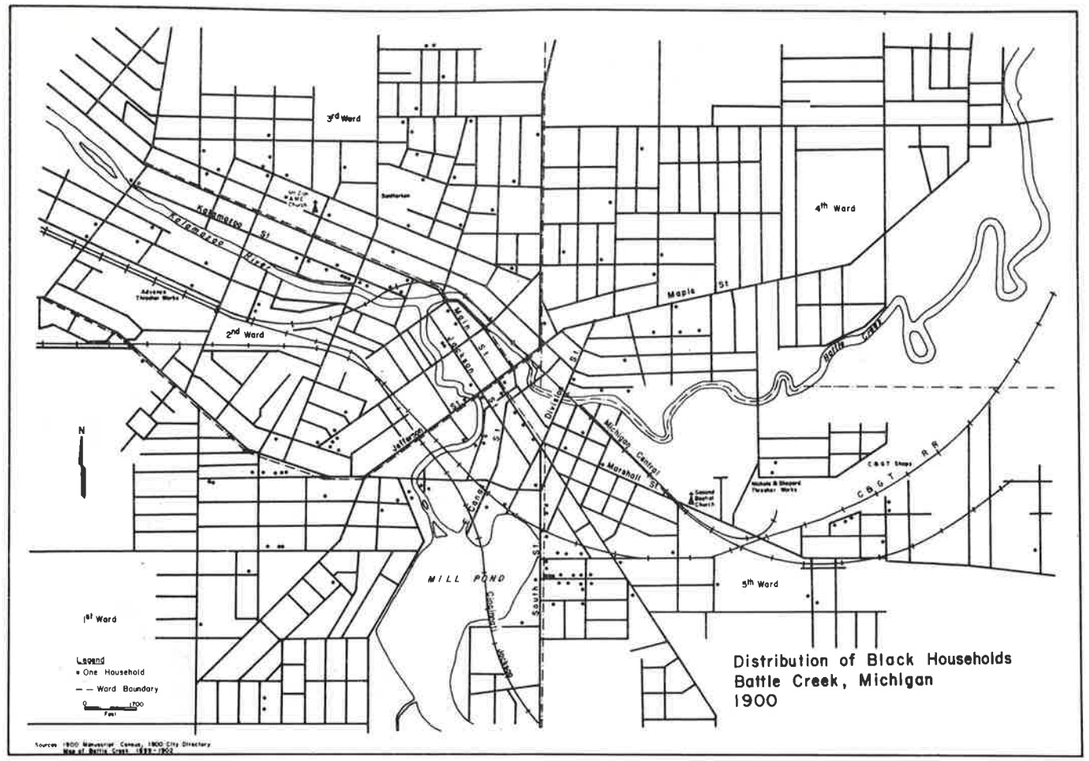


FIGURE 2. Distribution of Black Households, Battle Creek, Michigan 1900.

THE 1900 CROSS SECTION

A modest influx of blacks to Battle Creek occurred during the 1870's, 1880's, and 1890's. Many came because of family and friendship bonds, a few as a result of the active recruitment by the Battle Creek Sanitarium; some were attracted because of the Seventh Day Adventists, and others sought employment in the city's late nineteenth century economic boom. Thus, the black population increased from 315 in 1870 to 525 in 1900.

With the economic and concomitant building surge around 1900, Battle Creek expanded in all directins (11). Black households — newcomers and oldtimers — moved increasingly inward to and outward from old core areas on Warren Street and around the Mt. Zion Church, as these trends, advancing moderately on one front while contracting on the other, persisted (Figure 2). The gradual diffusion of black households toward the outskirts of the city is reflected in the decreasing density of the black households as they moved outward from the corner of Main and Jefferson Streets — "the heart of town." Seventeen black households were located within ¼ mile from the center of town; thirty were ¼ to ½ mile from the intersection; fifty-five were ½ to ¾ of a mile away; twenty-seven were ¾ to 1 mile; four were between 1 and 1¼ miles; and four were 1¼ to 1¾ miles from the center of town. In 1870, the farthermost distance of black households was about ¾ of a mile (12). Thus, at the turn of the century, dispersion continued to be the major characteristic of the residential patterns of blacks in Battle Creek.

The vast majority of black households were dispersed throughout the city, suggesting a general acceptance by and consequent spatial assimilation into the wider society. It should be noted that the occupational backgrounds of the migrants during these years most likely provided them with a head start toward assimilation. Migrating mainly from the Upper South and Border States, many of them came as artisans with some capital and quickly achieved financial stability. They tended to be better educated, more active in community leadership, and more

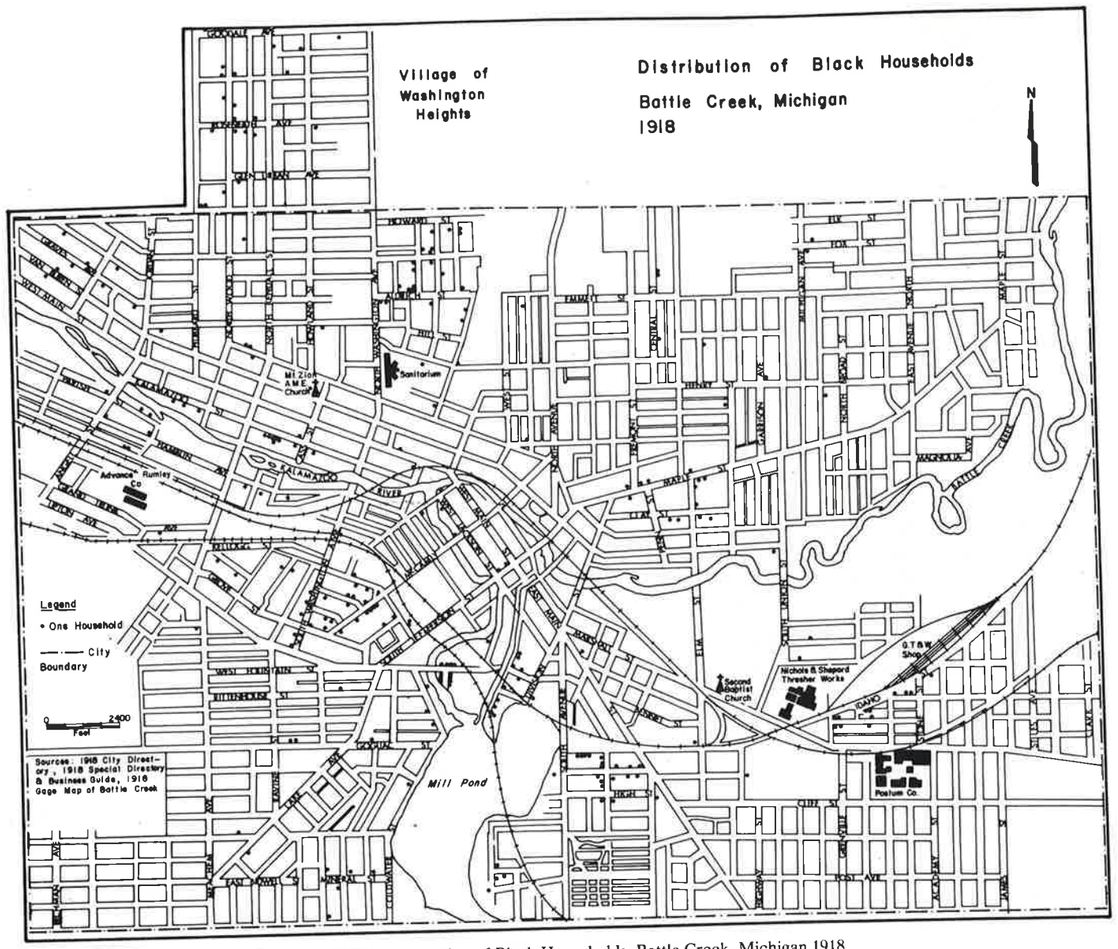


FIGURE 3. Distribution of Black Households, Battle Creek, Michigan 1918.

familiar with urban living than blacks migrating to Battle Creek after world War I. More important than their social and economic skills was probably the fact that arriving in Battle Creek in small numbers, the migrants did not "intrude on the host society and threaten its values" (13). Therefore, residential segregation did not occur.

THE 1918 CROSS SECTION

With the rapid influx of blacks during the war decade, the black population increased nearly two-fold to 1,055. The percentage of blacks, however, climbed less than one percent as the city as a whole grew from 18,000 to 25,000 by 1920. Significantly, the number of black households did not keep pace with the rapid influx of blacks. From 100 black households in 1910, the number increased slightly to 212 in 1920, indicating a high degree of "doubling-up." This "doubling-up" reflected the economically marginal life style of blacks arriving in Battle Creek after 1910.

Blacks tended to settle in the same genral areas as in 1900 (Figure 3) but on a larger scale (14). Despite a general decline in residences in the eastern half of the city (i.e., east of North and South Avenues) as the business core and industry displaced residences, there was a slight accretion of black households in the Warren Street cluster and around the Nicholas and Shepard Thresher Works. Seventy-six percent of the black households were located on the west side. there was also a small increase of black housing in three primary nodes. the first two — the Sycamore-Monroe Street and south McCamley Street areas — continued to develop as lower class neighborhoods. Frequent flooding railroads and nearby industries, and the absence of public sewers, served to make these areas unattractive to all but the poorest citizens of Battle Creek. The third pocket developed north of the Battle Creek Sanitarium as expansion of the sanitarium displaced residences northward from a semi-clustered spatial pattern. Most of the people in this area worked at the Sanitarium as cooks, barbers, nurses, and laundry workers.

In addition to these nuclei of black settlements, blacks were located in other sections of the city in fairly dispersed residences. Immediately to the north of the city limits, in the village of Washington Heights, blacks were spreading in moderate numbers. These were laborers, janitors, barbers, hairdressers, and machinists — some oldtimers, most

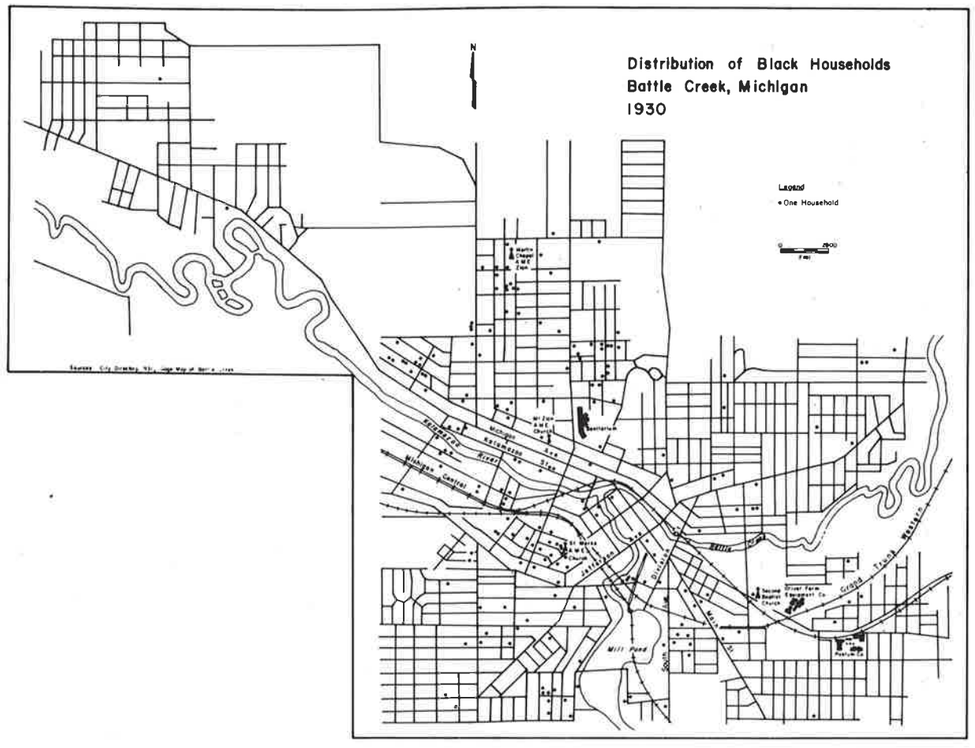


FIGURE 4. Distribution of Black Households, Battle Creek, Michigan 1930.

newcomers — who probably achieved a small degree of economic security; this, seemingly, was a better class residential area.

In sum, the 1918 residential pattern of blacks in Battle Creek was becoming increasingly more concentrated because of the influx of unskilled workers from cotton-belt states (Alabama, Mississippi, and Georgia). the low-income area between South Kendall and Division Streets was apparently developing as the core of the black community.

THE 1930 CROSS SECTION

The change in black residential patterns (Figure 4) was minimal between 1918 and 1930 (15). Generally, blacks continued to reside in the same areas as in previous years; however, the density of households increased in enclaves on the west side, specifically in the low income sector called "the bottoms" (area between Kendall Avenue and Division Street) and in better class residential areas north of the Kalamazoo River.

The most radical change occurred within the Sycamore-Monroe Street enclave — a low income sector in the central part of the city and an older site of black settlement. Displaced by heavy industry and a public institution, the densely settled Sycamore Street cluster was pushed westward into the low income Pearl-Liberty Street area referred to as the already mentioned "bottoms."

On the east side, blacks were living in the same general areas as in 1918, but they were becoming increasingly more dispersed as the density within the former clusters declined. Such then was the residential pattern of blacks in Battle Creek at the onset of the "Great Depression." Blacks continued to be found throughout the city; however, concentrations were increasing on the west side of town, specifically, in the low income sector called "the bottoms," and in the higher class residential areas north of the Kalamazoo River.

The black neighborhoods were by no means exclusively black. However, by the close of the period, the outline of the future black ghetto of Battle Creek had crystallized.

CONCLUSION

The hypothesis is confirmed by the study. Between 1850 and 1910, the migration of blacks to Battle Creek was light as indicated by the small population — up from 34 in 1850 to 575 in 1910. The highest percentage of blacks in the total population was 5.2% in 1870; 315 blacks were in residence at that time. Moreover, the residential patterns of blacks were widely dispersed. Beginning around 1914 and continuing through 1930, the black population increased threefold to 1.795. Growing chiefly by migration, the black population jumped almost 84% from 1910 to 1920; it increased a little over 70% from 1920 to 1930. Maps depicting the residential location of blacks for the period, 1918-1930, showed an increasing tendency toward clustering.

The factors working to produce the spatial distribution of blacks in Battle Creek appear to have been accessibility to job location, low cost housing and, to a lesser degree, kinship and friendship ties and group identification. After 1919, racial discrimination became an important factor in the residential patterns of blacks. While no formal restrictive covenants were imposed, it became increasingly difficult for blacks to purchase housing outside of certain areas.

The research findings indicate that the forces which created and changed the residential patterns of blacks in Battle Creek, a small city, as opposed to metropolitan cities, were different in degree rather than kind. Because of the small number of blacks in the city from 1850 to World War I, blacks were widely dispersed; later, residential clustering intensified in response to rapid in-migration. These stages in the development of residential areas were experienced in other cities, (e.g., Lansing, Chicago, Detroit, Seattle) at a much earlier period in their development. Such stages were dependent upon the size of the city and the magnitude of the black population. In fact, with the exception of Lansing and Seattle which developed black areas a few years later, a national ghetto pattern had emerged by 1930. It appears that Battle Creek was in the embryonic stage of ghetto development at the close of the study.

REFERENCES AND NOTES

1. Johnson, Charles. 1943. *Patterns of Negro Segregation.* Harper and Row, New York; Weaver, Robert C. 1948. *The Negro Ghetto.* Harcourt Brace Jovanovich, Inc., New York; Farley, Reynolds. 1970. "The Changing Distribution of Negroes Within Metropolitan Areas: The Emergence of Black Suburbs." *American Journal of Sociology.* 75:512-529.
2. Banfield, Edward C. 1970. *The Unheavenly City: The Nature and Future of Our Urban Crisis.* Little, Brown and Company, Boston, Massachusetts.
3. Deskins, Donald R. 1972. *Residential Mobility of Negroes in Detroit, 1837-1965.* University of Michigan Geographical Publication No. 5, Ann Arbor, Michigan; Meyer, David R. 1970. *Spatial Variation of Urban Households.* University of Chicago Department of Geography Research Paper No. 129, Chicago, Illinois.
4. For a discussion of the "Dagwood Sandwich Approach," see Newcomb, Robert N. 1969. "Twelve Working Approaches to Historical Geography." *Association of Pacific Coast Geographers Journal.* 31:27-50.
5. *Population Schedules of the Seventh Census of the United States. 1850.* Michigan: Calhoun County. Microcopy No. 432, Roll 348. Washington, D.C.: National Archives Microfilm Publications, 1963.
6. *Population Schedules of the Eighth Census of the United States, 1860.* Michigan: Calhoun County. Microcopy No. 653, Roll 539 Vol. 3 (1-760). Washington, D.C.: National Archives Microfilm Publications, 1967.
7. *Population Schedules of the Ninth Census of the United States, 1870.* Michigan: Calhoun County. Microcopy No. 593, Roll 666 Vol. 4 (338-589), Washington, D.C.: National Archives Microfilm Publications, 1965.
8. U.S. Department of Commerce, Bureau of the Census. *Fifteenth Census of the United States, 1930: Population.*
9. This information was ascertained from interviews with black senior citizens of Battle Creek, Michigan, January, 1975 through March, 1976.
10. *Population Schedule of the Ninth Census of the United States, 1870.* Michigan: Calhoun County; *Calhoun County Business Guide, 1869-70.* E.G. Rust Company, 1870, Battle Creek, Michigan.
11. *Battle Creek City Directory.* 1900. R. L. Polk and Company, Battle Creek, Michigan.
12. The distance was computed from ¼ mile tiers on a 1900 map of Battle Creek by R. L. Polk Company.
13. Johnson, R. J. 1972. *Urban Residential Patterns.* Praeger Publishers, New York, 49.
14. *Battle Creek City.* 1918. R.L. Polk Company, Battle Creek, Michigan; Evans, Claude L. 1918. *Special Directory and Business Guide for the Colored Citizens of Battle Creek.* Claude L. Evans, Battle Creek, Michigan.
15. *Battle Creek City Directory.* 1931. R. L. Polk Company, Battle Creek, Michigan; Interviews with black senior citizens of Battle Creek.

Proceedings of the Pennsylvania Academy of Science 51:85—87. 1977.

THE AGE OF THE MARTINSBURG FORMATION AT SWATARA GAP, PENNSYLVANIA[1]

THOMAS O. WRIGHT[2], SUSAN M. GARWOOD[2] and KRAIG DERSTLER[3]

ABSTRACT

Graptolites from the Martinsburg Formation at Swatara Gap, Pennsylvania belong to the *Climocograptus spiniferus* Zone. Range zones for the shelly fauna include the Late Barneveld Stage and possibly the earliest Eden Stage, consistent with the age determined from the graptolites. The dominant trinucleid trilobite is *Cryptolithus lorettensis;* however, our data indicate that the sub-specific (morphotype) classification methods previously used for this genus are inadequate and do not provide precise age determinations.

The Martinsburg Formation exposed at Swatara Gap is not part of the Hamburg Klippe. Lithologic and faunal evidence support the view that these rocks are autochthonous and are continuous with the Central Appalachian-type Martinsburg rocks.

INTRODUCTION

Swatara Gap is situated on the southern edge of the Folded Appalachian physiographic province in Lebanon County, Pennsylvania where Swatara Creek passes through Blue Mountain. Here, approximately thirty meters of the Martinsburg Formation are exposed along with an additional fifty meters of the disconformably overlying Tuscarora Quartzite. The Martinsburg is exposed in the roadcut for the southbound lanes of Interstate 81 and in an adjacent road-metal quarry. The outcrops are 3.0km (1.9 miles) NNW of Lickdale, Pennsylvania in the northeast corner of the Indiantown Gap 7.5' Quadrangle (Figure 1).

Two different interpretations of the Martinsburg Formation at Swatara Gap are available in the literature. The earlier one (e.g., Stose, 1946) considers these rocks to be autochthonous and they are correlated with the Middle Eden (Upper Ordovician). In a more recent interpretation, Epstein et al. (1972) indicate that these rocks are part of the Hamburg Klippe and that they are early Barneveld in age (Middle Ordovician). Our purpose in this paper is to present some new evidence which indicates that the Martinsburg Formation at Swatara Gap is either Late Barneveld or Early Eden age and that it is autochthonous.

GEOLOGIC SETTING

The Martinsburg Formation in south-central Pennsylvania, Maryland, and West Virginia is a coarsening upward, conformable sequence of olive gray shale and tan sandstone of Upper Ordovician age, younger that the underlying Middle Ordovician limestone and older than the overlying Bald Eagle or Oswego and Juniata Formations. However, between Harrisburg and Hamburg, the Martinsburg Formation is complicated by the apparent absence of the Juniata, Bald Eagle and part of the Martinsburg and the presence of the Hamburg Klippe, which is a large area containing highly deformed red, tan and gray shale with anomalously old graptolites, chert, thinbedded limestone, graywacke and basalt. The Klippe was described by Stose (1946, 1950) who considered it to be the remnant of a thrust sheet implaced overtop the autochthonous Martinsburg during Taconic deformation, prior to deposition of the Lower Silurian Tuscarora Quartzite. Later, the Hamburg Klippe was reinterpreted by Platt et al. (1972) as a series of gravity-implaced slide blocks. The blocks were thought to have been deposited in the Martinsburg basin during the Taconic, embedded within a matrix of Martinsburg silts and shales.

METHODS

Collections from Swatara Gap have been made over several years by the authors. Additional material for this study was made available to us principally from the collections housed at North Museum, Franklin and Marshall College and Bryn Mawr College. The fauna is abundant and diverse, known forms are listed in Table 1. This list is the cumulative result of the mapping, collecting and taxonomic investigations of one of us (K.D.); many of the forms have been examined by specialists, cited in the acknowledgements.

As *Cryptolithus* has been previously used to assign an age to this locality, twenty well preserved cephalons were selected for detailed investigation. Well preserved graptolites were examined in order to date these rocks according to Riva's (1969, 1974) graptolite zonation of Eastern North America. Matrix was removed when necessary and camera lucida drawings prepared. The number and arrangement of pits along the cephalic margin of the *Cryptolithus* cephalons were measured and the results compared to Whittington (1968) and Lesperence and Bertrand (1976). Graptolites were compared to Ruedemann (1947), Ross and Berry (1963) and to Riva (1969). Selected specimens were sent to Dr. John Riva, Laval University, for confirmation. These specimens will be reposited in the U.S. National Museum, Division of Paleontology and Stratigraphy.

RESULTS AND DISCUSSION

At Swatara Gap, the Martinsburg Formation is a sequence of poorly-bedded, fine grained dark gray siltstone interbedded with laterally discontinuous beds of coarse-grained brown siltstone. These brown siltstones, in beds up to 20cm in thickness, rest upon scour surfaces cut into the underlying gray siltstone and have small scale internal cross-laminations. The brown siltstone beds are ungraded. These brown siltstones are interpreted as a series of traction current deposits; the basal erosion surface formed as the current waxed and the siltstone deposited as the current waned (Derstler, 1975). Willard (1943) and Stose (1946) noted the similarity between the rocks at Swatara Gap and those of the Central Appalachian-type Martinsburg further west and south. This general lithology extends for approximately 3km to the south, where red and tan shales plus thin bedded limestones of the Hamburg Klippe type are first found.

Graptolites collected from Swatara Gap (Table 1) belong to the *Climacograptus spinferus* Zone. Dr. John Riva, who identified the graptolites as "*Orthograptus quadrimucronatus micracanthus* Elles and Wood (thecae are more closely spaced than in typical form)" and "*Climacograptus typicalis* (Hall) (three spined variety)" assigned these collections to the lower part of the *C. spiniferus* Zone. Riva (1974) indicates that the lower part of this Zone is approximately correlative

[1]Received May 20, 1977; revised; accepted October 17, 1977.
[2] Department of Geology, Allegheny College, Meadville, Pa. 16335.
[3]Department of Geological Sciences, University of Rochester, Rochester, New York 14627

TABLE 1

List of the Known Fossil Fauna and Flora from the Martinsburg Formation At Swatara Gap, Lebanon County, Pennsylvania.

Thallophyta-Dasycladacea
  Undescribed Form rr,c,c
Porifera-Calcarea
  Undescribed Form rr,c,c
Coelenterata-Conulariida
  Conularia trentonensis (Hall) r
Bryozoa
  Batostoma sp. r
  Berenicea sp. cr
  Dekayella sp. cr
  Hallopora cf. *H. dalei* (Edwards and Haine) rr
  Polypora sp. r
  Rhinidictya sp. cr
  Vinella sp. cr
Brachiopoda-Articulata
  Camerella sp. r
  Leptaena gibbosa (James) c
  Onniella multisecta (Meek) c
  Plectorthis plicatella (Hall) rr
  Rafinesquina alternata (Emmons) c
  Rafinesquina cf. *R. trentonsis* Conrad rc
  Sericoidea sericea (Sowerby) cc
  Sowerbyella rugosa (Say) c
  ??*Synatrophina* sp. r
  Zygospira modesta (Meek) c
  Undetermined Forms
Brachiopoda-Inarticulata
  Craniops cincinnatiensis (Meek) cr
  Lingula sp. rc
  Philhedra cf. *P. laelia* (Hall) rr
  Undetermined Linguloid rr
  Undetermined Conotretoid rr
Mollusca-Cephalopoda
  Indeterminate Orthocone cc
  Ordovician "*Kionoceras*" rr
  Undescribed Curtocone or Gyrocone rr
Mollusca-Monoplacophora
  Archinacella sp.
Mollusca-Gastropoda
  Liospira americanum (Billings) cr
  Lophospira sp. rc
  Sinuites cancellatus (Hall) c
  Several Undetermined Forms cr-rr
Mollusca-Hyolitha
  Hyolithes sp. r,nf
Mollusca-Pelecypoda
  ?*Byssonychia* cf. *B. vera* Ulrich r
  Cleidophorus planulatus (Conrad) cr
  Colpomya fabaintermedia (Ruedemann) cr
  Ctenodonta filistrata Ulrich cr
  Cuneamya sp. rc
  ?*Modioloposis* sp. rc
  Pterinea sp. rc
  Rhitimta radiata Ulrich r
  Rhitimya sp. r
Arthropoda-Merostomata
  Undetermined Form nf,rr,r
Arthropoda-Ostracoda
  Ceratopsis chambersi (Miller) rc,c
  Primiticella unicornis (Ulrich) rc,cr
  Two Undetermined Forms c,r
Arthropoda-Trilobita
  Acidaspis cincinnatiensis Meek rc,c,cr
  Cryptolithus "lorettensis" c,cc,cc
  Diacanthaspis sp. rr,r,r
  Flexicalymene granulosa (Foerste) cr,c,c
  Homotelus stegops (Green) r,cr,cr
  Mesotaphraspis n.sp. rc,rc,rc
  Platylichas sp. rr,rr,rr
  Pterygometapus (Achatella) achates Billings rr,rc,cr
  Proetus parvisculus Hall rr,r,r
  Triarthrus becki Green rc,cr,cr
Echinodermata-Asteroidea
  Mesopaleaster cf. *M. lancolatus* Schuchert rc,cr
  "Promopaleaster" pricei Cramer rr,r
  Promopaleaster bellulus (Miller) rr
  Schuchertia laxata (Schuchert) rr
  "Urasterella" pulchella (Billings) rr,rr
Echinodermata-Crinoidea
  Ectinocrinus simplex (Hall) cr,c
  Heterocrinus sp. r,rc
  Glyptocrinus sp. r,cr
  Iocrinus subcrassus Meek & Worthen r,rc
  "Lichenocrinus" (multiplated crinoid holdfast) r
  Undetermined Form (?Merocrinoid) r
  Undetermined Xenocrinoid r
  Undetermined Root-type Holdfast rc
  Undetermined Small Crinoid rr
Echinodermata-Ophiuroidea
  Phragmactis sp. r,rc
  Protasterina maximus (Willard) cr,cr,c
  ?*Taeniaster* sp. rr
Echinodermata-Stylophora
  Ateleocystites huxleyi Billings rr,rr,rr
  Paranacystis n.sp. rr,rc,rc
Protochordata-Graptolithina
  Climacograptus typicalis (Hall) (three-spined variety) cr
  Diplograptus nexus rc
  ??*Inocaulis* sp. rr
  Orthograptus quadrimucronatus micracanthus Elles & Wood cr
  Undetermined Dendrograptid rr
Annelida-Polychaeta
  Lepidocoleus jamesi (Hall & Whitfield) rr,rc,rc
  Plumulites sp. nf,r,rc
  Staurocephalites sp. nf, rr,rc
  Arabellites sp. nf,rr,rr
Incerta Sedis-Cornulitida
  Cornulites flexosus (Hall) cr
  Cornulites cf. *C. progressus* r
Incerta Sedis-"Styliolinida"
  Undetermined Form c

Amorphous carbon films and assorted shelly debris cannot be identified.
Abundance Code: cc-abundant (10+ specimens/hour collecting)
c - fairly common (more than 1 specimen/hour collecting)
cr - occasionaly found (about 1 specimen/hour collecting)
rc - found infrequently (about 1 specimen/10 hours collecting)
r - rare (about 1 specimen/30 hours collecting)
rr - extremely rare (1 specimen/100 hours collecting)
Abundance estimates based upon approximately 500 hours of collecting. Often, the rarer forms are found concentrated in small patches on a single bedding surface or within a small lens of siltstone.

When more than one abundance code is used, the first refers to articulated specimens, the second to isolated plates or sclerites and the third to identifiable broken fragments. "nf" indicates that articulated specimens were not found.

with the *O. 'intermedius'* Zone in Texas (Berry, 1960), to the upper Barneveld Stage and the upper Caradoc of Europe.

Lesperence and Bertrand (1976) recently restudied *Cryptolithus*, primarily using material from the Barneveld and Eden of the St. Lawerence Lowlands. They distinguished a series of discrete morphotypes, correlated them with the previously described "species" and noted that these morphotypes showed limited stratigraphic segregation. In the St. Lawrence Lowlands, morphotypes A and Db do not co-occur. A and B are limited to the lower Sherman (lower Barneveld), C ranges throughout the Barneveld and Eden and Db is found only in the Eden. Lesperence and Bertrand (1967; p. 607) found morphotype C to be dominant at Swatara Gap and apparently also found a few specimens of morphotype D and E (they report their morphotype association III, a mixture of C, D and E). In our collections we found morphotype C to be dominant, however we identified one specimen of morphotype A and one of Db. Thus, in Pennsylvania we do not find the same association of morphotypes as described from the St. Lawrence Lowlands, thus we are unable to use Lesperence and Bertrand's (1976) range zone assignments of their various morphotype associations.

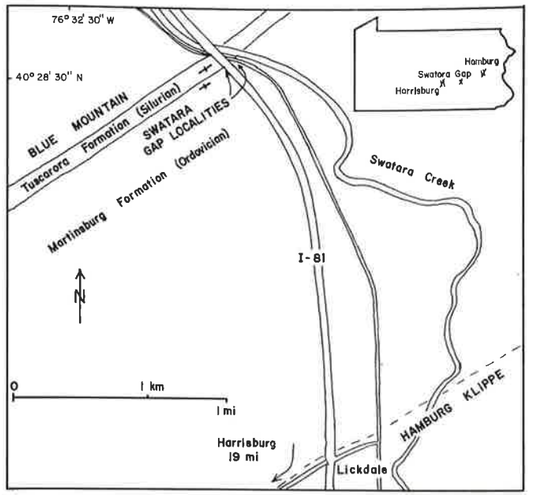


FIGURE 1. Location index map showing Swatara Gap, the Tuscarora and Martinsburg Formations, Interstate Route 81 and Lickdale, Pennsylvania.

Lesperence and Bertrand (1976) consider morphotypes A and C to be equivalent to *C. tesselatus* and *C. lorettensis*, respectively. Morphotype B is intermediate between these two "species" and Db is intermediate between *C. lorettensis* and *C. bellulus*. The distinction of morphotypes imparts what may be an artificial discreteness in the identification of these trinucleids. Lesperence and Bertrand (1976) discuss the transitional nature of the different morphotypes and morphotype associations. It may be more reasonable to consider the mean and variance of the pit counts for these trilobites since they show nearly continuous variation. Morphotype C is dominant in our collection and probably represents the mean arrangement of pits on the cephalon. Morphotype A, and Db are much less abundant and can be considered as end members in the variance of pit arrangement. The entire collection may be a sample from a population of *C. "lorettensis"* showing an unusually large variance in the arrangement of pits on the cephalon. This may be controlled by factors other than age.

Range zones for the other faunal elements are consistent with the graptolites, but add little precision to the correlation. Ostracodes identified as *Ceratopsis chambersi* are abundant at Swatara Gap, and Warshauer (1975) noted that they are limited to Eden strata in the Cincinnati Arch. We have not been able to compare our specimens with any pre-Eden ceratopsids, therefore, we hesitate to limit the age range of Swatara Gap to the lower Eden, although Lesperence and Bertrand (1976) do correlate the Eden Stage with the *C. spiniferus* Zone.

CONCLUSION

The Martinsburg Formation at Swatara Gap, below the disconformably overlying (Silurian) Tuscarora Formation, contains graptolites from the *Climacograptus spiniferus* Zone and the rocks are correlated with the upper Barneveld or lowermost Eden. Range zone of the shelly fauna, including *Cryptolithus "lorettensis"*, are consistent with this correlation. This fixes the Ordovician side of the unconformity at the Middle/Upper Ordovician boundary. These rocks are autochthonous; they are continuous with the Central Appalachian-type Martinsburg further west and they are not part of the Hamburg Klippe.

ACKNOWLEDGMENTS

Several colleagues, amateur and professional, generously provided taxonomic and other assistance, valuable criticism and discussion. John Riva, Universite Laval, Quebec, studied two collections of graptolites; Rousseau H. Flower, New Mexico Bureau of Mines and Mineral Resources, Socorro, examined a small collection of cephalopods; Paul S. Boyer, Fairleigh Dickinson University, Madison, New Jersey, identified the scolecondonts; F.H.C. Hotchkiss, Academy of Natural Science, Philadelphia and Jon Branstrator, University of California at Davis discussed their research on several of the asteroids and ophiuroids and offered their opinions on the taxonomic assignments of these fossils and Ellis L. Yochelson, United States Geological Survey, Washington, D.C., examined the monoplacophorans. Dr. John W. Price, Jr., North Museum, Franklin and Marshall College, Lancaster, has enthusiastically supported and encouraged our work and provided access to this extensive collections from this locality. Edward C. Beutner, Franklin and Marshall College, and Anita G. Epstein, U.S.G.S., Washington, D.C., offered useful discussion concerning the structural geology at Swatara Gap and vicinity. We thank these people for aid.

REFERENCES

Berry, W.B.N. 1960. Graptolite faunas of the Marathon Region, West Texas. *Univ. Texas Publs.* 6005: 179 p.

Derstler, K. 1975. Homoistelean carpoids. *unpublished Honors Thesis, Franklin and Marshall College, Lancaster, Pennsylvania.* 186 p.

Epstein, J.B., A.G. Epstein, and S.M. Bergstrom, 1972. Significance of Lower Ordovician exotic blocks in the Hamburg Klippe, eastern Pennsylvania. *U.S. Geol. Survey Prof. Paper 800-D:* D29-D36.

Lesperence, P.J. and R. Bertrand. 1976. Population systematics of the Middle and Upper Ordovician trilobite *Cryptolithus* from the St. Lawrence lowlands and adjacent areas of Quebec. *J. Paleont.* 50: 598-613.

Platt, L.B., R.B. Loring, A. Papaspyros and G.C. Stephens. 1972. The Hamburg Klippe reconsidered. *Amer. J. Sci.* 272: 305-318.

Riva, J. 1969. Middle and Upper Ordovician graptolite faunas of St. Lawrence lowlands of Quebec, and of Anticosti Island. *in AAPG Mem. 12, North Atlantic-Geology and Continental Drift.* 513-556.

Riva, J. 1974. A revision of some Ordovician graptolites of eastern North America. *Paleont.* 17: 1-40.

Ross, R.J., Jr. and W.B.N. Berry. 1963. Ordovician graptolites of the Basin Ranges in California, Nevada, Utah and Idaho. *U.S.G.S. Bull.* 1134: 177p.

Ruedemann, R. 1947. Graptolites of North America. *Geol. Soc. America Mem.* 19: 651p.

Stose, G.W. 1946. The Taconic sequence in Pennsylvania. *Amer. J. Sci.* 244: 665-696.

Stose, G.W. 1950. Evidence of the Taconic sequence in the vicinity of Lehigh River, Pennsylvania. *Amer. J. Sci.* 248: 815-819.

Warshauer, S.M. 1975. The sexual dimorphism and ontogeny of *Ceratopsis chambersi* (Miller) (Ostracoda, Palaeocopida) from the Upper Ordovician of southwestern Ohio and northern Kentucky. *Bull. Amer. Paleont.* 67 (287): 443-456.

Whittington, H.B. 1968. *Cryptolithus* (Trilobita): Specific characters and occurence in Ordovician of eastern North America. *J. Paleont.* 43: 702-714.

Willard, B. 1943. Ordovician clastic sedimentary rocks in Pennsylvania. *Bull. Geol. Soc. Amer.* 54: 1067-1121.

Proceedings of the Pennsylvania Academy of Science 51:89—90. 1977.

RESEARCH NOTE:

SUCCINATE DEHYDROGENASE ACTIVITY IN RANA CATESBEIANA TADPOLE LIVER DURING 3, 3′, 5-TRIIODA-L-THYRONINE-INDUCED METAMORPHOSIS[1]

DAVID OSTROVSKY and ROBERT SAHMS

Department of Biology
Millersville State College
Millersville, PA 17551

ABSTRACT

There is a significant increase in the specific activity of succinate degydrogenase in the liver of *Rana Catesbeiana* tadpoles 72 hours after 3, 3′, 5-triiodo-L-thyronine injection.

INTRODUCTION

Metamorphic changes that occur in the tadpole in response of thyroid hormone are accompanied by changes in the rate of cell respiration (1). These changes in cell respiration rate are probably related to an increased energy requirement brought about by the synthesis of a number of proteins involved in terrestrial adaptation. Tata's observation that there is an increase in cytochrome oxidase activity during induced anuran metamorphosis suggests that thyroid hormone acts to increase cell respiration rate by increasing the activity of mitochondrial enzymes (2).This hypothesis was further examined by a study of the effects of thyroid hormone on the specific activity of a key mitochondrial enzyme, succinate dehydrogenase.

MATERIALS AND METHODS

Bullfrog tadpoles, *R. Catesbeiana* (Carolina Biological Supply) at Taylor-Kollros stage IX-XI (3) were selected for the induced metamorphosis studies. Tadpoles were injected intraperitoneally via the tail muscle with 3, 3′, 5-triiodo-L-thyronine (T_3) at a dose of 300 pica moles per gram body weight (4). Control animals were injected with the same relative volume of vehicle (200 micronormal NaOH). Three animals were used in each experimental and control group. Preliminary studies demonstrated that the vehicle had no significant effect on succinate dehydrogenase (SDH) activity.

At selected times after injection (from 1 to 144 hours) the tadpole livers were removed and desanguinated by perfusion with cold (4°C) homogenization buffer (0.2 M Sucrose, 0.05 M Tris (Sigma), 0.005 M $MgCl_2$, and 0.001 M EGTA (Sigma) at pH 7.4).

The livers were homogenized in a chilled glass-teflon homogenizer and portions of the liver homogenate were set aside for the SDH assay (5) and for protein determination (6).

RESULTS AND DISCUSSION

The experimental and control groups showed a sharp rise in SDH specific activity 24 hours after injection and a sharp decline in specific activity after 72 hours (Table 1). During this interval, however, there was no significant difference between the SDH specific activity of the experimental and control groups. There was, however, on the basis of the Student's-t-Test a significant difference at the 95% confidence level in SDH specific activity between experimental and control groups after a 72 hour lag period, the experimental groups having the higher specific activity.

[1]Received January 29, 1977; revised; accepted June 17, 1977

TABLE 1

Effect of T_3 on SDH specific activity in R. Catesbeiana *tadpole liver.*

Hours After Treatment	SDH Sham Injected	Specific Activity* T_3 Injected
1	0.224±0.091**	0.111±0.021
3	0.042±0.029	0.056±0.014
24	0.483±0.031	0.375±0.106
48	0.523±0.301	0.579±0.080
72	0.098±0.059	0.267±0.054
96	0.088±0.056	0.229±0.045
120	0.059±0.062	0.347±0.054
144	0.067±0.062	0.433±0.137

*SDH specific activity is expressed in change in O.D. units at 490 mu/10 min./mg protein.

**Livers from 3 animals were assayed per group (the 72 hour sham injected group had 2 animals). The mean SDH specific activity values and standard deviations are presented.

TABLE 2

Relative changes in SDH specific activity in R. Catesbeiana *tadpole livers.*

Hours After Treatment	Relative SDH* Specific Activity
1	0.50
3	1.33
24	0.78
48	1.10
72	2.72
96	4.02
120	5.88
144	6.46

*The relative SDH specific activity is expressed as the ratio of the mean value of the SDH specific activity of the T_3 injected group to the mean value of the SDH specific activity of the sham injected group.

The relative changes in SDH specific activity, i.e. the ratio of the mean specific activity of the T_3 injected group to the mean specific activity of the sham injected group, for any given time period are presented in Table 2. Beyond 72 hours after treatment, when the initial significant differences between experimental and control groups were first detectable, the relative change in SDH specific activity increased by 148 percent (72 hours to 96 hours), 146 percent (96 hours to 120 hours) and 111 percent (120 hours to 144 hours). Experiments were terminated after this time because of animal death.

Data showing augmented tadpole mitochondrial DNA incorporation (4), an increased incorporation of amino acids into tadpole mitochondrial protein (Ostrovsky, unpublished data), and the enhanced SDH specific activity reported here suggest that T_3 stimulates mitochondrial biogenesis. Although the increased SDH specific activity may suggest that T_3 stimulated enzyme synthesis, the nature of this study did not allow us to

discern whether T_3: (i) stimulated SDH synthesis, (ii) decreased the rate of SDH degradation during a constant rate of synthesis, (iii) augmented SDH activity by changing the enzyme allosterically, or (iv) altered some other factor in the catalytic process. In fact, the rise of SDH activity after hormone injection may indicate a direct or indirect effect of the hormone on the enzyme involving any or all of these factors. In any event, the dramatic increase in SDH specific activity following T_3 injection underscores the critical role of thyroid hormone in the metabolic changes occuring in the tadpole liver during induced metamorphosis.

LITERATURE CREED

1. Lewis, E.J.C. and E. Frieden 1959. Biochemistry of amphibian metamorphosis. V. effect of triiodothyronine, thyroxine, and dinitrophenol on the respiartion of the tadpole. Endocrinology. 65: 273-282.
2. Tata, J.R. 1967. The formation, distribution, and function of ribosomes and microsomal membranes during induced amphibian metamorphosis. Biochem. J. 105: 783-801.
3. Taylor, A.C. and J.J. Kollros 1946. Stages in the normal development of *Rana pipiens* larvae. Anat. Rec. 94: 7-23.
4. Atkinson, B.G., K.G. Atkinson, J.J. Just and E. Frieden 1972. DNA synthesis in *Rana catesbeiana* tadpole liver during spontaneous and triiodothyonine-induced metamorphosis. Develop. Bio. 29: 162-175.
5. Pennington, R.J. 1961. Biochemistry of Cystrophic muscle. Biochem. J. 80: 649-654.
6. Lowry, O.H., J.J. Rosenbrough, A.L. Farr, and R.J. Randall 1951. Protein measurement with the folin phenol reagent. J. Biol. Chem. 193: 265-275.

Proceedings of the Pennsylvania Academy of Science 51:91—92. 1977.

RESEARCH NOTE:

THE LEAST WEASEL, MUSTELA NIVALIS, FROM MARYLAND[1]

JOSEPH A. CHAPMAN and DAN M. HARMAN[2]

Appalachian Environmental Laboratory
Center for Environmental and Estuarine Studies
University of Maryland
Frostburg State College Campus
Gunter Hall
Frostburg, Maryland 21532

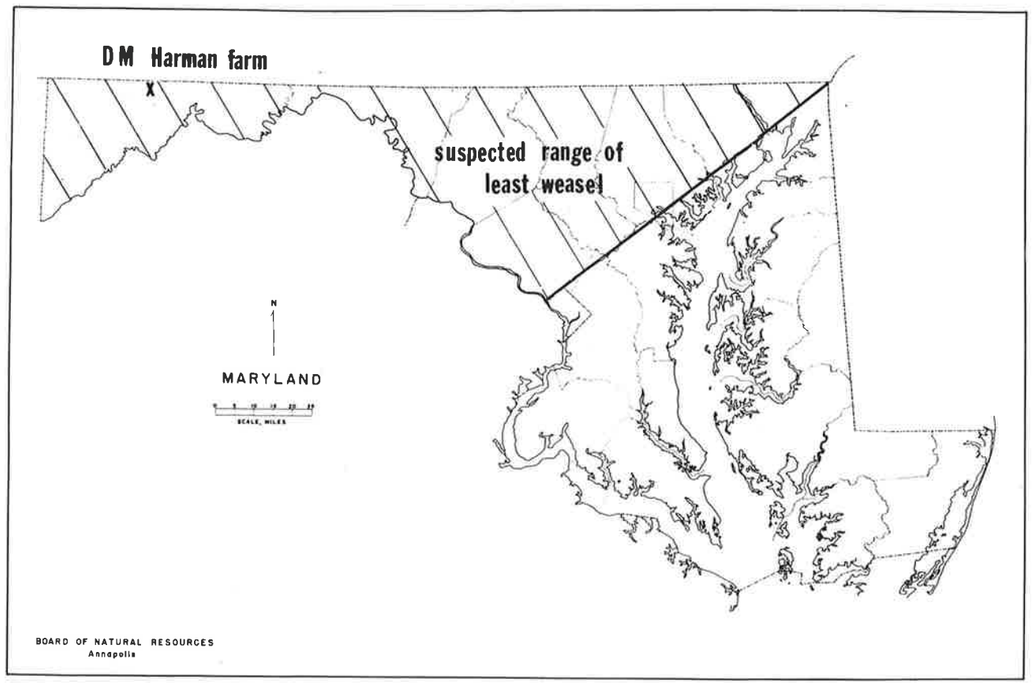


FIGURE 1. Map showing the location of the Dan M. Harman farm and the suspected range of the least weasel in Maryland (Hall and Kelson, 1959).

The least weasel, *Mustela nivalis,* is a holarctic mustelid that is widely distributed throughout North America. The sub-species *M. n. allegheniensis* occurs as the southern most extension of the species range, extending as far south as North Carolina (Hall and Kelson, 1959). According to Paradiso (1969), the least weasel has not been reported in Maryland although it has been taken in nearby West Virginia and Pennsylvania.

On 27 February 1977, we found a dead adult female least weasel adjacent to Getz Run, on the D.M. Harman farm, Garrett County, Maryland (39° 44' N. Lat., 78° 55' W. Long.) (Figure 1). The habitat in the vicinity of the find was open pasture interspersed with streamside

[1]Received April 20, 1977; revised; accepted July 6, 1977.
[2]Contribution No. 770-AEL, Appalachian Environmental Laboratory, Center for Environmental and Estuarine Studies, University of Maryland.

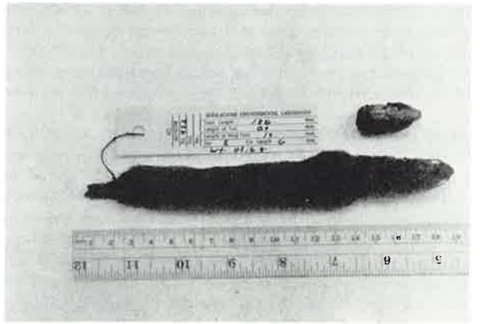


FIGURE 2. Photograph of the skin and skull of the least weasel collected in Garrett County, Maryland.

brush and thickets. This find represents the first published record of the least weasel in Maryland.

The skin and skull of the specimen are housed in the Museum of the Appalachian Environmental Laboratory (AEL #932) (Figure 2). The following external measurements were taken as described by Orr (1940) (in mm): total length 186; tail length 29; hind foot 19; ear length from notch 6; and body weight (in grams) 43.6.

LITERATURE CITED

Hall, E.R. and K.R. Kelson. 1959. The Mammals of North America. The Ronald Press Co., New York, N.Y. Vol. II. pp. 547-1083.

Orr, R.T. 1940. The rabbits of California. Occ. Pap. Cal. Acad. Sci. 19:1-227.

Paradiso, J.L. 1969. Mammals of Maryland. N. Amer. Fauna 66, 193 pp.

Proceedings of the Pennsylvania Academy of Science 51:93–99. 1977.

ABSTRACTS*

HORTON, ROGER, THOMAS JUBACH and MICHAEL KATORA. University of Pittsburgh, School of Dental Medicine, Pittsburgh, PA 15261. MARGINAL ADAPTATION OF DENTAL MATERIALS TO ENAMEL SURFACES. — Recurrent decay, i.e., decay under peviously existing dental restorations, has been a problem long plaguing the general dentist. The major contributing factor to recurrent decay appears to be marginal leakage of the tooth restoration interface. Thus, the purpose of the present investigation is to examine and compare, via scanning electron microscopy, the marginal adaptation of restorative materials, i.e., dispersealloy amalgam, conventional amalgam, spherical amalgam, concise resin, servitron resin, and silicate resin to the cavity preparation. Quantitative analysis of the distance between each restorative material and the cut enamel surface (gap distance) indicate that dispersealloy amalgam, with a gap distance of 2μ, provides the best marginal adaptation of restorative material to the tooth surface.

McLAUGHLIN, JAMES, MICHAEL KATORA and THOMAS JUBACH. University of Pittsburgh, School of Dental Medicine, Pittsburgh, PA 15261. SCANNING ELECTRON MICROSCOPY EVALUATION OF ACID ETCHED BASE CEMENTS. — Several different base cements are presently employed to protect the pulp and cut dentinal surfaces. The purpose of this study is to investigate the effect of acid etching on base cements. This becomes an important factor with increased use of the acid-etch technique for mechanical retention of restorative materials. Calcium hydroxide, zinc phosphate, and polycarboxylate base cements were each etched for two minutes with 37% or 50% phosphoric acid — the etched surface subsequently evaluated via scanning electron microscopy. Calcium hydroxide was shown to be effected the most by acid etching, while polycarboxylate base cement was effected the least.

HUGHES, ROBERT, THOMAS JUBACH and MICHAEL KATORA. University of Pittsburgh, School of Dental Medicine, Pittsburgh, PA 15261. COMPARISON OF TUNGSTEN CARBIDE AND DIAMOND BURS IN CAVITY PREPARATIONS. — There has long been in dentistry a controversy concerning the best type of bur to use in cavity preparations, the two most common types of burs being the tungsten carbide bur and diamond bur. The purpose of the present investigation is to determine what effect each bur type has on the cut enamel surface utilizing scanning electron microscopy. Enamel particles ranging from 2μ to 20μ in diameter were observed to cover approximately 50% of the enamel surface cut with a diamon bur. The enamel surface cut by a tungsten carbide bur, however, was relatively free from enamel particles. The results of the present investigation indicate that a more uniform enamel surface is obtained using the tungsten carbide bur.

KATORA, MICHAEL and THOMAS JUBACH. University of Pittsburgh, School od Dental Medicine, Pittsburgh, PA 15261. USE OF SCANNING ELECTRON MICROSCOPY IN DENTAL RESEARCH. — The advent of scanning electron microscopy (SEM) in dental research has greatly expanded the investigation of dental materials. The purpose of the present investigation is to examine new dental research methods made available by use of the SEM. Experimental methods examined are the evaluation of dental enamel and the effect of acid on enamel, evaluation of different types of dental restorative materials commonly used in clinical practice, evaluation of methods used in finishing stainless stell crowns, and quantitative analysis of the marginal integrity of certain cavity restorations.

LEWIS, LARRY M. Department of Biology, Millersville State College, Millersville, Pa. 17551. COMPARATIVE ULTRASTRUCTURE OF MITOTIC AND MEIOTIC SPINDLES OF PARAMECIUM BURSARIA. — If spindle microfilaments play a role in chromosome movement is a subject of controversy. Study of the early mitotic phases of micronuclear mitosis in *Paramecium bursaria* revealed a complex spindle apparatus consisting of microtubules, microfilaments, and unique structures termed microlamellae. The first meiotic prophase is found to have a similar spindle structure. Microfilaments are abundant and fill channels between condensing chromosomes. The chromatin is found in more states of electron density during meiosis relative to mitosis. Spindle microtubules are sparse in both divisions. The evidence supports the hypothesis that microfilaments play a role in chromosome movement.

KISH, CHARLES B. and DR. HENRY N. FREMOUNT. Department of Biology, East Stroudsburg State College, East Stroudsburg, Pa. 18301. IMMUNOELECTROPHORETIC ANALYSIS OF IMMUNOGLOBULINS IN MICE INFECTED WITH CHLOROQUINE-RESISTANT *PLASMODIUM BERGHEI*. — Mice were infected intraperitoneally with approximately 1 x 10^5 parasites taken from a previously infected animal. Beginning twenty-four hours after infection blood was drawn daily from a tail vein using heparinized hematocrit tubes. The serum was separated from the formed elements by centrifugation, placed in agarose gels and run against rabbit antimouse antisera. The rabbit antisera was commercially prepared for this study. Quantitative line immunoelectrophoresis of mouse immunoglobulins was performed using a Bio-Rad I.E. chamber operating at 8-10 v/cm for 4 hours. Quantitative measurements of serum immunoglobulins in infected mice were obtained by analyses of the patterns of precipitin lines formed in the agarose gels.

DELGROSSO, KATHLEEN J. and DR. HENRY N. FREMOUNT. Naomi Cottages #26, Cresco, Pa. 18326 and Department of Biology, East Stroudsburg State College, East Stroudsburg, Pa. 18301. IMMUNOGLOBULIN PROFILES IN HAMSTERS INFECTED WITH *BABESIA MICROTI* (GREY STRAIN). — Hamsters were inoculated intraperitoneally with approximately 1 x 10^6 parasites of *Babesia microti* (Grey strain) taken from a previously infected animal. Beginning 24 hours pre-infection and continiung for the duration of the study blood was drawn every other day and the serum separated from the cells. The serum specimen was diluted with buffer, placed in agarose gels and run against rabbit anti-hamster antisera. Quantitative line immunoelectrophoresis of hamster immunoglobulins was performed using a Bio-Rad I.E. chamber operating at 8-10 v/cm for 4 hours. Quantitative measurements of serum immunoglobulins in infected hamsters were obtained by analyses of the patterns of precipitin lines formed in agarose gels.

YURKIEWICZ, WILLIAM J, SHELLEY RHOADES and LISA NURMI. Department of Biology, Millersville State College, Millersville, PA 17551. RESISTANCE TO HONEY BEE VENOM IN THE GREATER WAX MOTH, *GALLERIA MELLONELLA*. — The wax moth is considerably more resistant to honey bee venom than several other insect species. Ouchterlony plate and immunoelectrophoretic studies show that molecules in the wax moth react with the honey bee venom constituent, melittin, in a fashion similar to the antigen-antibody reactions of vertebrate animals. Experiments to determine if melittin is altered by the wax moth are discussed.

OSTROVSKY, DAVID S. and GEORGE W. NACE. Departments of

*The abstracts published herein have not been subjected to editorial scrutiny.

Biology and Zoology, Millersville State College, Millersville, PA 17551 and University of Michigan, Ann Arbor, Michigan 48104, respectively. ISOZYMES OF LYSOZYME AND THE LUCKE RENAL ADENOCARCINOMA. — The normal kidney of the frog Rana pipiens contains eight isozymes of lysozyme. Three of these, however, were not present in five Lucké renal adenocarcinomas. No isozymes were found to be unique to the tumor kidneys. Of the five isozymes detected in tumor kidneys, only one was uniformly present, a second was present in four of five tumors, and the appearance of the other three was highly variable, although no tumor kidney contained all of them. The uniform absence of the three isozymes and the variable distribution of the other five among the tumors attested to the metabolic uniqueness of this tumor and was consistent with a prior hypothesis concerning the role of lysozyme in the etiology of this herpesvirus-induced tumor.

HANSON, HENRY, LESLIE BUCKHAM and RODGER LOWE. Department of Geology, Dickinson College, Carlisle, Pa. GEOCHEMISTRY OF THE EATON-DIKEMAN POND, CUMBERLAND COUNTY, PA. — In the late 1800's, a paper company dammed Mountain Creek in Cumberland County, Pa. Mountain Creek drains the quartzite terrain of South Mountain, has a low hardness (15-25 ppm.), and is useful for manufacturing filter paper. The dam is situated on the Tomstown dolomite. Groundwater entering the pond from the Tomstown is much harder (80-120 ppm). The pond contains several meters of unconsolidated sediment from Mountain Creek and is in an advanced state of eutrophication. For the past 10 months we have been studying the water chemistry of the pond (18 variables, 13 sites) to identify and separate the effects of the two water sources and seasonal biologic effects.

FURNISS, J.V., J. MONTINI, S.G. GALLIK, G.K. OWENS, and T.M. HOLLIS. Department of Biology, The Pennsylvania State University, University Park, Pa. 16802. REGIONAL DIFFERENCES IN AORTIC HISTAMINE SYNTHESIS AND STEADY STATE TRANSMURAL ALBUMIN UPTAKE UNDER NORMAL AND ATHEROGENIC CONDITIONS. — The relationship between regional thoracic aortic histamine synthesis and steady state aortic transmural albumin uptake has been examined in rabbits maintained on either Purina Rabbit Chow or Chow containing 0.5% cholesterol for 2 weeks. In controls, the ascending aorta and arch segment showed the highest net albumin uptake and highest *in vitro* histamine forming capacity (HFC), while both were significantly lower in the 3 lower segments. In the experimental group, the HFC of thoracic aortic segments increased to approximate that of the ascending and arch segment; steady state albumin content closely paralleled the regional HFC. (Supported by NSF grant PCM 76-01567).

OWENS, G.K., J. MONTINI, J.V. FURNISS, S.G. GALLIK, and T.M. HOLLIS. Department of Biology, The Pennsylvania State University, University Park, Pa. 16802. EFFECTS OF α-HYDRAZINOHISTIDINE ON AORTIC HISTAMINE SYNTHESIS AND ATHEROGENIC PLAQUE DEVELOPMENT. — The effects of a specific inhibitor of histidine decarboxylase, α-Hydrazinohistidine, on atherosclerotic plaque development in rabbit aorta were examined in order to study the role of aortic histamine synthesis in the atherogenic process. Plaque development and aortic *in vitro* histamine forming capacity (HFC) were examined in rabbits maintained on Purina Rabbit Chow or Chow containing 0.5% cholesterol for 4 weeks; with or without addition of the drug. Dosed rabbits showed a depressed HFC and had less severe plaque development than control animals. Results thus suggest that aortic histamine synthesis is involved in atherogenesis. (Supported by NSF grant PCM 76-01567).

GALLIK, S.G., J. MONTINI, J.V. FURNISS, G.K. OWENS, and T.M. HOLLIS. Department of Biology, The Pennsylvania State University, University Park, Pa. 16802. AORTIC HISTAMINE SYNTHESIS IN DIABETES. — Aortic histamine synthesis has been examined in rats maintained in a diabetic state for 2 and 4 weeks following subtotal pancreatectomy. Fasting plasma glucose levels after pancreatectomy were 150-200 mg.%. Aortic histamine synthesis showed a 30-40% increase over that of sham operated rats. Since previous reports have shown a high correlation between regional aortic histamine synthesis and transmural albumin uptake, the results suggest that the increased histamine synthesis in diabetic rats may produce an increase in aortic endothelial permeability which would lead to vascular disease so prevalent in diabetes. (Supported by grant #HL 20460 from the National Heart Lung Institute).

REISINGER, H. JAMES. Limnologist, RD #1, Fricks Lock Road, Pottstown, Pa 19464. A STUDY OF THE RELEASE OF SEVEN METALLIC ELEMENTS FROM THE SEDIMENTS OF THE SCHUYLKILL RIVER IN THE VICINITY OF POTTSTOWN, PENNSYLVANIA. — The concentrations of cadmium, chromium, copper, iron, lead, manganese, and zinc in the sediments of the Schuylkill River in the vicinity of Pottstown, Pennsylvania were investigated. Because this reach of River will be dredged by the U.S. Army Corps of Engineers, Standard Elutriate Tests were run to determine whether or not the metals would be released from the sediments in the dredging process. The tests revealed that cadmium, copper, iron, lead, manganese, and zinc would be released in quantities exceeding U.S. Environmental Protection Agency criteria, and would thus constitute a threat to biological communities in this stream reach.

YU, SHEA LING K. and WILLIAM E. DIETRICH, JR. 47-70, Fiu Shang Hsiang, Shiu Nan, Taichung, Taiwan, and Department of Biology, Indiana University of Pennsylvania, Indiana, PA 15701. EFFECT OF HOST HOMOGENATES ON PHOTOSYNTHATE EXCRETION BY ZOOCHLORELLAE OF *HYDRA VIRIDIS*. — Zoochlorellae were isolated from the gastrodermis of *Hydra viridis,* were illuminated in the presence of $Na_2{}^{14}CO_3$, isolated and resuspended, and the rate of ^{14}C excretion measured. Compared to the untreated control, those incubated with homogenates of gastrodermis tissue, of epidermis tissue, and of the whole hydra were stimulated 44, 3 and 8% respectively. This stimulation was abolished when the homogenates were boiled prior to their use. Contrary to a previous report, a host homogenate does stimulate zoochlorellae photosynthate excretion in *Hydra viridis.* The heat-labile stimulatory component is however limited to the tissue in which the zoochlorellae reside.

PASSARO, FRANK M., DR. PEI-SHOW JUO and DR. GEORGE ISENBERG. Department of Biology, State University College, Potsdam, New York 13676. THE *IN VITRO* EFFECTS OF BINDING MAGNESIUM IONS ON THE ELECTROPHORETIC AND IMMUNOELECTROPHORETIC PATTERN OF MOUSE SERUM PROTEINS. — The effects of $CrCl_3$ and $MgCl_2$ on the electrophoretic and immunoelectrophoretic patterns of mouse serum were evaluated by polyacrylamide disc gel electrophoresis and antigen-antibody crossed immunoelectrophoresis. Changes in electrophoretic patterns and antigen-antibody precipitation peaks were observed in serum treated with 0.019 molar $CrCl_3$. A significantly higher concentration of $MgCl_2$ is necessary to produce changes in antigen-antibody precipitation peaks, but no changes in electrophoretic patterns were noted. It is apparent that $CrCl_3$ causes structural changes on the antigens some distance to the antibody-binding site.

COPE, FREDERICK O. and DR. P.R. SUNDARESAN. Millersville State College, Millersville, Pa. 17551 and Lipids Laboratory, St. Joseph Hospital, Lancaster, Pa. 17604. THE EFFECTS OF ZINC DEFICIENCY ON VITAMIN A LEVELS, RETINAL REDUCTASE AND RETINAL OXIDASE IN LIVER AND TESTES OF THE RAT. — The zinc-vitamin A relationship has been implicated in certain clinical syndromes. Zinc deficiency is also associated with lowered plasma vitamin A and RBP levels. These studies were designed to further elucidate the role of zinc in vitamin A metabolism. The results show that zinc-deficient animals exhibited increased retinal oxidase activity in liver while retinal reductase and retinal oxidase activity in liver were significantly lower in testes when compared to control and pair-fed animals. There was no significant difference in the level of liver vitamin A or liver retinal reductase activity in the groups.

BUCKELEW, T.P. and D. M. KONTIR. Department of Biology, California State College, California, Pa. 15419. THE ULTRASTRUCTURE OF TWO COW RUMEN CILIATES, THE HOLOTRICH, *ISOTRICHA* SPP. AND THE SPIROTRICH, *EPIDINIUM ECAUDATUM.* — This investigation was conducted to compare ultrastructurally, two morphologically diverse cow rumen ciliates. *Isotricha* spp. are holotrichs with a conventional ciliate structure consisting of a relatively uniform external ciliation, complex pellicle,and a cytoplasmic matrix divided into an ectoplasm and endoplsam by two layers of myonemes. The spirotrich, *Epidinium ecaudatum,* is a structurally complex ciliate that lacks cilia on external surfaces except for a heavy concentration in the cytostome. *Epidinium ecaudatum* also has a more simplified pellicle subtended by myoneme layers, oral cirri, and aberrant kinetodesmal fibers. Another aspect of the study deals with the simple, yet effective technique used in specimen collection. This investigation compares the microstructure of the holotrichouse, cow rumen ciliates, *Isotricha* spp. with the spirotrichous rumen ciliate, *Epidinium ecaudatum.*

HESS, GERALD D. and MARK A. SMITH. Department of Biology, Messiah College, Grantham, PA 17027. COMPARISON OF ADRENOCORTICAL RESPONSE TO ETHER STRESS IN 1.5 AND 4.5 MONTH FEMALE RATS FOLLOWING THYROXINE TREATMENT. — Female Long-Evans rats received injections of L-thyroxine (17.5 micrograms per 100 grams body weight daily) for 12 days. Plasma corticosterone levels in response to an acute ether stress regime were determined before and at the conclusion of thyroxine treatment. Corticosterone levels following thyroxine treatment were significantly higher then pre-treatment levels in each age group. While plasma corticosterone levels of 1.5 month rats were significantly lower than those of 4.5 month rats prior to treatment, this parameter showed similar levels of response in both age groups following thyroxine administration.

SCHREIBER, KURT C. and KIRTI VALIA. Department of Chemistry and School of Pharmacy, Duquesne University, Pittsburgh, PA 15219. SPECTROPHOTOMETRIC INVESTIGATION OF THE HAYASHI REARRANGEMENT. — The synthesis and characterization of 2-(4′-methoxybenzoyl)-3-methylbenzoic acid and of 2-(4′-methoxybenzoyl)-6-methylbenzoic acid will be described. The rearrangement of the former acid in concentrated sulfuric acid, known as the Hayashi rearrangement has been followed spectrophotometrically, by NMR analysis and by isolation of products at various intervals. The spectral changes clearly show that at least two intermediates are involved in the rearrangement. Structural interprtation of the peaks at 365, 455 and 470 nm will be given and the importance of steric interactions in the rearrangement demonstrated.

MEYERS, BRIAN E., DILIP K. MOONKA, RONALD MELINCOFF, ROBERT H. DAVIS, Ph.D. PA. College of Podiatric Medicine, Philadelphia, PA 19107. EFFECT OF MAMMARY TUMOR TRANSPLANTS ON TISSUE GRAFTING IN MICE. — Fifteen adult female RIII mice received single intraperitoneal injections of mammary tumor homogenate on day one, with an equal number of animals, receiving IP saline, serving as controls. On day 21, a skin allograft was performed on each animal utilizing adult Swiss Webster mice as graft donors. Three additional groups of fifteen animals each received RIII skin isografts 21 days after either IP or subcutaneous administration of tumor homogenate, or IP saline. Twenty-one days post grafting (subsequent to assessment of graft acceptance) all animals were sacrificed and connective tissue beneath the graft was examined for the presence and number of leukocytes. The IP administration of tumor homogenate enhanced iso- and allogenic skin graft acceptance and significantly ($p<0.01$) reduced leukocyte count within connective tissue beneath grafts.

MONTINI, J., J.V. FURNISS, S.G. GALLICK, G.K. OWENS, and T.M. HOLLIS. Department of Biology, The Pennsylvania State University, University Park, Pa. 16802. INHIBITION OF ATHEROSCLEROTIC LIPIDOSIS WITH HISTAMINE RECEPTOR ANTAGONISTS. — Lipid deposition has been examined in 3 groups of rabbits maintained on a 0.5% cholesterol diet for one month. In two of the groups either H_1 or H_2 histamine receptor antagonists were included in the cholesterol diet. A fourth group was fed a cholesterol free diet. Aortas were visually rated on a scale of 1 to 4 based on the degree of lipid deposition. Results showed a significant decrease in lipid deposition in the dosed groups compared to controls. These data suggest that aortic histamine may play a role in regulating aortic endothelial premeability, and suggest histamine receptor antagonists may be useful in preventing atherosclerosis.

WALEWSKI, JOSE and DR. RONALD R. KEIPER. Department of Zoology, Penn State University, Mont Alto, Pa. 17237. INTERNAL PARASITES OF FERAL PONIES. — To investigate the nature and extent of parasitic infection among the feral ponies of Assateague Island, fecal samples from over 60 individuals were examined. Qualitative analysis was conducted by examining fecal smears, and revealed the presence of coccidia, eggs and adult stages of *Oxyuris equi,* eggs of various strongyloid species, and eggs of the ascarid *Parascaris.* Quantitative analysis involved use of a flotation technique to separate the parasitic ova. The ova present in 1 gram of feces were counted and revealed a high level of parasitic infestation.

URICCHIO, WILLIAM A., Ph.D. Department of Biology, Carlow College, 3333 Fifth Avenue, Pittsburgh, PA 15213. BIOLOGY OF FERTILITY CONTROL BY NATURAL METHODS. — Biology of fertility control by natural methods are those which take advantage of the human biological fact that women are at most times infertile throughout their reproductive lives. Sexual intercourse may take place during such times without risk of conception whereas, on fertile days, abstinence from sexual intercourse is required in all natural methods. Determination of fertile and infertile days of the menstral cycle will be discussed through the use of three natural methods.

ADAMS, PETER R. and JAMES J. DEPLOEY. Departments of Chemistry and Biology, Penn State - York Campus, York, PA 17403. EXTRACELLULAR ENZYME PRODUCTION BY SOME THERMOPHILIC FUNGI. — Qualitative methods were used to determine the production of 7 extracellular enzymes by 10 species of thermophilic fungi including: *Dactylomyces thermophilus, Humicola lanuginosa, H. grisea* var. *thermoidea, H. insolens, Papulaspora thermophila, Mucor miehei, Sporotrichum thermophile, Talaromyces leycettanus, Thermoascus aurantiacus,* and *Torula thermophila.* The fungi were cultured (45°C) on a variety of agar media contained in petri dishes. All 10 fungi produced lipase and urease, but none produced DNAase. Only *T. leycettanus* produced chitinase, and four fungi produced pectinase (*P. thermophila, M. miehei, S. thermophile, T. leycettanus*). Three fungi failed to produce protease (*D. thermophilus, M. miehei, T. leycettanus),* and four fungi did not produce RNAase (*P. thermophila, M. miehei, S. thermophile, T. aurantiacus*).

MESSERSMITH, JENNIFER A. and ROBERT F. DENONCOURT. Department of Biological Sciences, York College of PA, York, PA 17405. CONTRIBUTIONS TO THE LIFE HISTORY OF THE SATIN-FIN SHINER *NOTROPIS ANALOSTANUS,* IN THE CODORUS CREEK DRAINAGE, YORK COUNTY, PENNSYLVANIA. — Specimens and field data were collected weekly in summer months of 1976 and more or less monthly in 1975 and 1976. Over 1100 specimens were used to obtain data relative to age, growth, condition factor, fecundity, sex-ratio, breeding coloration and tuberculation. Length fequencies and scale examination showed *Notropis analostanus* to be a short-lived species (2+). Females averaged ova, were more abundant in 16 of 18 collections in 1976, and usually had higher condition factors. Sexual differences in condition factor decreased in July coincident with decreased tuberculation in males.

DENONCOURT, ROBERT F., CHARLES H. HOCUTT and JAY R. STAUFFER, JR. Department of Biology, York College of PA, York, PA 17405 and Appalachian Envion. Lab., University of Maryland,

Frostburg State College Campus, Frostburg, MD 21532. OBSERVATIONS OF NATURAL AVOIDANCE IN FISHES. — Fishes were observed under two different environmental conditions that caused fish kills: (1) cold shock and (2) oxygen depletion. Water quality data were available before, during and after the fish kills. In both cases, several species were observed to avoid adverse conditions by attempting to seek refuge in available microhabitats that offered relief. Carp and catfishes were found to survive a 33°C drop in temperature in the first case, while several species survived an oxygen concentration of 0.35 mg/l for two days in the second case.

MILLER, E. WILLARD. Penn State University, University Park, PA. 16802. COAL MINING AND ECONOMIC REVITALIZATION OF APPALACHIA. — The basic question to be investigated in this paper is, will the recovery of the coal industry in Appalachia since the early 1960's influence a total revitalization of the economy? This study indicates that the revitalization of the coal industry has had little affect on the total economy of the expanding coal regions of Appalachia. Further, the existing trends indicate that the growth counties will maintain their present rural character. Thus, the nineteenth century coal economy is not being repeated in the twentieth century.

HALLEZ, TANYA APRIL. Department of Education, Wilkes College, Wilkes-Barre, PA. 18703. THE PLANKTON OF BEAR LAKE, LACKAWANNA COUNTY, PENNSYLVANIA, 1976. — Bear Lake is a relatively sterile lake on the Pocono Plateau. Plankton samples have been taken at the outlet during the period in which ice covered the lake, or from the center of the lake when the lake was open, at intervals of two weeks, from March through December of 1976. A bathymetric chart of Bear Lake and quantitative chemical values, for SiO_2, Fe, Ca, Mg, SO_4, PO_4, and NO_3 are presented.

PYRON, ARTHUR J. 924 Hale Street, Pottstown, Pa. 19464. CONTACT METAMORPHISM IN SOUTH-EASTERN PENNSYLVANIA. — Throughout south-eastern Pennsylvania, there are two connected basins composed of pelitic sediments of Late Triassic-early Jurassic age. In these basins, there are three major lithologies; pelitic sediments, diabase, and a lowgrade contact metamorphic which was formed by the intruding diabase. Careful study has shown that this contact metamorphic falls below the albitehornfels facies in Turner's (1968) schema. Some secondary growth of pyroxene, along with the alteration of primary mineralogical features, allows for this interpretation. This lithology is very important in this region because it provides both a topographic control and a source for trap rock, a local building stone.

ADAMS, P.R. and J.J. DEPLOEY. Departments of Chemistry and Biology, Penn State University, York Campus, York, Penna. 17403. AMYLASE PRODUCTION BY *HUMICOLA LANUGINOSA*. — Quantitative methods were used to determine the activity of extracellular amylase produced by the thermophilic fungus *Humicola lanuginosa*. The fungus was incubated (45°C) for up to 36 days in a liquid basal (defined) medium (50 ml) contained in 250 ml Erlenmeyer flasks. The fungus mycelium was separated from the liquid medium by suction filtration after varying periods of incubation, and the filtered liquid medium was assayed for amylase activity using the dinitrosalicylic acid technique described by Bernfeld. The values reported for amylase. activity are linear with time and concentration of amylase. Maximum activity of amylase produced by *H. lanuginosa* was detected after approximately 15 days of growth.

JUBACH, THOMAS and MICHAEL KATORA. University of Pittsburgh, School of Dental Medicine, Pittsburgh, PA 15261. IN VITRO SURFACE CHARACTERISTICS OF DENTAL RESTORATIVE MATERIALS. — The surface characteristics of polished restorative dental materials are an important etiological factor in periodontal disease and restoration failure. Rough surfaces act as an attachment for dental disease-forming bacteria as well as providing an irritation to gingival tissues when placed at the cervical margin. With the aid of the scanning electron microscopy, this study compares the surface characteristics of three metallic materials, i.e. conventional amalgam, dispersealloy amalgam, and spherical amalgam and three non-metallic materials, i.e. concise resin, servitron resin, and silicate resin. The metalic restorative materials exhibited a smooth, flat surface whereas the non-metalic restorative materials were shown to contain numerous surface projections ranging from 2 μ to 200 μ in diameter.

KERBY, RONALD, MICHAEL KATORA and THOMAS JUBACH. University of Pittsburgh, School of Dental Medicine, Pittsburgh, PA 15261. EFFECT OF TEMPERATURE CYCLING ON MARGINAL ADAPTATION OF RESTORATIVE MATERIALS. — Marginal integrity is an important factor in choosing a dental restorative material being that cavosurface marginal breakdown is responsible for most recurrent decay since the gap formed provides decay-producing microorganisms with an ideal environment. The purpose of this study is to investigate the effect of temperature cycling on the cavosurface margins of several commonly used dental restorative materials. Comparison was made, using the scanning electron microscopy, among three metallic restorative materials and three non-metalic restorative materials which were subjected to alternative water baths for a total of 10 minutes, simulating oral conditions in eating and drinking. Dispersealloy (a metalic restorative material) was observed to maintain the best cavosurface marginal integrity following temperature cycling.

KLOSE, PETER N. Department of Biology, Lehigh University, Bethlehem, PA. 18015. BIOACCUMULATION OF ZINC AND CADMIUM IN AQUATIC STREAM BIOTA. — The study presents results of a one-year research project on Saucon Creek, Northampton and Lehigh Counties, Pa., of the bioaccumulation of zinc and cadmium in various biotic and abiotic components of the stream system. Source of the heavy metals contamination is an active zinc mine which daily discharges from 35 to 50 MGD of ground water, containing about 1.0mg/1 and .005 mg/1 zinc and cadmium, respectively, to Saucon Creek. Two control and four test stations were utilized. Heavy metals concentrations were determined for: water, sediments, macrophytes (*Potamogeton, Fontinalis, Typha*), aquatic macroinvertebrates, and fish (brown trout, sunfish, golden shiner, white sucker). These samples were taken bimonthly; water chemistry was performed monthly. bioaccumulation of the metals ranged from 2X to 97X, depending on the biota considered. High metals concentrations may have been one the primary causes of extreme reduction of the benthic macroinvertebrate community below the outfall.

DWYER, KATHLEEN and DR. HENRY FREMOUNT. Department of Biology, East Stroudsburg State College, East Stroudsburg, PA. 18301. CLASSIFICATION OF ANTIBODIES TO *BABESIA MICROTI* (GRAY STRAIN) AS PRODUCED BY THE HAMSTER. — Classifications of antibodies was determined on the basis of changes in immunoelectrophoretic patterns. Twenty animals were used in the study. Ten were inoculated with 4 X 10^5 live parasites and ten were inoculated with 4 X 10^5 formalinized parasites. Animals were bled at periodic intervals, the serum separated, and then subjected to immunoelectrophoresis using rabbit anti-hamster serum. The procedure was carried out using a Biorad Immunoelectrophoretic Chamber operating at 8-10 volts/cm. The agarose gels were then scanned using an Ortec Densitometer.

BERRYMAN, BRUCE F. Dr. Department Environmental Science, Wilkes College, Wilkes-Barre, PA. 18703. SUNLIGHT DURATION IN VALLEYS — From the elevation of the local horizon for a city (Wilkes-Barre) located on a valley floor in the mountainous region of Northeastern Pennsylvania, local daily sunrise and sunset times and solar azimuth angles were determined. These values were compared with those expected in flat terrain and studies related to the yearly cycle of daily sunlight duration and mountain shadow patterns were conducted. A brief discussion relating the results to the concerns of amateur and professional astronomers, meteorologists, and agriculturist is also presented.

RADULSKI, HENRY A. and HELEN H. DARRAH. Department of Biology, Gettysburg College, 41 W. Lincoln Ave., Gettysburg, PA. 17325. A HISTOLOGICAL ANALYSIS OF THE REGENERATION OF THE FORELIMB IN *TRITURUS VIRIDESCENS*. — When the forelimb of the adult newt, *Triturus viridescens,* is amputated, many changes occur in the tissue of the regenerating limb. By histologically studying the tissue of the amputated limb, the variations which occur in muscle, cartilage, bone, and connective tissue are illustrated. Photomicrographs are used to trace the changes that occur in the following stages of regeneration: amputation, wound reaction, apical cap formation, blastema formation, and functional recovery of the amputated limb.

BENNETT, T.E., G.R. BIENVENUE, M.J. DURKOT, J.R. VIOLONSINGER, P.L. MICHAEL AND A. ANTHONY. Physiology Laboratory and Environmental Acoustics Laboratory, The Pennsylvania State University, University Park, Pa. 16802. LOUDNESS DIFFERENCE INDEX AND SERUM CORTISOL LEVELS IN HUMANS EXPOSED TO NOISE. — Human subjects (3 male, 3 female) were exposed to 100 dB SPL broadband noise for 15 minutes. Blood samples, pure tone thresholds and loudness difference indices were taken prior to and following noise exposure. Serum cortisol levels were taken prior to and following noise exposure. Serum cortisol levels were determined using radioimmunoassay techniques. Preliminary data analysis indicates a positive correlation between cortisol ratio and loudness difference index ratio. The loudness difference index and cortisol assay show promise as early indicators of individual noise susceptibility. Furthermore, the results support the hypothesis that noise induced hearing changes are hormonally mediated.

DeSOUSA, PATRICIA E. and HENRY N. FREMOUNT. Department of Biology, East Stroudsburg State College, East Stroudsburg, PA. 18301. THE ANATOMICAL DISTRIBUTION OF *BABESIA MICROTI* (GRAY STRAIN) IN THE HAMSTER *MESOCRITIUS AUREUS* — The anatomical distribution of developing stages of *Babesia microti* in the hamster was evaluated. The number of parasitized red blood cells within each organ was compared to that of the peripheral blood. Possible mechanisms regulating parasite distribution include immunologic paralysis as well as possible altered hemoreologic properties.

THERRIEN, C. DALE, G.K. DUKER, M. DERESINSKI and C. KOWALSKI. Department of Biology, The Pennsylvania State University, University Park, PA. 16802. CYTOCHEMICAL ANALYSIS OF NUCLEAR HISTONES AND RIBONUCLEIC ACID IN NORMAL AND TRANSFORMED MOUSE FIBROBLASTS. — Balb/C 3T3 aneuploid mouse fibroblasts were transformed by either Simian Virus 40 or Rous Sarcoma Virus, then stained by the napthol yellow S/azure B method. Prior to staining specific amino groups were blocked by either deamination or acetylation. Nuclear basic proteins and RNA were then quantified by absorption cytophotometry. Mean total nuclear RNA for the nontransformed cell line was in all cases significantly lower than that of either of the transformed cell lines. Conversely, the histone/RNA ratio was in all cases significantly higher in the non-transformed cells. The possible use of this staining reaction for the identification of carcinomas of the uterine cervix will be discussed.

GREGOREK, JOSEPH Rev., Ph.D., GEORGE KENNEDY and DARLENE SNIDER. Department of Biology, Gannon College, Erie, Pa. 16501. THE EFFECTS OF BLINDING AND PINEALECTOMY ON REPRODUCTIVE ORGANS AND GLANDS IN RODENTS. — The pineal gland may be responsible for production of an antigonadotropic substance. In laboratory rodents, this secretion appears to be stimulated by an absence of light. Orbital enucleation of Golden Brown Hamsters and Gerbils resulted in atrophy of reproductive organs and glands. Blindness in conjunction with pinealectomy however, did not result in this phenomenon. Other rodents were studied to determine the extensiveness of these results. The albino rat and PET mouse did not respond to this lack of light. Pinealectomy alone does not effect an increase in reporductive organ size in any of the animals studied.

BRISTER, N.W., G.J. COLURSO, M.J. DURKOT and A. ANTHONY. Physiology Laboratory and Department of Biology, The Pennsylvania State University. ZONAL DIFFERENCES IN THE EXTENT OF ACTH INDUCED DEPLETION OF REDUCING GROUPS IN ADRENAL SECTIONS MAINTAINED *IN VITRO*. — the Chayen cytochemical assay for biologically active ACTH exploits the fact that ACTH depletes reducing groups in cultured sections of the guinea pig cortex, the extend of which can be quantified using a ferric ferrocyanide (Prussian blue) staining reaction. Although all adrenocortical zones exhibit a positive staining reaction for reducing groups only the zona reticluaris and inner fasciculate cells give a stoichiometric dose response curve to graded dilutions of standard ACTH. Rat adrenal sections can be used by yield too few sequential sections for extensive validation checks or multiple plasma sample analyses.

COLURSO, G.J., N.W. BRISTER and A. ANTHONY. Physiology Laboratory and Department of Biology, The Pennsylvania State University, University Park, Penna. 16802. INTERFEROMETRIC MEASUREMENT OF TISSUE SECTION THICKNESS VARIATION ASSOCIATED WITH CRYOSTAT MICROTOMY. — Interferometric measurements were used to assess the extent of section thickness variability associated with cryostat microtomy of adrenal sections over a working range of 10 to 20 microns using a Bright Cambridge rocking type and a Damon Minot rotary type cryostat microtome. Intrasection variability approximated 25% with the rocking and 13% with the rotary microtome. Intersection thickness variability was 11% with the rocking and 5% with the rotary microtome. Comparison of calibration curves correlating true section thickness with instrument setting revealed that the performance of both instruments is comparable with respect to yielding sections suitable for analytical cytochemistry.

ROMANOSKY, A.J., J.J. DOCHERTY and A.A. ANTHONY. Physiology Laboratory and Department of Cell Biology and Microbiology, The Pennsylvania State University, University Park, Penna. 16802. METABOLIC STATE OF HUMAN ENBRYONIC LUNG CELLS DURING HERPES SIMPLEX VIRUS REPLICATION. — Cultured human embryonic lung cells were infected with herpes simplex virus types I/II and analyzed for Feulgen DNA and glucose-6-phosphate dehydrogenase (G6P DH) activity on an individual cell basis. The latter served as an index of the functional state of the host cell during viral replication. Enzyme activity and F-DNA levels were quantified by scanning-integrating microdensitometry. It was established that virus replication (examplified by increased F—DNA levels) is associated with marked elevation in G6P DH activity in herpes infected cells over a 6 to 25 hour post infection interval. This is consistent with the hypothesis that viral replication has a profound influence on the metabolic state of the cell.

NEFF, W.H., M.J. DURKOT, J.A. PENMAN, T.E. BENNETT and A. ANTHONY. Physiology Laboratory and Department of Biology, The Pennsylvania State University, University Park, Penna. 16802. SERUM AND URINARY ELECTROLYTE CHANGES AND CORTICOSTERONE RESPONSES IN NOISE STRESSED RATS. — Male Wistar rats were exposed daily to three one hour periods of intense noice (105-106 dBA, 500-20,000 Hz). controls were sequestered under ambient laboratory conditions (50-52 dBA) or subjected continuously to very low intense noise levels (77-79 dBA, 20 KHz). No changes were evidenced in serum or urinary sodium and potassium despite a protracted (4 day) or brief (1 day) diuresis with intermittent and continuous noise exposure, respectively. A moderate elevation of serum corticosterone (measured by competitive protein binding) was evidenced only in intense noise exposed rats during the five to seven day exposure interval.

SYLVESTER, M.A. and B.B. HUNTER. Department of Biology, California State College, California, Pa. 15419. AN UNUSUAL *STREPTOCOCCUS* ISOLATED FROM DOMESTIC SEWAGE. —

Isolation of a microaerophilic-anaerobic streptococcal organism from sewage was accomplished by employing a dilution to extinction method. the dilution from which these organisms were isolated suggested that they comprise an extremely large portion of the microflora of domestic sewage. These streptococal organisms have been show to undergo morphological and staining variations during their life history. Tentatively, we believe these bacteria to be *Streptococcus sanguis* or closely related species. Further investigations will be concerned with speciation and the ecological role of this streptococcal microorganism.

BUCKELEW, T.P. and B.B. HUNTER. Department of Biology, California State College, California, PA. 15419. THE ULTRASTRUCTURE OF THREE COMMONLY STUDIED PROTOZOA; *EUGLENA GRACILIS, SPIROSTOMUM AMBIGUUM,* AND *PARAMECIUM MULTIMICRONUCLEATUM.* — This study attempts to further elucidate the morphology and organelle composition of the phytoflagellate *euglena gracilis,* and the free-living ciliates *Spirostomum ambiguum* and *Paramecium multimicronucleatum,* but at a more highly resolute (ultrastructural) level. These microbes are common protists and they have been studied intensively at the light microscopic level. this investigation of their fine structure defines more completely the flagellum, reservoir, stigma, nucleus, and chloroplasts of *euglena,* and the pellicle, cilia, cytoplasm, and nulceation of the two ciliates.

HUNTER, B.B. and M.A. SYLVESTER. Department of Biology, California State College, California, PA. 15419. THE EFFECTS OF AMMONIA AND OTHER ARTIFICIALLY GENERATED GASES ON TWO ISOLATES OF *CYLINDROCLADIUM SCOPARIUM*$^{-1,2}$ AND TWO OTHER DEUTEROMYCETOUS FUNGI. — *Cylindrocladium scoparium*$^{-1,2}$, *Aspergillus clavatus,* and *Trichoderma viride* were incubated in sealed Fernbach flasks (3,000 ml) and exposed to varying concentrations of gaseous ammonia (NH_3) at varying pH levels to ascertain the effect upon conidial germination. The cylindrocladia isolates were also investigated in NH_3, SO_2, and saturated H_2O atmospheres to determine whether any morphogenic modifications of vegetative and/or reproductive structures would occur. Increasing concentrations of NH_3 (5.0 mg to 40.0 mg $(NHy)_2$ SO_4) were found to decrease the percent of conidial germination, especially when the agar media were adjusted to pH's of 6.0 and 8.0. Ammonia acted mainly as an inhibitor of conidial germination and germ tube elongation of *C. scoparium*$^{-1,2}$ and upon aeration most of the conidia would germinate and form fungal colonies. Sulfur dioxide prevented conidial and vesicular formation of *C. scoparium*$^{-1,2}$ and initially retarded mycelial growth, whereas sparse conidial and vesicular production were observed in CO_2, NH_3, and high humidity atmospheres.

BUCKELEW, T.P., F.B. PETERNEL and J.J. KRZTON. Department of Biology, California State College, California, Pa. 15419. THE ULTRASTRUCTURE OF THREE TRYPANOSOMATIDS: *CRITHIDIA FASCICULATA, TRYPANOSOMA LEWISI,* AND *TRYPANOSOMA RANARUM.* — The objective of this study is to compare the ultrastrucutre of three diferent members of the family Trypanosomatidae. Each organism parasitizes a different host and represents a different morphological phase in the generalized trypanosomatid life cycle. *Crithidia fasciculata* parasitizes insects and represents the choanomastigote stage. *Trypanosoma ranarum* infects frogs and represents the epimastigote stage. *Trypanosoma lewisi* from *Rattus norvegicus* is a trypomastigote. Each organism has a similar microstructure consisting of a flagellum, basal body, pellicle, nucleus, chondriome, and kinetoplast. Variations were observed in the number and distribution of the above organelles and in the presence of other specialized in some, but not all of these trypanosomatids.

CRILLEY, R.V. and T.B. BUCKELEW. Department of Biology, California State College, California, Pa. 15419. THE ULTRASTRUCTURE OF *ICHTHYOPTHIRIUS MULTIFILIIS.* — The holotrichous ciliate *Ichthyopthirius multifiliis* was investigated to determine the general ultrastructure of a histophagous ciliate. The feeding stage was studied following removal of the trophozoite from epithelial tissue of common varieties of tropical fish. The investigation revealed a pellicle similar to other ciliates, with cilia emerging from obliquely-spiralling ridges. The pellicle was shown to contain an agranular ectoplasmic layer, but no subtending myoneme. Structures believed to be instrumental in extracellular digestion were observed in the pellicular region, including elongate bodies with darkened cores and small ovoid vacuoles. The general cytoplasm contained multiloculate lipid bodies, various stages of digestive vacuoles, bacteria, polyribosomes, large accumlations of rough endoplasmic reticula. The mitochondria were shown to contain tubular cristae, typical of many ciliates.

YAKSHE, PAUL N., DENISE DELIO and SUSAN WARD. Allentown College of St. Francis de Sales, Allentown, PA. THE EFFECTS OF ANTIDEPRESSANT DRUGS ON THE CORTICAL ACTIVITY IN THE BRAIN OF A RAT. — The response patterns of pyramidal cortical nerve cells in the rat were investigated through the use of Ag/AgCl wick-contact electrodes placed directly on the cortical surface; monopolar recording methods were employed. A comparative study using various antidepressant drugs was performed on the responses elicited by these same nerve cells. Our experimental evidence indicates that these drugs exert stimulatory effects on the firing rate of cortical activity. They may alsoi elicit similar effects on the heart rate.

EWIG, JAMES E. Ph.D. and KEITH J. LOOKINGLAND. Department of Biological Sciences, Towson State University, Towson, Md. 21204. — UTERINE AND SERUM PROSTAGLANDIN $1F_{2a}$LEVELS AT THE VARIOUS STAGES OF THE RAT ESTROUS CYCLE. — Uterine and serum prostaglandin F_{2a}(PGF_{2a}) levels at various stages of the estrous cycle of the albino rat were determined by radioimmunoassay. Significant elevations in both serum and uterine PGF_{2a} occured at early diestrus Day 1 as compared to other days of the cycle. These findings are in agreement with those from other species that exhibit a uterine luteolytic effect.

LOOKINGLAND, KEITH J. and JAMES E. EWIG, Ph.D. Department of Biological Sciences, Towson State University, Towson, Md. 21204. DETERMINATION OF SERUM MELATONIN LEVELS BY RADIOIMMUNOASSAY DURING THE VARIOUS STAGES OF THE RAT ESTROUS CYCLE. — A quantitative radioimmunoassay has been developed for determination of serum melatonin levels. Rabbit antimelatonin serum was produced in response to immunization with D, L-5 methoxytryptophan-thyroglobulin (MNAT-TG) conjugate and evaluated for sensitivity and percent cross-reactivity with melatonin analogs. The most specific and sensitive antiserum was then used in radioimmunoassay to determine serum melatonin levels during the various stages of the rat estrous cycle.

WELCH, JOHN P. ROBERT B. MITCHELL and JOHN C. DAVIS. Department of Science, John Hopkins University, University Park, Pa. 16802. HISTOCHEMICAL IDENTIFICATION OF IMMATURE RAT SERTOLI CELLS *IN VITRO* AND CYTOPHOTOMETRIC ASSESSMENT OF THEIR RESPONSE TO FSH. — Following 24 hours culture of homogenates of 15 day rat testes, discrete colonies of cells formed on the base of flasks. The number and size of colonies increased with FSH in the medium. By demonstrating cytoplasmic lipid inclusions and phagocytic activity as well as nuclear satellite karyosomes, these cells were identified as Sertoli cells. Cytophotometric assessment of Feulgen-DNA content of these Sertoli cells indicated that they were diploid. Cells grown in the presence of FSH showed increased Feulgen stainability along with increased RNA and basic protein content. This may represent increased metabolic activity and/or gene amplification.

O'TOOLE, AUSTON J. Dr., SUZANNE MURRAY and CARMEN P. GIOIA. Department of Biology, Gannon College, Erie, PA. 16501. THE DAY-NIGHT MIGRATORY HABITS OF LAKE ERIE'S PRESQUE ISLE BAY ZOO PLANKTON. — Physical and chemical data were collected from the surface, Middle, and bottom water at each of 3 stations. Water sampled for biological evaluation were collected with a Kemmerer sampler (1 liter capacity) from three

stations in the bay area on eight sampling dates during June, July and August of 1976. Zoo plankton population was determined by using the net plankton method. Water samples were passed through a nanno plankton net (10 micron aperture) and organisms were concentrated into a 50 ml vial. One ml from the 50 ml vial was placed in a Sedgewick Rafter counter. Zoo plankton were counted by the strip count method and a multiplication factor of 30 was used for the actual count of organisms per liter. A randomly selected location in the lake proper was chosen to serve as a comparative ecosystem. During the eight week period nearly 200 samples were analyzed. Day and night migration was evident at all stations sampled. Cladocera and Rotifera exhibited maximum migratory habits during June and July. In early August Protozoa and Rotifera exhibited high migratory habits.

KASARDA, FRANCES E. and E.W. WICKERSHAM, Ph.D. Department of Biology. Penn State University, University Park, Pa. 16802. CYTOPHOTOMETRIC ANALYSIS OF LUTEOLYTIC EFFECTS OF PROSTAGLANDIN F_{2a} IN PSEUDOPREGNANT RATS. — The effects of prostaglandin F_{2a} (PGF_{2a}) on leteal cell regression in pseudopregnant rats were assessed using cytophotometric analysis of Feulgen DNA and Azure B RNA. PGF_{2a} (1 mg/rat) was administered intramuscularly to ten rats on day 6 of pseudopregnancy. Three, four, and three animals were sacrificed at 12, 24, and 36 hours post injection, respectively. Luteal tissue was extracted and processed for histochemical analysis. Feulgen DNA and Azure B RNA levels of luteal cells from control animals did not change during the 36 hours post injection period. Feulgen DNA levels of luteal cells from PGF_{2a} injected animals were significantly lower than control values at 36 hours. Azure B RNA values for luteal cells of PGF_{2a} treated animals were significantly lower than control values at 12 hours post injection, but appeared to return to control levels at 24 and 36 hours.

RAPP, KEVIN M. ROBERT F. DENONCOURT and JACK C. FISHER. York College of Pennsylvania, York, PA. 17405. A FRESHWATER POPULATION OF THE MUMMICHOG, *FUNDULUS HETEROCLITUS,* IN THE SUSQUEHANNA RIVER DRAINAGE OF PENNSYLVANIA. — An established population is reported from Pennsylvania for the first time. Three year classes of *Fundulus heteroclitus,* normally a brackish water fish, were taken on 17 August 1976 from Letort Spring Run, a tributary of the Conodoquinet Creek in Cumberland County, Pennsylvania. Its occurence in the Delaware River drainage is also recorded. Presence in both drainages is believed the result of bait bucket introductions.

OVERLEASE, WILLIAM R. Department of Biology, West Chester State College, West Chester, PA. 19380. THE RED OAK GROUP, ERYTHROBALANUS, IN MICHIGAN AND NEARBY STATES. — A study of the inter-realtionships between species of the Red Oak Group including Black Oak, Red Oak, Scarlet Oak, and their small-fruited northern forms. Material on Pin Oak will also be included. Special emphasis will be given to genetic realtionships, hybridization, and speciation in these oaks. A SUMMARY OF STUDIES OF TWENTY-FIVE FOREST STANDS IN SOUTHERN CHESTER COUNTY, PENNSYLVANIA. Data is presented on precent crown cover and stem counts of understory strata of woody plants for twenty-five stands of the Oak-Chestnut Forest Region in Chester County. Stand stability, general patterns, and successional status are discussed.

*The abstracts published herein have not been subjected to editorial scrutiny.

SMITH, BRUCE B. and MARGARET CRAMER. Department of biology, York College of Pennsylvania, York, PA. 17405. THE USE OF 100% ETHYL ALCOHOL AS A PRETREATMENT OF *RHEO DISCOLOR* OVULES PRIOR TO IMMRESION IN HERR'S CLEARING FLUID (HCF). — Herr clearing fluid (HCF), chloral hydrate, clove oil, lactice acid, phenol, and xylene, 2:2:2:2:1, by weight, has proven to be a valuable method for clearing botanical tissue. The use of this fluid for qualitative evaluations of ontogenetic events of early ovule development through megagametogenesis has lessened the time and effort needed in paraffin sectioning techniques. The usual procedure involves the fixing of material at least 24 hours in $FPA_{50\text{-}70}$ (formalin, proprionic acid, ethly alcohol, 50-70%), immersion into the HCF for a few minutes, then viewing of cleared material via phase microscopy. However, some materials require variations in fixatives and/or the need for a pretreatment prior to immersion in HCF. *Rhoeo discolor* ovules apparently clear their best with a pretreatment of 100% ETOH prior to immersion in HCF. The purpose of this study was to determine the correct timing of pretreatment prior to the use of HCF.

WILSON, THOMAS G. and BERNARD FRIED. Department of Biology, Lafayette College, Easton, Pa. 18042. LARVAL TREMATODES FROM AQUATIC SNAILS IN PENNSYLVANIA. — A survey of larval trematodes from snails collected in about 200 ponds in eastern Pennsylvania was made in the summer of 1976. Snails were isolated and crushed to determine infections. Snails examined included lymnaeids, physids, planorbids, and viviparids. Larval trematodes included strigeids, echinostomes, notocotylids, and avian schistosomes. Specific identifications of snails and larval trematodes are in progress.

HANSON, **HENRY**, MARGIE CARPENTER, DON WINSTEL and CHANDRA MOWERY. Department of Geology, Dickinson College, Carlisle, Pa. 17013. THE GROUNDWATER GEOCHEMISTRY AND PLANT COMMUNITIES ALONG A TOPOGRAPHIC PROFILE ACROSS ASSATEAGUE ISLAND, MARYLAND. — A strong relationship between distance from shore, elevation, groundwater geochemistry and plant communities is demonstrated in a topographic profile across Assateague Island, Maryland. Six plant communities exist along this section on landscapes which they control by their effectiveness in trapping wind-blown sediment. These topographic forms influence the groundwater by determining the surface flow pattern of rain and over-wash water. Tolerance of plants to wind-blown and ground water salt determines the location of the plant communities.

GRIESACKER, P.B., Ph.D., S.E. HAYWOOD, D.C. JORDAN, C. NIEDERRITER, and W. CHRISTIAN. Department of Physics, Gannon College, Erie, PA. 16501. OPTICAL IMAGE ENHANCEMENT BY SPATIAL FREQUENCY FILTERING. — A well corrected coverging lens and a coherent He-Ne laser source are used to demonstrate the effects of spatial frequency filtering on optical image formation. The spatial frequency spectra of some simple objects are recorded and various filtering techniques are used to modify the images of previous calculations and applications to optical microscopy are discussed.

CHRISTIAN, WOLFGANG, Ph.D., S.E. HAYWOOD, D. C. JORDAN, C. NIEDERRITER and P.B. GRIESACKER. Department of Physics, Gannon College, Erie, PA. 16501. THE CONSTRUCTION OF A LOW COST CARBON DIOXIDE LASER FOR UNDERGRADUATE RESEARCH. — The construction of a medium power CO_2 laser for under $250.00 is described. Three methods of detecting the infrared laser beam are compared, calibrated, and utilized to measure the operating characteristics of the laser. Expermients suitable for undergraduate research participation are described.

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. *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. *Acknowledgments.* 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: Shyamal K. Majumdar, Department of Biology, Lafayette College, Easton, Pennsylvania 18042.

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.

PROCEEDINGS OF THE PENNSYLVANIA ACADEMY OF SCIENCE Vol. 51, Issue 1, 1977

CONTENTS

President of the Academy and Academy Officers . . . 3
Program of the 53rd Annual Meeting . . . 4
Executive Council Meeting . . . 5
Academy Business . . . 7
THE DARBAKER PRIZE PAPER — BIOLOGY: Electron Microprobe Analysis of Colloidal Iodine in Thyroid Gland of White-Throated Sparrow, *Zonotrichia Albicollis* — *Jack Harclerode, David Zeigler, William Zeigler and Eugene W. White* . . . 19
BIOLOGY: Spontaneous Activity of Pregnant and Nonpregnant Control CF-1C Mice — *Howard S. Pitkow, Ph.D., Mark Warnquist, Steven Phillips, and Robert H. Davis, Ph.D.* . . . 23
BIOLOGY: Mercury in North Atlantic Lobster of the New York Bight — *Salvatore J. Ali, Jr. Mary Jane Bradford and G. Earl Peace* . . . 26
BIOLOGY: A Simple Culture Technique for *Equisetum hyemale* Through the Entire Life Cycle — *Frank M. Hoffman* . . . 29
BIOLOGY: Field Observations Including Acoustic Behavior of the Black-Digger Wasp, *Sphex pennsylvanicus* (Linn.) — *Louis Rigley and Herbert Hays* . . . 32
BIOLOGY: A Histological Study of the Short Term Effects of Anthophyllite Fibers on Guinea Pig Lungs — *Stephan R. Sanko and Allan F. Wolfe* . . . 35
BIOLOGY: A Seasonal Study of the Ectoparasites of *Sylvilagus transitionalis* — *Dan M. Harman and Joseph A. Chapman* . . . 40
BIOLOGY: A Re-examination of the Subspecific Status of the Maryland Shrew, *Sorex cinereus fontinalis* Hollister — *Gordon L. Kirkland, Jr.* . . . 43
BIOLOGY: A Study of the Realtionship Between Scarlet Oak (*Quercus coccinea* Muenchh.) and Hill Oak (*Quercus ellipsoidalis* E.J. Hill) in Michigan and Nearby States — *William Roy Overlease* . . . 47
BIOLOGY: Effects of a Zinc Mine Ground Water Effluent on a Stream Diatom Community — *David M. Bell* . . . 51
BIOLOGY: Formed Blood Elements of the Mussel *Elliptio complanatum* — *Bonni J. Hazleton and George R. Isenberg* . . . 54
BIOLOGY: Observations on the Nocturnal Behavior of Feral Ponies — *Dr. Ronald R. Keiper* . . . 57
BIOLOGY: Fishes of the Conewago Creek Drainage, York and Adams Counties, Pennsylvania — *Philip C. Ritson, Janet L. Polk and Robert W. Malick, Jr.* . . . 59
BIOLOGY: Initial Survey of the Plankton of Twenty-Seven Lakes Near Wilkes-Barre, Pennsylvania, 1976 — *Charles B. Reif* . . . 67
GEOGRAPHY: Fertility and Levels of Development in Mid-Nineteenth Century Pennsylvania — *George A. Schnell* . . . 70
GEOGRAPHY: Geographic Variations of Infant Mortality in Pennsylvania: 1960 and 1970 — *Mark S. Monmonier* . . . 75
GEOGRAPHY: Residential Patterns of Blacks in Battle Creek, Michigan, 1850-1930 — *Juanita Gaston, Ph.D. and Walter C. Farrell, Jr., Ph.D.* . . . 79
GEOLOGY: The Age of the Martinsburg Formation at Swatara Gap, Pennsylvania — *Thomas O. Wright, Susan M. Garwood and Kraig Derstler* . . . 85
RESEARCH NOTE: *Succinate Dehydrogenase Activity in Rana catesbeiana* Tadpole Liver During 3, 3', 5-Triioda-L-Thyronine-Induced Metamorphosis — *David Ostrovsky and Robert Sahms* . . . 89
RESEARCH NOTE: The Least Weasel, *Mustela nivalis*, from Maryland — *Joseph A. Chapman and Dan M. Harman* . . . 91
Abstracts . . . 93
Suggestions to Authors . . . 100