Proceedings of the Arkansas Academy of Science - Volume 33 1979

Academy Editors

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PAST PRESIDENTS OF THE ARKANSAS ACADEMY OF SCIENCE

Charles Brookover, 1917
Dwight M. Moore, 1932-33, 64
Flora Haas, 1934
H. H. Hyman, 1935
L. B. Ham, 1936
W. C. Munn, 1937
M. J. McHenry, 1938
T. L. Smith, 1939
P. G. Horton, 1940
I. A. Wills, 1941-42
L. B. Roberts, 1943-44
Jeff Banks, 1945
H. L. Winburn, 1946-47
E. A. Provine, 1948
G. V. Robinette, 1949
R. H. Totter, 1950
R. H. Austin, 1951
E. A. Spessard, 1952
Delbert Swartz, 1953
Z. V. Harvalik, 1954
M. Ruth Armstrong, 1955
W. W. Nedrow, 1956
Jack W. Sears, 1957
J. R. Mundie, 1958
C. E. Hoffman, 1959
N. D. Buffaloe, 1960
H. L. Bogan, 1961
Trumann McEver, 1962
Robert Shideler, 1963
L. F. Bailey, 1965
James H. Fribourgh, 1966
Howard Moore, 1967
John J. Chapman, 1968
Arthur Fry, 1969
M. L. Lawson, 1970
R. T. Kirkwood, 1971
George E. Templeton, 1972
E. B. Whittle, 1973
Clark McCarty, 1974
Edward Dale, 1975
Joe Guenter, 1976
Jewel Moore, 1977
Joe Nix, 1978

INSTITUTIONAL MEMBERS

The Arkansas Academy of Science recognizes the support of the following institutions through their Institutional Membership in the Academy.

ARKANSAS STATE UNIVERSITY, State University
ARKANSAS TECH UNIVERSITY, Russellville
COLLEGE OF THE OZARKS, Clarksville
HENDERSON STATE UNIVERSITY, Arkadelphia
HENDRIX COLLEGE, Conway
JOHN BROWN UNIVERSITY, Siloam Springs
OUACHITA BAPTIST UNIVERSITY, Arkadelphia
SOUTHERN ARKANSAS UNIVERSITY, Magnolia
UNIVERSITY OF ARKANSAS AT FAYETTEVILLE
UNIVERSITY OF ARKANSAS AT LITTLE ROCK
UNIVERSITY OF ARKANSAS AT MONTICELLO
UNIVERSITY OF ARKANSAS AT PINE BLUFF
UNIVERSITY OF CENTRAL ARKANSAS, Conway

EDITORIAL STAFF

EDITOR: GARY A. HEIDT, Dept. of Biology, University of Arkansas at Little Rock, Little Rock, Arkansas 72204.

EDITOR FOR NEWSLETTER: HENRY W. ROBINSON, Dept. of Biology, Southern Arkansas University, Magnolia, Arkansas 71753.

ASSOCIATE EDITORS:
Timothy C. Klinger
Anthropology-Sociology

Dale V. Ferguson
Biology

Alex R. Nisbet
Chemistry

John K. Beadles
Environmental Science

Walter L. Manger
Geology

James E. Mackey
Physics

Neal D. Buffaloe
Science Education
Jim Scholtz died unexpectedly on December 27, 1978, while on a trip to New Orleans. For the past ten years he had served as the Assistant Director of the University of Arkansas Museum. He had a BA in anthropology from the University of Iowa, his home state, and an MA in anthropology from the University of Arkansas. Until turning his career toward the museum field, he had spent eight years doing archeological field work, principally in Arkansas. He had successfully combined his interests and talents in his position in the University Museum.

He was instrumental in introducing anthropology into the scope of the Arkansas Academy of Science, and for many years prodded and encouraged his colleagues, particularly in archeology, into participation in the annual programs, and then in publication of papers in the Academy's proceedings. His was a quiet, persuasive, and pervasive contribution to science and professionalism in Arkansas.

Hester A. Davis
Arkansas Archeological Survey

Editor's Note: Jim's contributions toward the Arkansas Academy of Science through his position as Associate Editor for Anthropology-Sociology were many and his help and encouragement in that area will be sorely missed.
PROCEEDINGS OF THE
ARKANSAS ACADEMY OF SCIENCE
1980
MINUTES OF THE SIXTY-THIRD ANNUAL MEETING—6-7 April 1979

FIRST BUSINESS MEETING

Dr. P. M. Johnston, President, opened the meeting. He introduced Dr. Roy Schilling, President of Hendrix College, who welcomed the Academy to his institution.

President Johnston recognized Dr. John Gilmour for the Secretary’s report. Gilmour reported that the Proceedings of the sixty-second meeting of the Academy containing minutes of the First and Second Business Meetings were available. He said a motion for approval of the minutes would be made at the Second Business Meeting.

President Johnston then introduced Dr. Charles Leone, Vice-President and Provost of the University of Arkansas, Fayetteville. Leone described a new National Science Foundation Experimental Program to Stimulate Competitive Research. He said a Planning Proposal had been completed which would: a) conduct a survey of scientific potential in Arkansas and evaluate that potential, b) formulate criteria for selecting research areas to be developed, c) stimulate submission of nationally competitive research proposals, and d) prepare an implementation proposal to the fund provided by NSF for $3 million over a period of 5 years. He asked the Arkansas Academy of Science to endorse this proposal. Discussion followed. Dr. W. L. Evans then made the following motion:

On behalf of the Executive Committee of the Arkansas Academy of Science, I move that the Academy and its members offer full cooperation and assistance in every way possible for this project.

The motion was seconded and passed.

President Johnston then recognized Dr. William L. Evans for the Treasurer’s report. Evans stated that financial statements were available. He then discussed the financial statement shown below.

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**Financial Statement**

March 31, 1979

<table>
<thead>
<tr>
<th>Items</th>
<th>Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cash Balance in Checking Account, March 23, 1978</td>
<td>$1,002.59</td>
</tr>
<tr>
<td>Less Outstanding Checks (449, 433)</td>
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</tr>
<tr>
<td>FLA (Heritage) Certificate Acct 71+950</td>
<td>1,284.99</td>
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<tr>
<td>FLA (Heritage) Passbook Acct 7679</td>
<td>2,982.03</td>
</tr>
<tr>
<td>Total Funds, March 23, 1978</td>
<td>$5,269.64</td>
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**Income (March 24, 1978 through March 31, 1979)**

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<tr>
<th>Items</th>
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</tr>
</thead>
<tbody>
<tr>
<td>1. Memberships</td>
<td>$1,926.00</td>
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<tr>
<td>a. Regular</td>
<td>$410.00</td>
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<tr>
<td>b. Institutional</td>
<td>1,516.00</td>
</tr>
<tr>
<td>2. Subscriptions to the PROCEEDINGS</td>
<td>900.00</td>
</tr>
<tr>
<td>3. Page charges for the PROCEEDINGS</td>
<td>938.88</td>
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---

**Total Disbursements**

<table>
<thead>
<tr>
<th>Items</th>
<th>Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>5. Publication of the PROCEEDINGS</td>
<td>4,812.76</td>
</tr>
<tr>
<td>a. Phillips Lithio, Printing (469)</td>
<td>2,295.95</td>
</tr>
<tr>
<td>b. Gilmour, Printing (464)</td>
<td>1,516.00</td>
</tr>
<tr>
<td>c. Editorial Ass. Salary (476)</td>
<td>50.00</td>
</tr>
<tr>
<td>d. Editorial Ass. Salary (475)</td>
<td>50.00</td>
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<tr>
<td>e. Gilmour, Postage (474)</td>
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</tr>
<tr>
<td>f. ALA Travel Agency, Editor (421)</td>
<td>50.00</td>
</tr>
<tr>
<td>g. Gilmour, Postage (473)</td>
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</tr>
<tr>
<td>h. Dept. Fin., Postage (472)</td>
<td>50.00</td>
</tr>
<tr>
<td>i. Editorial Ass. Salary (471)</td>
<td>50.00</td>
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<tr>
<td>j. Herald, Postage (467)</td>
<td>50.00</td>
</tr>
<tr>
<td>k. Herald, Travel (457)</td>
<td>50.00</td>
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</table>

**Summary**

<table>
<thead>
<tr>
<th>Items</th>
<th>Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beginning Balance, Checking and Reserve</td>
<td>$9,160.66</td>
</tr>
<tr>
<td>Total Income</td>
<td>$6,324.81</td>
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<tr>
<td>Total Expenditures</td>
<td>$4,812.76</td>
</tr>
<tr>
<td>Funds on Hand, March 31, 1979</td>
<td>$4,737.05</td>
</tr>
</tbody>
</table>

Outstanding Bills, March 31, 1979: $3,072.25

Debtor Funds: $5,725.25

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Journal of the Arkansas Academy of Science, Vol. 33 [1979], Art. 1
Evans said a motion for approval would be made at the Second Business Meeting. He then reported that the Research Fund currently contains $844.

President Johnston recognized Dr. Clarence Sinclair, Chairman of the Nominating Committee who gave the following report.

The members of the Nominating Committee, as appointed by you, were Dr. Earl Hannebrink and Dr. David Becker with myself as chairman. We compiled a potential list of candidates, then asked each candidate if he/she would serve if elected, then narrowed the field to two for each position. The names submitted to the Academy for the two positions are as listed below.

I. For President-Elect
   H. Robison - UASM
   E. Bacon - UAM

II. For Secretary
   D. Chittenden - ASU
   D. L. Zachry - UAF

President Johnston asked for nominations from the floor. There were none. He then moved that the slate be accepted. The motion was seconded and passed.

President Johnston then recognized Dr. Gary Heidt, Editor, who gave the following report.

I would again like to thank the Associate Editors for their help in handling the Section Programs for this meeting and seeing that the submitted manuscripts from last year were reviewed by competent scientists in the appropriate areas of expertise. These tasks have greatly reduced the work load of the Editor and are greatly appreciated.

A total of 39 manuscripts was submitted for publication in Volume 32 of the Proceedings of the Arkansas Academy of Science. Of these, 3 were deemed unsuitable for publication and 5 others were withdrawn, either editorially or by the authors for various reasons. Of the remaining 31 manuscripts, 22 appear as Feature Articles and 9 as General Notes.

Because this issue of the Proceedings is smaller, both in pages [94 as opposed to 123 in 1977] and printed copies [450 as opposed to 500], the total cost of producing this year’s issue was $3202 plus editorial expenses. This amounts to $7.00/book rather than last year’s $8.25. In addition, Phillip Litho of Springdale only increased their prices 5%; thus, we have received a temporary reprieve in the battle of cost control.

I am looking forward to receiving a group of quality manuscripts from this meeting and producing a Proceedings of which the scientific community of Arkansas can remain proud.

Heidt then made the following motion.

I would like to move that the Academy allocate $400 for editorial assistance in preparing Volume 33 [1979] of the Proceedings of the Arkansas Academy of Science during the next Academy fiscal year.

The motion was seconded and passed.
rechartered and a new and complete roster of chapters and members will be compiled and maintained.

An attempt was made this year to disseminate information concerning the Academy to science teachers in the state by personal contact and by television. The results have been encouraging, with a number of teachers seeking information and new schools participating.

Mrs. Arthur then made the following motion.

I move that revisions in the Constitution of the Junior Academy of Science approved by the Executive Committee of the Junior Academy be accepted and that the Academy provide $200 support to the Junior Academy for the coming year.

The motion was seconded and passed.

President Johnston announced the appointment of the Auditing (Clark McCarty, Neal Buffalo), Resolutions (John Seelander, Jewel Moore) and Meeting Place (Glen Good, Ed Bacon) Committees. He noted that Arkansas State University had already extended an invitation for the 1980 Annual Meeting. Thus, the Meeting Place Committee would be considering locations for the 1981 Annual Meeting.

President Johnston then made some general announcements and adjourned the First Business Meeting.

SECOND BUSINESS MEETING

President Johnston called the Second Business Meeting to order. Election of officers was conducted by ballot. Henry Robison was elected to the office of President-Elect and David Chittenden was elected to the office of Secretary.

President Johnston then recognized Dr. John Gilmour who made the following motion.

I move that the minutes of the 62nd Annual Meeting published in the 32nd Proceedings of the Arkansas Academy of Science be approved as written.

The motion was seconded and passed. The Secretary notes that the Sponsor of the Collegiate Academy is Dr. Glen Good, not Dr. Glen Wood as written in the minutes.

President Johnston recognized Dr. William Evans who made the following motion.

I move the acceptance and approval of the Treasurer’s financial statement and report for the period March 24, 1978, through March 31, 1979, as submitted to the Membership at the first Business Meeting and circulated.

President Johnston pointed out a replacement Auditing Committee of Leon Richards and James Nichols had been named after the First Business Meeting; Leon Richards made the following report.

James Nichols and myself audited the books. We found the financial records correct, and Dr. Bill Evans should be commended for this work.

The motion was seconded and passed.

President Johnston called on the Historian, Professor Robert Kirkwood, who reported that the cost of a banquet at the first meeting of the Academy at Hendrix was $200. President Johnston then recognized Dr. Glen Good for the Collegiate Academy Report shown below.

The Arkansas Collegiate Academy of Science has been emphasizing increased membership during 1978-1979. One of the major problems plaguing the Collegiate Academy during the past two years has been lack of interest and discontinuity. President Rich Brown of Ouachita Baptist University, and President-Elect Frank Brown of Harding College, along with Sandra Thompson, Secretary and David Dube, Treasurer (both of Ouachita) have worked in their own schools to promote interest, and have sent out information regarding the Collegiate Academy’s annual meeting at Hendrix College.

The problems of discontinuity, low membership, and low interest are by no means solved. The officers of the Collegiate Academy feel that help from faculty members of the Senior Academy in promoting interest in their own schools will be the key to promoting membership. Thus, student research can be promoted more effectively. Again, faculty-student interaction is the key to a strong Academy of Science, both for the college student and the faculty member.

The Collegiate Academy congratulates those students presenting research at the 1979 meeting of the Arkansas Academy of Science.

The Collegiate Academy conducted its annual business meeting Friday April 6, 1979, and elected the following officers: Jane Spandel from Hendrix as President-elect; Pam Ellington of Harding as Treasurer. Arthur Johnson was selected as co-sponsor for the Collegiate Academy.

Rich Brown, outgoing President, gave a talk entitled “Recombinant DNA.”

The new President, Frank Brown of Harding, assumed his duties, and the sponsor will be Ed Wilson.

Of the $175 granted by the Senior Academy, $50 was requested for travel and replenishing the supply of stationery and envelopes. This leaves a balance of $45 in the treasury for the new president.

Good then made the following motion.

I move that the Senior Academy approve up to $175 to cover expenses and operations of the Collegiate Academy for the coming year.

The motion was seconded and passed.

President Johnston then called on Dr. Leo Paulissen for a report on the Arkansas Science Talent Search. The report is shown below:

For the first time in twenty-eight years of participation, there are three honorees from Arkansas in the Westphul Science Talent Search. And, for the second time, one of these is a “winner” and was awarded an all-expense trip to Washington, D.C. These three people are the state winners this year and are being awarded cash prizes and certificates.

First Place:
Elizabeth Anne Thiele
School: Southside High School, Pt. Smith
Teacher: Larry E. Withers
Project: The purification and characterization of bovine placental lactogen.

Second Place:
Keely Irwin Nix
School: Arkansas Senior High School, Texarkana
Teacher: W. A. Dempsey
Project: The thermal separating effect of a forced vortex as exhibited by the vortex tube.

Third Place:
Wesley Frederic Trott
School: Hot Springs High School, Hot Springs
Teacher: Richmond G. Edwards
Project: A study of the effects of radiation and temperature surrounding the Hot Springs in Hot Springs National Park, Arkansas.
President Johnston recognized Dr. Henry Robison, Editor of the Newsletter, who made the following motion.

I move that $100 be set aside for the Newsletter next year.

The motion was seconded and passed.

President Johnston then recognized Dr. Ed Bacon of the Meeting Place Committee who made the following recommendation and motion.

The Meeting Place Committee recommends that the invitation of Arkansas State University for the 1980 meeting to be held on 4-5 April 1980 be accepted and that the University of Arkansas at Little Rock be considered for the 1981 meeting. I move that the invitation of Arkansas State University be accepted.

The motion was seconded and passed.

President Johnston then asked that the Academy give special thanks to Dr. Art Johnson for his efforts in arranging this year's meeting.

President Johnston recognized Dr. John Sealander, Resolutions Committee, who read the following.

Be it resolved:

By the members of the Academy in session on April 7 at Hendrix College in Conway that the Academy wishes to express its sincere thanks and appreciation to Dr. Roy B. Shilling, President of Hendrix College, and to the faculty and staff of Hendrix College for the use of their facilities and their warm hospitality.

Furthermore, the Academy extends its congratulations to the local Arrangements Committee, Dr. Arthur Johnson, chairman, and to the chairpersons of the Academy sections; Alex Nisbet, Robert Eslinger, Dale V. Ferguson, John K. Beadles, Neal Buffaloe, Robert Kirkwood, John Rickett, Walter L. Manger and Charles Niquette.

The Academy also wishes to express its thanks to P. M. Johnston, President of the Academy, John Gilmour, Secretary, William L. Evans, Treasurer, Gary Heidt, Editor, Robert Kirkwood, Historian, and Henry Robison, Editor of the Newsletter, for the excellent manner in which they have discharged their duties during the past year.

The Academy also expresses its congratulations to the outstanding work of the organizations sponsored by the Academy and its appreciation to the sponsors and directors of these groups: Marie Arthur, Director of the Junior Academy of Science; Tom Palko, Director, Junior Science and Humanities Symposium; Glen Good, Sponsor, Collegiate Academy of Science; Carl Rutledge, Director, State Science Fair; Leo Paulissen, Science Talent Search and to Wayne Everett, Coordinator and Liaison Officer for all sponsored activities.

The Academy also expresses its thanks to the following exhibitors: Science Instructional Supplies, Inc.; Micro-Tech Instruments, Inc.; Info Lab; Preiser Scientific Co. and Actinorex.

Sealander moved the resolution be adopted. The motion was seconded and passed.

President Johnston recognized Dr. Jewel Moore who made the following motion.

I move that a committee be appointed to consider the certification requirements for the teaching of sciences in the high schools of the state.

The motion was seconded and passed.

President Johnston appointed Denver Prince, E. E. Hudson and Jewel Moore to serve on the committee described in the motion above.

President Johnston noted that memorial contributions in memory of Ruth Armstrong could be made to the Fort Smith Audubon Society or the University of Arkansas Foundation for the Class of 1926.

President Johnston asked for new business.

Dr. Gary Heidt then made the following motion.

I move that the Arkansas Academy of Science, through the Executive Committee, do something appropriate in the memory of Dr. James A. Schulz, who had served the past several years as the Anthropology Associate Editor for the Proceedings of the Arkansas Academy of Science.

The motion was seconded and passed.

President Johnston then recognized Dr. Leo Paulissen who noted that the third installment of the Biota Survey is available from him. Paulissen encouraged members to send updated and new lists.

President Johnston called on Dr. Glen Good who noted that no collegiate awards were given this year because of scheduling difficulties.

President Johnston then made his farewell address in which he stated that the year had been a learning experience for him. President Johnston passed the gavel to Dr. Leon Richards, President-Elect, who presented Dr. Johnston a certificate of appreciation for his year as President.

President Richards then appointed a Nominating committee of Jewel Moore (Chairman), Dan England and Jim Wickliffe and a Constitutional Revision Committee composed of Art Johnson (Chairman), Ed Dale and Dave Chittenden.

President Richards adjourned the Second Business Meeting.

Respectfully submitted,

John T. Gilmour
Secretary
PROGRAM
Arkansas Academy of Science

Sixty-Third Annual Meeting
HENDRIX COLLEGE
Conway, Arkansas

Meeting concurrently with sessions of:
The Collegiate Academy of Science

Friday, 6 April

SENIOR AND COLLEGIATE ACADEMIES -- Registration
SENIOR ACADEMY -- Executive Board Meeting
COLLEGIATE BUSINESS MEETING I
SENIOR ACADEMY -- First General Business Meeting
WESTINGHOUSE SCIENCE TALENT SEARCH AWARDS
Lunch
SENIOR AND COLLEGIATE ACADEMIES -- Registration
SENIOR AND COLLEGIATE ACADEMIES -- Papers [Concurrent Sessions]:
- Chemistry
- Mathematics and Physics
- General Physiology/Invertebrate Zoology
- Environmental and Engineering Sciences I
- Science Education
ARKANSAS BIOLOGICAL CURRICULUM DEVELOPMENT PLANNING
ENDANGERED SPECIES TECHNICAL COMMITTEE
ENDANGERED AND THREATENED PLANT SPECIES IN ARKANSAS
SENIOR AND COLLEGIATE ACADEMIES -- Banquet

Speaker: Governor Bill Clinton
"Utilization of Arkansas Scientists"

Saturday, 7 April

SENIOR AND COLLEGIATE ACADEMIES -- Registration
SENIOR AND COLLEGIATE ACADEMIES -- Papers [Concurrent Sessions]:
- Vertebrate Zoology
- Botany
- Environmental and Engineering Sciences II
- Anthropology/Archaeology
- Geology
COLLEGIATE BUSINESS MEETING II
SENIOR ACADEMY -- Second General Business Meeting
SECTION PROGRAMS

[ Papers marked with * are presentations by Collegiate Academy members ]

CHEMISTRY SECTION
Chairman: Alex R. Niebet

*SYNTHESIS OF CALLISTEPHIN CHLORIDE.
Johnny E. Brian and Thomas E. Goodwin, Hendrix College

*A RADIOIMMUNOASSAY FOR PHOSPHOGLUCOSE ISOMERASE AND ITS INITIAL UTILIZATION IN DETECTING CROSS REACTIVE MATERIAL IN VARIANT FORMS OF PHOSPHOGLUCOSE ISOMERASE.
Roy S. Jones, K. Purdy and Robert W. Gracy, Hendrix College and North Texas State University

*EXPERIMENTAL PROCEDURE FOR THE DETERMINATION OF TRACE-LEVEL URANIUM IN ROCK AND LIQUID SAMPLES USING ARGON PLASMA SPECTROSCOPY.
Richard A. Roberts, Hendrix College and Joe R. Trim n, Tennessee Valley Authority

PYRAZOLE AND PYRAZOLATO COMPLEXES OF PLATINUM[II].
W. C. Deese, M. L. Howe, and D. A. Johnson, University of Arkansas at Fayetteville and Christian Brothers College

THE SYNTHESIS OF HEX-1-ENOPYRAN-3-ULOSES.
Thomas A. Goodwin and Richard Jackson, Hendrix College

THE REDUCTION OF TOSYLHYDRAZONES BY 9-BBN.
Dominic T. C. Yang, Jim W. Purser, and Chris M. Moser, University of Arkansas at Little Rock

SYNTHESIS OF A SERIES OF 2,5- AND 5,6-DIHALONICOTINIC ACIDS.
Frank L. Setliff, University of Arkansas at Little Rock

MATHEMATICS AND PHYSICS SECTION
Chairman: Robert Eslinger

*UNIFORM LIMITS OF STEP FUNCTIONS.
Ages L. Tulio, Hendrix College

*THE KERNEL OF THE LAPLACE TRANSFORM.
David Sutherland, Hendrix College

*CHARACTERIZATION OF CONVEX SETS.
Lisa M. Orton, Hendrix College

*HIGHER ORDER SYMMETRIC DERIVATIVES.
Gene Weber, Hendrix College

GENERAL PHYSIOLOGY/INVERTEBRATE ZOOLOGY SECTION
Chairman: Dale V. Ferguson

THE EFFECT OF TURF FUNGICIDES ON EARTH WORMS.
J. H. Roark and J. L. Dale, University of Arkansas at Fayetteville

CAVE FAUNA OF ARKANSAS: ADDITIONAL INVERTEBRATE AND VERTEBRATE RECORDS.
Kenneth N. Paige, V. Rick McDaniel and C. Renn Tumlinson, Arkansas State University

MOLLUSCA OF THE ILLINOIS RIVER, ARKANSAS.
Mark E. Gordon and Arthur V. Brown, University of Arkansas at Fayetteville

TIME COURSE OF PR OF UV-INDUCED CHROMOSOMAL ABERRATIONS AND LETHAL DAMAGE IN 5 AND 62 XENOPUS CELLS.
Jan Payne and Gaston Griggs, John Brown University

GENIC VARIATION IN WHITE-TAILED DEER FROM ARKANSAS.
Phyllis K. Price, Memphis State University and Michael Carwright and Mitchell Rogers, Arkansas Game and Fish Commission

ENZYME VARIABILITY IN TWO MEMBERS OF THE VIRILIS GROUP OF DROSOPHILA SPECIES.
William C. Guest, Richard O. Dockins and Virgil Wooten, University of Arkansas at Fayetteville

ELECTROPHORETIC ANALYSIS OF BLOOD SERUM PROTEINS IN THREE SPECIES OF NERODIA (WATER SNAKES).
Phyllis Garnett, University of Arkansas at Little Rock

ANALYSIS OF THE MOTILE APPARATUS OF THE AFLAGELLATE SPERMATOZOOON OF MACROSTROMUM TUBUM.
W. Donald Newton and Danny W. Phillips, Arkansas State University

THE ROLE OF THE NATURE CONSERVANCY IN ARKANSAS.
Kenneth Lee Smith, The Nature Conservancy-Arkansas Heritage Program

*COMPUTER APPLICATIONS IN POPULATION GENETICS.
Cassandra Scrinshire, Hendrix College

*DEGENERATING AND REGENERATING INDIRECT FLIGHT MUSCLES OF THE RICE WATER WEEVIL (LISSORHOP TERUS ORYZOPHILUS, KUSCHEL): THEIR COMPARISON AND DESCRIPTION.
Beth Haizlip, University of Arkansas at Fayetteville

*ULTRASTRUCTURAL OBSERVATIONS OF THE CERTAIN TOPOGRAPHICAL FEATURES OF LARVAE AND PUPAE OF THE YELLOW JACKET Wasp, VESPULA SQUAMOSA.
Richard Roller and William R. Bowen, University of Arkansas at Little Rock

*A COMPARISON OF THE LENS PROTEIN PROFILES OF THREE SPECIES OF OZARK SALAMANDERS.
James M. Britton, University of Arkansas at Fayetteville

SMALL ANIMAL WHOLE BODY GAMMA COUNTER - MULTIPLE ADAPTATIONS AND EVALUATIONS.
James T. McVey, John Hunziker, Joseph F. Holon and John F. Young, The National Center for Toxicological Research

IS THE SUPRACHIASMATIC NUCLEUS [SCN] A RHYTHM GENERATOR?
James N. Pasley, Ervin W. Powell and Lawrence E. Scheving, University of Arkansas for Medical Sciences

ENVIRONMENTAL SCIENCE AND ENGINEERING SCIENCES I SECTION
Chairman: John K. Beadles

THE FATE OF RADIONUCLIDES INJECTED INTO LAKE DAR DANELLE.
David Chittenden, Arkansas State University
A NOTE OF THE FOOD HABITS OF SELECTED RAPTORS FROM NORTHEASTERN ARKANSAS.
Earl L. Hanebrink, Alan Posey and Keith Sutton, Arkansas State University

ABUNDANCE AND DIVERSITY OF FISH FROM ONE SAMPLING DATE IN THE FLAT BAYOU DRAINAGE AREA, JEFFERSON COUNTY, ARKANSAS.
John D. Rickett, University of Arkansas at Little Rock

ABUNDANCE, DIVERSITY, AND DISTRIBUTION OF BENTHIC MACROINVERTEBRATES IN THE FLAT BAYOU DRAINAGE AREA, JEFFERSON COUNTY, ARKANSAS.
John D. Rickett, University of Arkansas at Little Rock

THE EFFECTS OF CERTAIN AQUATIC PLANTS ON A SIMULATED MUNICIPAL SEWAGE.
Elizabeth Hunt, Pulaski County Health Dept. and Theodore V. Croxley, University of Arkansas at Little Rock

HABITAT DISCRIMINATION WITHIN AN AVIAN OMNIVORE FEEDING GUILD.
Alan F. Posey, Arkansas State University and Douglas James, University of Arkansas at Fayetteville

SOME GROWTH CHARACTERISTICS OF WHITE CRAPPIE, POMOXIS ANNULARIS RALINESQUE, FROM A FLOOD-CREATED POND IN MISSISSIPPI COUNTY, ARKANSAS.
Stephen A. Sewell, Arkansas State University

SCIENCE EDUCATION SECTION
Chairman: Neal Buffaloe

SCIENCE WORKSHOP FOR TEACHERS.
Carl T. Rutledge, Southern Arkansas University

EVALUATION OF UNDERGRADUATE COURSES BY INSERVICE BIOLOGY TEACHERS.
Jewel E. Moore and Robert T. Kirkwood, University of Central Arkansas

UNORTHODOX FOOD SOURCES OF INSERVICE BIOLOGY TEACHERS.
Karen Johnson, Liz Ellis, Jeannie Russell, Susan Shaffer, and Sue Thompson, University of Central Arkansas

VERTEBRATE ZOOLOGY SECTION
Chairman: John D. Rickett

*A SURVEY OF THE FISHES OF TEN MILE CREEK IN SOUTHEASTERN ARKANSAS.
Carl D. Jeffers and Edmond J. Bacon, University of Arkansas at Monticello

THE RECENT STATUS OF THE SOUTHERN CAVEFISH, TYPHLECHTYS SUBTERRANEUS, IN ARKANSAS.
Ken N. Paige, C. Ren Tumlinson and V. Rick McDaniel, Arkansas State University

DISTRIBUTION OF THE ORNATE BOX TURTLE (TERRAPENE ORNATA ORNATA) IN ARKANSAS.
Lawana England, Arkansas Natural Heritage Commission

HABITAT USE IN AN ARBOREAL SNAKE OPHEODRYS AESTIVUS (REPTILIA: COLUMBRIDAE).
Michael V. Plummer, Harding College

UNUSUAL CONCENTRATION OF SCARLET SNAKES (CEMOPHORA COCCINEA) IN VILLAGE CREEK STATE PARK, ARKANSAS.
Keith B. Sutton and V. R. McDaniel, Arkansas State University

A COMPARATIVE PHYSIOLOGICAL STUDY OF DIVING IN THREE SPECIES OF NERODIA AND ELAPHE OBSCOLA (REPTILIA: SERPENTES).
M. W. Patterson, D. A. Baeyens and C. T. McAllister, University of Arkansas at Little Rock

MODIFICATIONS AND IMPROVEMENTS IN THE FORMAX METHOD OF PREPARING SMALL AVIAN STUDY SPECIMENS.
Martin D. Floyd and Gary A. Heidt, University of Arkansas at Little Rock

A SURVEY OF THE BIRDS OF VILLAGE CREEK STATE PARK, ARKANSAS.
Keith B. Sutton, Arkansas State University

HOVERING FLIGHT IN RED-TAILED HAWKS (BUTEO JAMAICENSIS).
Norman Lavers, Arkansas State University

UNUSUAL RESULTS FROM PELLET ANALYSIS OF THE AMERICAN BARN OWL (TYTO ALBA PRATINCOLA).
Chris T. McAllister, Kenneth N. Paige and C. Ren Tumlinson, Arkansas State University

STATUS OF ENDANGERED BATS (MYOTIS SODALIS, M. GRISESCENS, PLECOTUS TOWNSENDII INGENS) IN ARKANSAS.
John J. Cassidy and Gary G. O'Hagen, Memphis State University

OCCURRENCE OF THE PLAINS HARVEST MOUSE IN ARKANSAS.
Douglas James, John A. Sealander, and Jeffrey J. Short, University of Arkansas at Fayetteville

STATUS OF THE RED-COCKADED WOODPECKER AT THE SELSENBAL NATIONAL WILDLIFE REFUGE IN ARKANSAS.
Douglas James and Fred L. Burnside, University of Arkansas at Fayetteville

AGE AND HUDDLING AS DETERMINANTS OF METABOLIC RATE IN GRASSHOPPER MICE (ONYCHOMYS LEUCOGASTER).
Meredith Bailey, Dennis Baeyens, and Lana Mann, University of Arkansas at Little Rock

A MORPHOLOGICAL INVESTIGATION OF HARVEST MICE, REITIrodontomys, FROM ARKANSAS.
John C. Huggins and V. Rick McDaniel, Arkansas State University

MATURATION AND FECUNDITY OF REDEAR SUNFISH.
James C. Adams and Raj V. Kilambi, University of Arkansas at Fayetteville

APPLICATION OF CHRONOBIOLOGICAL PRINCIPLES TO CHEMOTHERAPY.
Lawrence E. Scheving, University of Arkansas for Medical Sciences

BOTANY SECTION
Chairman: Robert Kirkwood

THE FRESHWATER ALGAE OF ARKANSAS III: FURTHER ADDITIONS.
Richard L. Meyer. University of Arkansas at Fayetteville

THREE SPECIES OF TRYPETHELIUM NEW TO ARKANSAS.
George T. Johnson, University of Arkansas at Fayetteville

ARKANSAS LICHENS I.
Jewel E. Moore, University of Central Arkansas
*ULTRASTRUCTURAL OBSERVATIONS OF A FLORIDEAN RED ALGA.
Rosemary Rosell and William R. Bowen, University of Arkansas at Little Rock

*ULTRASTRUCTURAL OBSERVATIONS ON THE PRESENCE OF A FIBER-LIKE INCLUSION IN CERTAIN LEAF CELLS OF THE TRIFOLIATE ORANGE, *PONCIRUS TRIFOLIATA*.
Bettee Stallings and William R. Bowen, University of Arkansas at Little Rock

ADDITIONS, DELETIONS, AND CORRECTIONS FOR THE ATLAS AND ANNOTATED LIST OF THE VASCULAR PLANTS OF ARKANSAS.
Edwin B. Smith and M. Gwen Barber, University of Arkansas at Fayetteville

AN ANALYSIS OF *HYPERICUM GRAVEOLENS*, *H. MITCHELLIANUM* AND FIELD INTERMEDIATES.
Donald E. Culwell, University of Central Arkansas

RAPHIDES: THEIR MOVEMENT IN CANALS.
J. H. Whitesell, Clarence B. Sinclair, and Joe Meador, University of Arkansas at Little Rock

LEAF TRICHOMES OF THE FAMILY LOASACEAE.
Rachel Goss and Clarence B. Sinclair, University of Arkansas at Little Rock

THE VEGETATIVE CELL OF THE CHLOROPHYLCEAN ALGA, *HAEMATOMOCOCUS ZIMBABIENSIS*.
Danna Rosell and William R. Bowen, University of Arkansas at Little Rock

Timothy J. Mulkey and Forrest E. Lane, University of Arkansas at Fayetteville

ALLELOPATHY VS. COMPETITION AS A MODE OF ACTION OF JOHNSONGRASS ON SOYBEAN.
Briggs W. Skulman and Forrest E. Lane, University of Arkansas at Fayetteville

ENVIRONMENTAL AND ENGINEERING SCIENCES II SECTION
Chairman: John K. Beadles

PRIMARY GROWTH-LIMITING FACTORS IN COMMUNITIES OF *NELUMBO LUTEA* (WILD) PERSONS.
Jeffery H. Rentig, Arkansas State University

EFFECTS OF CROPPING ON GROWTH OF CHANNEL CATFISH (*ICHTHYOLOGASTER CATFISHES*).
William W. Stephens and John K. Beadles, Arkansas State University

THE EFFECTS OF CHANNELIZATION ON FISH POPULATIONS OF THE Cache River and Bayou deView, Arkansas.
Morris Mauney, Virginia Polytechnic Institute and George L. Harp, Arkansas State University

SEASONAL ABUNDANCE AND HABITAT DISTRIBUTION OF BIRDS IN NORTHEASTERN ARKANSAS.
Earl L. Hanebrink and Alan F. Posey, Arkansas State University

ADDITIONS TO THE STRAWBERRY RIVER Ichthyofauna.
Henry W. Robison, Southern Arkansas University

THE GOLDEYE IN THE BLACK RIVER.
John K. Beadles, Arkansas State University

ANTHROPOLOGY/ARCHAEOLOGY SECTION
Chairman: Charles M. Niquette

APPLICATIONS OF STERELOGIC METHODS IN STANDARDIZING INFORMATION ON THE INCLUSIONS OF GROG-TEMPERED PREHISTORIC CERAMICS AT THE TOLTEC SITE, 3L42.
Jeyne Bennett, University of Arkansas at Fayetteville

CLOTHING STYLE AND SOCIAL VALUE.
J. M. Bruers, University of Arkansas at Fayetteville

NUTRITIONAL DIFFERENCES AND HUMAN SELECTION OF OAK ACORNS.
Jerry E. Hilliard, University of Arkansas at Fayetteville

ARCHAEOLOGICAL INVESTIGATIONS AT THE BURRIS SITE (3CG218).
David H. Jurney, Jr., University of Arkansas at Fayetteville

PROJECTILE POINTS VERSUS PREFORMS: A MODEL FOR THE ASSESSMENT OF PREHISTORIC SITE FUNCTION WITHIN THE OUACHITA MOUNTAINS REGION.
William A. Martin, University of Arkansas at Fayetteville

SOME RECENT TRENDS IN CONTRACT ARCHAEOLOGY: a BRIEF OVERVIEW.
Charles M. Niquette, University of Arkansas at Fayetteville

DEER BEHAVIOR AND ETHNOGRAPHIC MAN.
David C. Quin, University of Arkansas at Fayetteville

SELF-PERCEIVED HEALTH AND LIFE OUTLOOK AMONG THE RURAL ELDERLY.
Mary Jo Schneider, University of Arkansas at Fayetteville

CERAMICS AND CLAYS AT TOLTEC INDIAN MOUNDS (3LN42): A TEST OF X-RAY DIFFRACTION REGIONAL BASIS.
Judith C. Stewart, University of Arkansas at Fayetteville

LIFE SATISFACTION AND AGING: A STATISTICAL MODEL FOR CRAWD FOR COUNTY, ARKANSAS.
Michele Sunderland, University of Arkansas at Fayetteville

GEOLOGY SECTION
Chairman: Walter Manger

HYDROGEOLOGIC INVESTIGATION OF A LAND-FILL SITE IN WASHINGTON COUNTY, ARKANSAS.
Albert E. Ogden and Carlos J. Quintana, University of Arkansas at Fayetteville

A PRELIMINARY INVESTIGATION OF THE RURAL-USED AQUIFERS OF BOONE, CARROLL, AND MADISON COUNTIES, ARKANSAS.
Albert E. Ogden, Nancy L. Taylor, and Steve D. Thompson, University of Arkansas at Fayetteville

LITHOSTRATIGRAPHY OF THE BOONE FORMATION (LOWER MISSISSIPPIAN), NORTHWEST ARKANSAS.
Jeffrey L. Liner, University of Arkansas at Fayetteville

REPLACEMENT TEXTURES WITHIN THE ARKANSAS BARITE.
Stephen E. Laney, University of Arkansas at Fayetteville

CALCITIZATION AND DOLOMITIZATION PATTERNS: PITKIN LIMESTONE (UPPER CHERUSTERIAN), NORTHWEST ARKANSAS.
Dallas W. Greenberg and Walter L. Manger, University of Arkansas at Fayetteville
Program

LITHOSTRATIGRAPHY OF THE CANE HILL MEMBER OF THE HALE FORMATION (TYPE MORROWAN), NORTHWEST ARKANSAS.
Robert T. Liner, University of Arkansas at Fayetteville

LITHOSTRATIGRAPHIC ANALYSIS OF SELECTED SHELF FACIES, PITKIN LIMESTONE (CHESTERIAN), NORTHWEST ARKANSAS.
Richard Mollison, University of Arkansas at Fayetteville
MINUTES OF THE BUSINESS MEETING, 5 APRIL 1979

Rich Brown, in opening the meeting, expressed concern for low membership in past years.
Frank Brown was introduced as the 1978-79 president.
It was announced that there would be no meeting on Saturday, April 6.
The Treasurer’s Report given by David Dube was as follows:

- $37.40 Previous Balance at last meeting
- 50.00 Senior Academy Receipts
- 41.53 1978-79 Debits
- 45.87 Present Balance

Rich Brown stated that funding for research was available to Collegiate Academy Members; last year $175.00 was made available to cover expenses for officers and to cover some research expenses of collegiate members.
The floor was opened for nomination of officers, beginning with the office of president-elect. Motions were made and seconded that the following people be nominated:
- Sonya Quandt of Harding
- Alex Ray of Harding
- Clarissa Ply of UAM

After a majority vote, Sonya Quandt was acclaimed president-elect.

Motions were made and seconded that the following be nominated for treasurer:
- Pam Ellington of Harding
- Steve Stiles of UAM

By a majority vote, Pam Ellington was declared treasurer.

Frank Brown announced that he had no choice for secretary at the present time.

It was brought to the attention of the Collegiate Academy by a member from UAM that not more than two executive officers are to be held by members of the same school simultaneously. (All executive offices at this point belonged to members of Harding College."

Section 11:30 of the Collegiate Academy Constitution was read and was found to be in agreement with the member’s statement.

At this point the discussion was reversed to the president, Rich Brown, who determined that the vote for president-elect was invalid.
The floor was reopened for nomination of president-elect.
The following were nominated by a motion and a second to that motion:
- Clarissa Ply of UAM
- Jane Spradley of Hendrix

After voting, Jane Spradley was acclaimed the new president-elect.
Rich Brown presented a paper on Recombinant DNA.
The meeting was adjourned.

Respectfully Submitted,

Sandra Thompson
Secretary
Arkansas Collegiate Academy
1978-79

ARKANSAS COLLEGIATE ACADEMY MEMBERS

RICH BROWN
PRESIDENT

SANDRA THOMPSON
SECRETARY

DAVID DUBE
TREASURER

SPONSOR: DR. GLEN GOOD

ABSTRACTS OF PAPERS PRESENTED BY COLLEGIATE ACADEMY MEMBERS

Editor’s Note: Not included in the following abstracts are those of James M. Britton and Carl D. Jeffers, whose papers were accepted for publication and are presented elsewhere. Titles of papers presented by Collegiate Academy Members are identified in the preceding Section Programs by *.

SYNTHESIS OF CALLISTEPHIN CHLORIDE

Johnny E. Brian and Thomas E. Goodwin, Dept. of Chemistry, Hendrix College, Conway, Ark. 72032

The synthesis of callistephin chloride, a naturally occurring plant pigment, has been previously reported in the literature. Work on the preliminary reactions of this synthesis and modifications of them will be discussed. Also discussed will be the reason for synthesis of the compound, its suspected biological activity. The goal of this project is to prepare enough of the compound to allow it to be screened for antitumor properties by the National Cancer Institute.

DEGENERATING AND REGENERATING INDIRECT FLIGHT MUSCLES OF THE RICE WATER WEEVIL LISSOHOPTROPUS ORYZOPHILUS, KUSCHEL: THEIR COMPARISON AND DESCRIPTION

Beth Hazelip, Dept. of Entomology, University of Arkansas at Fayetteville, Fayetteville, Ark. 72701

The median dorsal longitudinal and dorso-ventral muscles of the rice water weevil, (Lissorohtropus oryzophilus, Kuschel) undergo degeneration in rice fields, and regeneration occurs after diapause development but before spring emergence. Muscles were found to be in three general states—well-developed, developing, and histolyzing. Developing median dorsal longitudinal and dorso-ventral muscles were found to comprise 3 significant categories of development, whereas in flooded fields they consisted of 3 significant categories. Sections of median dorsal longitudinal muscles in the developing, well-developed, and histolyzing conditions revealed alterations in size and shape of nuclei and changes in fibrillar structure.

A RADIOIMMUNOASSAY FOR PHOSPHOGLUCOSE ISOMERASE AND ITS INITIAL UTILIZATION IN DETECTING CROSS REACTIVE MATERIAL IN VARIANT FORMS OF PHOSPHOGLUCOSE ISOMERASE

Roy S. Jones, K. Purdy, and Robert W. Gracey, Dept. of Chemistry, Hendrix College, Conway, Ark. 72032, and Dept. of Biochemistry, North Texas State University, Denton, Tex. 76201

A method for isolation, purification, and radiolabeling phosphogluco- cose isomerase (PGI) was devised to develop a quantitative radioimmunoassay for the detection of enzyme irrespective of its catalytic activity. In four genetic variants of PGI, no difference was observed in the molecular specific activity. In another variant (PGI-Denton), a decreased molecular specific activity was observed which may imply that these samples contain cross reactive material which is not catalytically active.

CHARACTERIZATIONS OF CONVEX SETS

Lisa M. Orton, Dept. of Mathematics, Hendrix College, Conway, Ark. 72032
A subset $C$ of a metric space $X$ has the unique nearest-point property if for every $x \in X$ there exists a unique $c \in C$ nearest to $x$. T. S. Motzkin (1935) has shown that a nonempty class $C \subseteq X$ is closed and convex if, and only if, $C$ satisfies the unique nearest-point property. Theorem 1. If $C$ is a nonempty, closed, and convex subset of a complete inner product space $X$, then $C$ satisfies the unique nearest-point property. Suppose $C$ is a nonempty set of a complete inner product space $X$ such that $C$ has the unique nearest-point property. Theorem 2. $C$ is closed. Define $d(x) = \inf \{d(x,c) : c \in C\}$ and define $f(x) = c$ such that $d(x)$ is the unique nearest-point in $C$ to $x$. The following characterizations will be shown. Theorem 3. $C$ is convex if, and only if, $d(x)$ is a convex function.

**EXPERIMENTAL PROCEDURE FOR THE DETERMINATION OF TRACE-LEVEL URANIUM IN ROCK AND LIQUID SAMPLES USING ARGON PLASMA SPECTROSCOPY.**

Richard A. Roberts and Joe R. Trim, Dept. of Chemistry, Hendrix College, Conway, Ark. 72032, and General Analytical Laboratory, Fundamental Research Branch, Division of Chemical Development, National Fertilizer Development Center, Tennessee Valley Authority, Muscle Shoals, Ala. 35660.

A sample preparation and analysis procedure was developed for the determination of trace-level uranium in solid and liquid samples utilizing an argon plasma spectrometer. Previous procedures using colorimetric methods and atomic absorption had been judged unsatisfactory due to a lack of sensitivity and reproducibility. A sample dissolution procedure, extraction process, optimum concentration range, and matrix effects were studied. The procedure developed proved both accurate and precise down to the 5 parts per million range.

**ULTRASTRUCTURAL OBSERVATIONS OF CERTAIN TOPOGRAPHICAL FEATURE OF LARVAE AND PUPAE OF THE YELLOW JACKET WASP, Vespula squamosa.**

Richard Roller and William R. Bowen, Dept. of Biology, University of Arkansas at Little Rock, Little Rock, Ark. 72204

Living larvae and pupae were removed from the cells of a subterranean nest of the Common Yellow Jacket Wasp, *Vespula squamosa*. Sufficient numbers were present to allow the identification of several stages in the development of the adult from the pupa and the larva. These specimens were subsequently fixed in Bouin’s, dehydrated, critical point dried, coated with gold-palladium and observed with a scanning electron microscope. An initial survey indicated the more interesting features in the development of this wasp at the ultrastructural level included the cuticle, the mandible, and the appendages.

**ULTRASTRUCTURAL OBSERVATIONS OF A FLORIDEAN RED ALGA.**

Rosemary Rossell and William R. Bowen, Dept. of Biology, University of Arkansas at Little Rock, Little Rock, Ark. 72204

Aquarium plants (real and artificial) obtained from a pet shop in Arkansas were found to have epiphytic growths of an as yet unidentified floridean red alga. These growths consisted of tufts of bluish-green filaments. Specimens were fixed in glutaraldehyde/osmium tetroxide, dehydrated embedded, and thin-sectioned for observation with transmission electron microscopy. Ultrastructural observations on the floridean pit, the chloroplast, the pyrenoid, and other features of this alga will be reported.

**COMPUTER APPLICATIONS IN POPULATION GENETICS.**

Cassandra Scribshire, Dept. of Mathematics, Hendrix College, Conway, Ark. 72032.

The author explores the programmability of techniques for finding the number of generations required for a population to change from one frequency of a gene to its equilibrium frequency or some other frequency when taking into consideration such factors as mutation, selection, migration, and inbreeding.

**ULTRASTRUCTURAL OBSERVATIONS ON THE PRESENCE OF A FIBER-LIKE INCLUSION IN CERTAIN LEAF CELLS OF THE TRIFOLIATE ORANGE, PONCIRUS TRIFOLIATA.**

Betty Stallings and William R. Bowen, Dept. of Biology, University of Arkansas at Little Rock, Little Rock, Ark. 72204

An interesting cellular inclusion, consisting of a cluster of radiating fiber-like structures, was discovered in certain leaf cells of the trifoliate orange, *Poncirus trifoliata*. The leaves were taken from plants that were undergoing greening after an initial fungal-induced albinoism. These inclusions were found to appear first in the nucleus and later in the cytoplasm, including plastids and other organelles. They were never found to occur in the nucleolus, vacuoles, and the cell wall. Their presence in a differentiating xylem element was associated with the presence of a tertiary "wall thickening" in this type of cell. The exact nature of these inclusions has not yet been ascertained. Efforts at elucidating the nature of these inclusions through variations in fixation and staining will be described.

**THE KERNEL OF THE LAPLACE TRANSFORM.**

David Sutherland, Dept. of Mathematics, Hendrix College, Conway, Ark. 72032

The kernel of the Laplace transform, $\mathcal{L}\{f(t)\} = \int_0^\infty e^{-st}f(t)dt$. It is shown that the kernel can be exhibited as the kernel of the morphism $\mathcal{L}^{-1}$ between two multiplicative semigroups, one of which is a semigroup of continuous functions defined on $[0, \infty)$ with the operation being pointwise multiplication and the other is a semigroup of equivalence relations of continuous functions defined on $[0, \infty)$ with the operation being convolution. Intermediate results include the uniqueness of the inverse Laplace for continuous functions on $[0, \infty)$ and demonstration of the Dirac-delta function as the identity for convolution.

**UNIFORM LIMITS OF STEP FUNCTIONS.**

Agnes L. Tullo, Dept. of Mathematics, Hendrix College, Conway, Ark. 72032

Take $C$ to be the class of all uniform limits of sequences of step functions on $[a, b]$. Studies show that $C$ is a proper subclass of all Riemann integrable functions on the same interval. More significantly, we find that $C$ is precisely the completion of $\mathcal{T}$ where $\mathcal{T}$ is the vector space of all piecewise continuous functions on $[a, b]$ with the supremum norm defined on it.

**HIGHER ORDER SYMMETRIC DERIVATIVES.**

Gene Weber, Dept. of Mathematics, Hendrix College, Conway, Ark. 72032

Define the first symmetric derivative of $f$ at $x$ by $f'(x) = \lim_{h \to 0} \frac{f(x+h) - f(x-h)}{2h}$. The author will compare the symmetric derivative with the usual derivative. Then a representation of higher order symmetric derivatives will be given. Theorems concerning the symmetric derivative analogous to those proved in calculus for the ordinary derivative will be considered.
EXCERPTS OF
Governor Bill Clinton's Address
to
The Arkansas Academy of Science

Editor's Note: Governor Clinton graciously accepted the Academy's invitation to speak at the Banquet this year. A portion of the Governor's speech, which has special meaning to each of us in the scientific community, follows.

They (the legislature) ... along with me, dealt with a number of issues which were fundamentally scientific in nature and, because of those issues and the judgments I had to make, ... I would like to talk with you in a general way ... about the complex and important relationship between the sciences and politics.

I signed a bill this year to regulate strip mining in Arkansas more comprehensively, a bill to regulate the installation of hazardous landfills or landfills to accommodate hazardous chemicals, a bill to regulate the extraction from the ground of brine, a bill which had strong pharmacological overtones dealing with the question of to what extent optometrists could apply prescription drugs in screening and evaluation of patients, and many other bills of various scientific natures. Throughout, ... laymen, including the governor, ... had to make ... decisions about how this society would conduct its business in very uncertain, complicated and, on occasion, profoundly dangerous areas.

I suppose almost everyone who has had any sort of an education in these matters has discarded in his, or her, own mind the notion that the scientific method in any given area can produce an opinion which is TRUE, or that there is a completely objective and obvious answer to all these dilemmas. I can see that, and I don't think that is the problem. Although there is still ... (a) lot of blind faith that people in general, and politicians in particular, accord to scientific judgments which are made for them by experts who they happen to rely on. Whether it is in the area of nuclear energy or the production of hazardous chemicals ... we, more or less, ... understand that we don't expect you to be the next thing to God as scientists ... . On the other hand, we don't want to go off the deep end as many people have, I think, and just decide that you can get any kind of scientific advice you want, as long as you've got the money to pay for it.

There is a crying need in government, particularly in the environmental and energy areas, for an incredible amount of scientific knowledge that can, at least, be placed at the disposal of those who have the public interest, in a larger sense, at heart, but who have no way, on their own, not only of getting the information, but of understanding it if they had it, unless it is explained to them; and then, who need some advice, but who must maintain the final decision-making authority.

What we need, I think, is public officials who are more secure in their decision-making process; that also have much more access to scientific information than we've had in the past. Now we've got a project going in Arkansas that will provide more scientific and technological information to the governor's office and another one which will provide much more information to the legislative branch ... . I think there is a growing awareness on the part of people in politics that we need to know more, that we need to have more information. I think there is a growing healthy skepticism about information which is provided to us from others (non-scientists).

And I am here tonight to tell you that, as politicians go, I've had the benefit of a fairly good education and I've tried to use it to develop my mind as well as I could, and I've tried to use it to maintain a fair degree of humility, in an intellectual sense, about all the things that I do not know. And I am telling you that we need a lot of knowledge and a lot of perspective that we don't have. We need also to know that there are people involved in the sciences who are interested in the public interest, in the larger sense, and who are interested not only in telling us about the systems and the imperatives that dominate our lives now in the context of this nuclear crisis or that hazardous materials crisis, but who also really believe that the major function of science in all-areas is discovery, still. And that we have to free ourselves of some of the systems, imperatives, and ideas that we are living under, if we are going to solve the problems that we have before us.

And so, I would say to all of you, wherever you are from, and whatever you are doing, I would take it as an act of citizenship and as a personal favor if, through this organization, through your departments and the various universities or on a personal basis, if you were willing in the context of a particular crisis or problem, or on a general basis, to give me the benefit of your ideas, your opinions, your knowledge, and your explanations. I would be ... grateful to have it because we are going into a time when people like me who haven't been trained in the areas that you have been trained in are going to have to make decisions that affect the rest of this country and the rest of the people in this state in areas that only you have been trained in. I suppose the first step is to know what we don't know, so I come here pleading ignorance and asking for help. But also asking, even though we recognize that there is no absolute truth, that science still be deployed primarily in the public interest in the larger sense, without regard to the short term profit or advancement of a few.
Maturation and Fecundity of Redear Sunfish

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ABSTRACT

Based on gonosomal indices and ovum diameter frequency distributions, the redbear sunfish spawns from May through July. Fast growing 2-year-old (above 150 mm) and older fish attain sexual maturity. Mature ovum diameter ranged from 0.80 to 1.30 mm. Fecundity-total length, total weight, and age relationships were: \( \ln F = 5.95 + 0.01967L - 0.83 \). The monthly gonosomal values were low from August through October, gradually increasing to a peak in late May, denoting full maturation (Fig. 1). The indices decreased during June and July. During May-July, Crystal Lake water temperature ranged from 19 to 25°C with 19-21°C in mid May when gonosomal indices were highest. In Alabama (Swingle, 1949), Illinois (Lopinot, 1961) and Michigan (Huston, 1966) waters, the temperatures at redbear spawning were 24, 20-21, and 21°C, respectively. These temperatures correlated with the Crystal Lake temperatures during the spawning period.

One-year-old females showed no increase in the gonosomal indices during the summer; however, the maximum value occurred in October. Since no larval fish were either observed or collected during October, it is reasonable to assume that the gonadal development of this age group was not related to spawning at this time of the year. Omlandt (1974) reported similar observations with largemouth bass from Lake Fort Smith, Arkansas.

Of only 25 percent of 2-year-old females were mature. The immature fish ranged from 100 to 144 mm, and the mature fish size ranged from 151-213 mm. All 3-year-old and older females were mature, and the smallest mature 3-year-old fish was 166 mm. Attainment of sexual maturity in redbear may be a function of length rather than of age (Wilbur, 1969). Dineen (1968) reported that in South Florida redbear spawned initially at eight months and at a length of 138 mm. According to Gerking (1951) the mature 2-year-old redbear in Lake Gominy, Indiana averaged 138 mm. Due to these correlations of length with sexual maturity, we concluded that in Crystal Lake, fast growing 2-year-old (>150 mm) and older fish attain sexual maturity.

Ova development and spawning periodicity

Ovum diameter studies are useful in assessing spawning time and frequency of spawning (Clark, 1934; Prabh, 1956). Comparison of ovum diameter distributions between the anterior, middle and posterior sections within the ovaries of three 3-year-old (184, 187, and 203 mm) redbear by the Kolomogorov-Smironov test (Sokal and Rohlf, 1969) indicated random distribution of ova. Therefore ovum diameter measurements and counts were made from a cross section from the midregion of one of the ovaries.

Ovum diameter frequency distributions (Clark, 1934) for mature redbear of ages two through six showed similar annual patterns. Therefore, 3- and 5-year-old fish were selected to present the monthly progression of ovum frequency distributions (Fig. 2). From September through February the ova were less than 0.30 mm in diameter and were platelet in form with transparent cytoplasm. Ova matured from March to May.

A spawn occurs in late May as evidenced by the lack of ova in the last mode (0.95-1.30 mm). By the middle of June the ova size increased, and the ova (0.85-1.25 mm) were extruded by the end of June. The July ovaries are the last evidence of spawning for the season, and the residual ova in the August ovaries indicate that the ova above 0.60 mm were extruded during spawning activities. Appearance and disappearance of the ova in the last mode from May through July indicate multiple spawning by the redbear sunfish during the spawning season (May-July). The maximum gonosomal index in
May (Fig. 1) coincided with the presence of the full complement of maturing to mature ova (0.60-1.30 mm) in the ovaries. The gradual decrease of the indices for June and July is due to spawning of the ova as they attain larger size.

Based on the ovum diameter distributions, the redear exhibit multiple spawning. In Florida spawning may start in late February and continue until October (Clugston, 1966). Redear sunfish in Alabama spawn in spring and again in the fall, but sparingly in summer (Swingle, 1949; Swingle and Smith, 1950). In Tennessee (Schoffman, 1939) and Illinois (Lopinot, 1961) the redear spawn from May to September and during May-June, respectively.

Fecundity

Since the ova of the size range 0.60-1.30 mm were extruded during the spawning season, fecundity was estimated as the total number of ova (> 0.60 mm) present in both the ovaries prior to spawning. The 15 fish collected in May were used in fecundity estimates as these fish contained the full complement of the mature ova.

The total length, weight, and age of redear were exponentially related to the fecundity estimates. The fecundity - total length relationship (Fig. 3) was \( \ln F = 5.95242 + 0.01967L \) with the correlation coefficient and standard error of estimate of 0.95 and 0.18775, respectively.

The fecundity - total weight relationship (Fig. 4) was \( \ln F = 8.80328 + 0.00594W \) with 0.96 and 0.16272 as correlation coefficient and standard error of estimate.

Of the 15 redear used in this study, there was one fish each in age groups II, and VI, two in age group V, and the remainder were 3-year-olds. The fecundity-age relationship (Fig. 5) was expressed as \( \ln F = 8.19332 + 0.50231A \). The correlation coefficient and the standard error of estimate were 0.91 and 0.25239, respectively.

Wilbur (1969) gave fecundity data for the Florida redear, but he gave standard length measurements. These lengths were converted to total lengths using the total length - standard length relationship for bluegill (Carlander, 1977). The total length - fecundity relationship was calculated as \( \ln F = 8.01624 + 0.00773L \). Covariance analysis showed significant difference between the Crystal Lake redear and Florida redear (\( F_{2.24}=55.73 \)). For a given size range of 200 - 260 mm, that were common in our and Wilbur's collections, the Crystal Lake redear sunfish were more fecund than the Florida fish. Redear of 230 and 260 mm in total length from Crystal Lake produce 35,500 and 64,000 mature ova compared to 17,900 and 22,600 ova by the Florida redear.
Figure 1. Length-fecundity relationship of the Crystal Lake redear sunfish.

Figure 2. Monthly frequency distributions of ova diameter measurements of three and five year old redear sunfish.

Figure 3. Length-fecundity relationship of the Crystal Lake redear sunfish.
**LITERATURE CITED**


Hematology as Related to Diving Characteristics of Elaphe obsoleta, Nerodia erythrogaster, Nerodia fasciata and Nerodia rhombifera

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ABSTRACT

The diving capabilities of Nerodia erythrogaster flavigaster and Nerodia fasciata confluens were investigated and the results were compared with similar studies on Nerodia rhombifera rhombifera and Elaphe obsoleta obsoleta (Baeyens et al., 1978). In addition, morphological and hematological parameters contributing to underwater survival were examined.

The duration of underwater survival for N. erythrogaster and N. fasciata was approximately one hour with no difference between the species. The lung volumes of the two species were also similar but were significantly less than lung volumes reported for E. obsoleta. There were no significant differences in hemoglobin concentration, red blood cell count or hematocrit between N. rhombifera, N. erythrogaster, N. fasciata, and E. obsoleta. Based on similarities in underwater tolerance, lung morphology and hematology, Nerodia more closely resembles the terrestrial E. obsoleta than those reptiles specifically adapted to an underwater existence.

INTRODUCTION

Certain representatives from all the vertebrate classes display pronounced respiratory and cardiovascular changes in response to submergence. These animals, collectively referred to as the diving animals, are physiologically and morphologically suited for underwater survival. Most of the experimentation to date has focused on the diving mammals and birds, and relatively little is known of the physiology of diving reptiles.

This study represents a continuation of work reported earlier (Baeyens et al., 1978) and has two specific purposes. First, to compare the diving abilities of two species of water snakes (Nerodia erythrogaster flavigaster, and Nerodia fasciata confluens) with the diving ability of the terrestrial black rat snake. Second, to explore some of the hematological and morphological attributes which might contribute to underwater survival in N. erythrogaster, N. fasciata, N. rhombifera and E. obsoleta.

MATERIALS AND METHODS

Specimens of N. erythrogaster, N. fasciata and N. rhombifera were collected at night from various minnow farms in Lonoke County, Arkansas. E. obsoleta were collected during the day from wooded areas in Pulaski County, Arkansas. Weights of all the experimental animals ranged between 450 and 800 g. Most snakes were utilized within one week of capture. Snakes kept in captivity over two weeks were fed leopard frogs and minnows (Nerodia) or small mice (Elaphe). Most experiments were carried out between March and September, a period during which snakes are most active in Arkansas. For statistical analysis a Student-Newman-Keuls test was used to make multiple comparisons among means, and values considered significantly different have a p value of 0.05 or less (Sokal and Rohlf, 1969).

The duration of underwater survival for N. erythrogaster and N. fasciata was determined by subjecting the snakes to involuntary dives as previously described (Baeyens et al., 1978). The dive began the instant the animal voluntarily submerged its external nares at which time the cage containing the animal was totally submerged. The snakes were kept under close observation throughout the dive. Termination of the dive occurred at the first sign of stress. The outward indications of stress varied from snake to snake but were usually associated with a release of air from the lung and a sudden increase in activity in an attempt to reach the surface. Snakes remained under close observation after surfacing to insure that they were not seriously impaired as a result of the dive.

Lung volumes were determined for N. erythrogaster and N. fasciata by injecting air into the lung until the point of maximal lung expansion was reached (Baeyens et al., 1978). The lung capacities are expressed in terms of ml per kg body weight.

In all four species blood samples were collected from the hepatic portal vein with a 23 gauge needle fitted to a 5 cc syringe containing EDTA as an anticoagulant. Approximately 4 ml of blood were drawn from each animal. Hemoglobin concentration was measured as cyanmethemoglobin using Drabkin's diluent (Davidsohn and Wells, 1963). For hematocrit determinations, nonheparinized capillary tubes were filled with blood and one end was sealed with clay. The tubes were immediately centrifuged at approximately 10,000 RPM for ten minutes. Red blood cells were counted with a standard Neubauer counting chamber with Hayem's solution as the diluent (Davidsohn and Wells, 1963). Five red blood cell counts were made for each snake and the average was recorded.

RESULTS

Dive Times - Snakes were closely watched throughout the dive and at the first sign of stress the dive was terminated. When a snake was severely stressed as a result of a dive, it would be comatose and would take several hours to recover. Dive times were recorded only for those snakes which showed no signs of hypoxic stress upon surfacing.

Members of each species tolerated dive periods exceeding one hour (Table 1). There were no significant differences in the submergence times of the two species.

Lung Morphology - In both N. erythrogaster and N. fasciata the left lung has been lost, and the right lung is a simple tubular-shaped structure. The general lung structure of both species was similar to that described for N. rhombifera and E. obsoleta (Baeyens et al., 1978). The vascular portion of the lung comprised 24% of the total lung length in N. erythrogaster and N. fasciata, and there were no significant differences in total lung volume between the species. The lung volumes of N. erythrogaster and N. fasciata were similar to values reported for N. rhombifera but were significantly less than values reported for E. obsoleta (Table 1).

Hematology - The results of the hematological studies are given in Table 2. Statistical analysis revealed no significant differences within or between species in any of the hematological values measured.
Hematology as Related to Diving Characteristics

Table 1. Dive times and lung volumes for Nerodia and Elaphe.

<table>
<thead>
<tr>
<th>Species</th>
<th>Dive Time (min)</th>
<th>Lung Volume (ml/kg body wt)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean ± S.E (N)</td>
<td>Mean ± S.E (N)</td>
</tr>
<tr>
<td>N. erythrosigna</td>
<td>28.4 ± 12.6 (10)</td>
<td>64.0 ± 12.2 (10)</td>
</tr>
<tr>
<td>N. fasciata</td>
<td>93.3 ± 20.2 (5)</td>
<td>61.4 ± 9.2 (5)</td>
</tr>
<tr>
<td>N. rhomiferi</td>
<td>67.3 ± 10.2 (10)</td>
<td>31.7 ± 11.1 (12)</td>
</tr>
<tr>
<td>E. obsoleta</td>
<td>20.5 ± 8.3 (9)</td>
<td>30.2 ± 12.7 (6)</td>
</tr>
</tbody>
</table>

*Significant difference from Nerodia at the 5% level.

1From Baeyens et al. 1978.

Table 2. Hematocrits (PCV), hemoglobin concentrations (Hb) and red blood cell counts (RBC) for Nerodia and Elaphe.

<table>
<thead>
<tr>
<th>Species</th>
<th>Number of Snakes</th>
<th>Hb g%</th>
<th>RBC/mm³</th>
</tr>
</thead>
<tbody>
<tr>
<td>N. erythrosigna</td>
<td>10</td>
<td>10.7 ± 1.2</td>
<td>0.71 ± 0.07</td>
</tr>
<tr>
<td>N. fasciata</td>
<td>5</td>
<td>9.7 ± 1.5</td>
<td>0.57 ± 0.03</td>
</tr>
<tr>
<td>N. rhomiferi</td>
<td>10</td>
<td>10.9 ± 2.1</td>
<td>0.75 ± 0.09</td>
</tr>
<tr>
<td>E. obsoleta</td>
<td>7</td>
<td>11.5 ± 2.2</td>
<td>0.65 ± 0.04</td>
</tr>
</tbody>
</table>

ACKNOWLEDGEMENTS

We wish to thank Dr. Thomas Lynch and Dr. Phyllis Garnett for critically reviewing the manuscript and offering helpful suggestions during its preparation. We are also indebted to Charles Calhoun and Joe Bailey for their help in collecting the animals used in this study.

LITERATURE CITED


Age and Huddling as Determinants of Metabolic Rate In Grasshopper Mouse (Onychomys leucogaster)

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ABSTRACT

The metabolic rates of grasshopper mice (Onychomys leucogaster) were determined every third day from birth to adulthood. Metabolic rates were quantitated by measuring oxygen consumption in an open circuit system. There was a rapid fall in oxygen consumption from the third day after birth until the ninth day. Mice which were housed separately assumed a constant metabolic rate at an earlier age than mice which were kept with litter-mates. The greatest increases in metabolism occurred when immature mice were separated from litter-mates for oxygen consumption determinations. It is concluded that huddling plays an important role in reducing the metabolic rate of young grasshopper mice.

INTRODUCTION

It is well known that metabolism varies inversely with the size of a homeothermic animal. This is particularly evident when comparing the young and adult animals of a single species; for example, studies involving rats (Benedict and MacLeod, 1929) have demonstrated that oxygen consumption is greater at two months of age than at four months. Likewise, Davis and Hastings (1934), working with rats, observed a 34% decrease in oxygen consumption from the second to the fourth month of age. In a related study McCashland (1951) found a 57% decrease in the oxygen consumption of rats from the thirteenth to the twenty-ninth day of age. These reports suggest great metabolic changes during the period of rapid growth in rats.

There is some controversy in the literature concerning the effect of huddling on the oxygen consumption of young mammals. Hill and Hill (1913) showed that, when two-month old rats were placed together in a calorimeter, their heat production dropped below that of rats studied singly. Taylor (1960) found only slight decreases in oxygen consumption as a result of huddling in 48 hr old mice. Finally, Fitzgerald (1953) measured a decrease in the oxygen consumption of young mice as the ambient temperature was lowered. From this observation he predicted that huddling would tend to increase the ambient temperature and, thus, the oxygen consumption of young mice.

The objectives of our study were twofold. First, to follow the changes in oxygen consumption and general metabolic pattern of the grasshopper mouse (Onychomys leucogaster) from three days of age to the adult. Second, to observe the effects of huddling on the oxygen consumption of young grasshopper mice.

MATERIALS AND METHODS

The Northern grasshopper mouse (Onychomys leucogaster) used in this study were first generation offspring of adults captured in June 1976 in Quay County, New Mexico. The mice were housed in polypropylene cages and were provided with Aspen bedding. Food (Purina Labello 5008) and water were provided ad libitum.

Experimental animals were arranged in two groups. Group 1 consisted of two female litter-mates which were weaned before metabolic determinations were started on the eighteenth day after birth. Metabolic determinations were performed every third day until the animals were 102 days old. The animals were housed for the first two determinations only, thereafter they were housed separately, and all subsequent determinations were performed on individual animals.

Group 2 consisted of five litter-mates (four female, one male). Metabolic determinations for Group 2 started on the third day after birth and continued every third day for 97 days. The first seven determinations were performed on the five mice grouped together, and subsequent measurements were done on individual mice. The litter-mates in Group 2 were housed as a group and were kept with their mothers throughout the experimental period.

Metabolic determinations were performed by measuring oxygen consumption in an open circuit system. During the measurements the mice were confined in a cylindrical Plexiglas chamber (22.9 cm long, 8.9 cm diameter). In order to minimize the possibility of disturbing the mice during a measurement, the chamber was covered with a sheet of black plastic, and cotton was provided for nesting material.

A low-pressure pump was used to push air through a tube containing water absorbent (Drierite) and into one end of the chamber. The air passed through the chamber, exiting at the opposite end, and flowed through a rotometer for measuring and adjusting flow rate. Flowing at 100 ml/min, the air was passed through a second tube of Drierite and entered a Beckman Model E2 oxygen analyzer.

Mice were placed in the chamber and allowed to acclimate for a 15 min period before measurements were taken. Oxygen uptake was measured for 5 min periods, and five consecutive measurements were made on each mouse or group and the results averaged. After the measurements, the mice were weighed to the nearest 0.5 g.

Recording started when the rate of oxygen uptake reached its lowest steady level. Occasionally a mouse would become active during a metabolic determination, and its oxygen uptake would be elevated and erratic. In such cases recording was delayed until the oxygen uptake stabilized or near a resting level. From the resting oxygen uptake and the rate of air flow, the oxygen consumption was calculated in terms of ml of oxygen consumed/hr/g with all values being corrected to S.T.P.

RESULTS AND DISCUSSION

Figures 1 and 2 show the metabolic pattern of the two groups of grasshopper mice from early life to the adult. There was not a detectable difference between the oxygen consumption of the female mice and the single male in Group 2, which is in agreement with the results of Kieller and Brody (1942) in young rats.

From day three to approximately day 70, the oxygen consumption of the grasshopper mice remained essentially constant throughout both day and night. This is probably due to the fact that the young mice had not yet developed nocturnal activity patterns characteristic of the adults. After day 70 the oxygen consumption was considerably elevated during nighttime hours, thus it was necessary to confine metabolic determinations to the late morning and early afternoon hours (times when grasshopper mice are normally in a quiescent state).

An increase in oxygen consumption shortly after birth has been demonstrated in a variety of mammals. This increase has been shown to be two-to-threefold in lambs (Dawes and Mott, 1959), monkeys (Dawes et al., 1960), dogs (Gelineo, 1957) and mice (Fitzgerald, 1953). Similarly, in our study, the oxygen consumption of the grasshopper mice in Group 2 fell from a value of 2.51 ml/hr/g on day 3 to 1.26 ml/hr/g on day 9 (Figure 2). This decrease in metabolism coincided with the first appearance of a slight covering of fur on day six. By day eight the dorsal fur was velvety and dark, and white fur
covered the ventor. The fur provided an insulatory effect by maintaining an unstirred layer of air next to the skin, thus aiding the 9-day old mice in coping with the lower temperatures of the metabolic chamber without increasing their metabolism.

The metabolic rates of the animals in Group 1 reached an adult level at an earlier date than did those of Group 2 (Figures 1 and 2). This is explained by the fact that the animals in Group 1 attained their maximum adult weights by day 66 while the animals in Group 2 were not fully grown until day 80. These unequal growth rates are a reflection of dietary differences between the two groups. The mice in Group 1 were weaned early (day 18) and, thus, were forced to utilize the exogenous food supply provided them. The mice in Group 2, on the other hand, grew at a slower rate because they relied on the diminishing supply of maternal milk for a greater period of time before turning to the exogenous food supply.

The most pronounced increases in metabolism were evidenced when the mice were separated for the first time on day 24 for the oxygen consumption determinations (Figures 1 and 2). The increased metabolic rates observed after day 24 were most likely a response to a reduction in temperature when moving from the nest to the metabolic chamber. According to observations by Mourek (1959) and Taylor (1960) the average nest temperature for small rodents lies between 30 and 32°C. The mean temperature and standard deviation for the oxygen consumption measurements in our study was 24.8 ± 1.6°C. The increased oxygen consumption in response to lowered ambient temperatures would be necessary to promote additional heat production to maintain a constant deep-body temperature. Thus, grasshopper mice, even at the very early age of 24 days, are quite capable of thermoregulation.

The increased metabolism which we observed in response to lowered temperatures agrees with the results of Lagerspetz (1966) and Stanier (1975) who found that during a fall in ambient temperature from 35 to 30°C, young white mice demonstrated increased motor activity and oxygen consumption. It also agrees with observations by Taylor (1960) who showed that rags, as young as 4 hours, respond to a reduction in ambient temperature by increasing oxygen consumption. Our results are, however, at variance with those of Fitzgerald (1953) who measured a fall in the oxygen consumption of young mice as the ambient temperature was lowered from 35 to 30°C.

Hill (1976) found that young Peromyscus leucopus could maintain normal body temperatures in the nest, but when individuals were removed from the presence of litter-mates their body temperatures declined. In the grouped grasshopper mice of our study the effect of huddling would help to maintain the elevated temperatures characteristic of the nest, which in turn would bring down the oxygen consumption per animal, as compared to that of solitary litter-mates. According to Fitzgerald’s hypothesis the huddling of grouped mice would have had the opposite effect, tending to raise the oxygen consumption.

The effect of huddling to lower metabolism which we observed is of importance for survival in a natural habitat. The huddling of young mice would help maintain an elevated nest temperature even when the mother is away. This would have an important energy conserving effect by reducing the amount of energy spent on heat production to maintain a constant deep-body temperature.

The mice in Group 1 did not demonstrate as pronounced an increase in oxygen consumption as a result of a separation as did those in Group 2. The mice in Group 1 were housed separately beginning on day 24. The mice in Group 2, however, were only separated for the actual oxygen consumption measurements and afterwards were returned to their mother and litter-mates. The greater increase in oxygen consumption witnessed in Group 2 is probably the result of the added trauma induced by removal from the nest for the metabolic determinations.


A Comparison of the Lens Protein Profiles Of Three Species of Ozark Salamanders

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ABSTRACT

The vertebrate lens has a high protein content (35%), 80-90% of which is composed of the soluble, lens-specific structural proteins, the crystallins. The lens protein profiles of urodelean species have been found to be qualitatively distinct. On this basis the lens proteins have been proposed as a measure of true speciation in urodeles.

This paper is the result of our effort to derive a technique for comparison of lens protein profiles on a purely qualitative basis without utilizing the complex methodology employed by previous workers. With this object in mind, the lens protein profiles of *Plethodon glutinosus*, *Ambystoma annulatum*, and *Ambystoma maculatum* were studied to determine the degree of difference actually observable on a purely qualitative basis, and thus the applicability of this technique to urodelean taxonomy. Definite observable differences were found in the lens protein profiles of all species; thus confirming the potential value of this technique to urodelean taxonomy.

The protein content of the vertebrate lens is very high (approx. 35%). The crystallins, soluble lens-specific structural proteins, comprise 80-90% of the total lens protein (Clayton, 1970). Investigations of the lens proteins of the various vertebrate classes have shown extensive differentiation at that level (e.g. Cobb et al., 1968). Brahma and van Dijk (1969) found distinct differences in the lens proteins of five phylogenetically distant species of anurans and urodeles.

McDevitt and Collier (1975), using cellulose acetate electrophoresis, examined the soluble lens proteins of 12 species of North American salamanders; 10 species of which were in the same family, the Plethodontidae. They were able, using qualitative differences in the electrophoretic profiles, to distinguish all of the 12 species, several of which are very closely related phylogenetically. Based on these findings they suggested the use of the lens proteins as a sort of "phylogenetic fingerprint" in distinguishing urodelean species. They further suggest that the lens proteins, recognized to be evolutionarily conservative, could be used as a measure of true speciation in urodeles. The potential of such a procedure in urodelean taxonomy, based as it often is on meristic criteria, is obvious.

This study was undertaken with the object of eliminating much of the complex methodology employed by previous workers so as to provide a simple, systematic, purely qualitative test of speciation in urodeles. Thus no attempt was made to quantify data as regards sample concentration or density of corresponding bands (some reference is made to density differences in certain regions of the total pattern). The lens protein profiles of three species of Ozark salamanders were studied to determine the degree of difference actually observable using such simplified methods.

METHODS

Salamanders were captured in the field during the month of November, 1978. *Ambystoma annulatum* were collected during their annual breeding migration crossing Highway 45 (Washington Co.) at a point approximately ten miles east of the Fayetteville campus of the University of Arkansas. *Ambystoma maculatum* and *Plethodon glutinosus* were collected in the area below the dam at Lake Wedington (Washington Co.), 13 miles west of Fayetteville on Highway 16.

After sacrificing the animals, the eyes were removed with the aid of scalpels and forceps and placed in a petri dish containing cold buffer (Tris HCl .05M pH 7.2). Lenses were then removed by gripping the eyeball in a small hemostat, slipping the wall and forcing the lens out with blunt dissecting needle. The lenses were often extruded free of extraneous ocular material; any remaining extraneous material was removed with watchmaker's forceps and dissecting needles. Due to the small amount of lens material provided by individual salamanders, the material for each species was pooled for use in electrophoresis. The pooled lenses were placed in cold buffer (Tris HCl .05M pH 7.2) and, if not used immediately, were stored at near freezing temperature until use.

Samples of the soluble lens protein for use in electrophoresis were obtained by preparing a homogenate of the lens material using ground glass - ground glass homogenization of the lenses in an amount of the above buffer approximately equal to the volume of lens material. The homogenate was then centrifuged and the supernatant collected. Samples of soluble lens protein thus obtained were refrigerated at 4°C until use in electrophoresis.

Cellulose acetate electrophoresis was chosen as the most suitable method for resolution of the protein samples because of the previously reported anomalous behaviour of the high molecular weight alpha-crystallins when polyacrylamide gel or other such "molecular sieve" methods are used (McDevitt, 1967). Gelman Sepaphore III cellulose polyacrylate strips were pre-soaked for at least five minutes in Tris-Glycine buffer (0.1M pH 8.3). Lens protein samples were applied using a Gelman sample applicator, with the number of sample applications per strip varying from three to five. Electrophoresis was then performed using a Gelman Deluxe electrophoresis chamber and a Gelman power supply at a current of 1.25 to 1.5 m.a. per strip for 40-45 min.

Following electrophoresis, strips were stained in a solution of 0.2% Ponceau S in 3% trichloracetic acid for at least five minutes; then destained in several rinses of 5% acetic acid until no background stain remained. The following results were based on the results of eight electrophoresis trials utilizing lenses from a total of 19 salamanders (eight *P. glutinosus*, seven *A. annulatum* and four *A. maculatum*).

RESULTS

The crystallins have been separated into three heterogeneous groups: alpha, beta and gamma in order of decreasing molecular weight and mobility in an electric field (Clayton, 1970). Using cellulose acetate electrophoresis and companion immunoelectrophoresis of protein fractions obtained by column chromatography of whole lens protein samples, McDevitt and Collier (1975) were able to determine the distribution of alpha, beta, and gamma in the total electrophoretic pattern (Fig. 1). As they themselves emphasized, such a crude separation is useful for discussion purposes only.

Photographs of the patterns produced by electrophoresis of the lens proteins of *P. glutinosus*, *A. annulatum*, and *A. maculatum* are shown in Fig. 2. Schematic representations of the banding patterns.
Figure 1. The distribution of the crystallins in a typical electrophoretic pattern (adapted from McDevitt and Collier, 1975).

Figure 2. The lens protein profiles of three species of salamanders.
(a) Plethodon glutinosus
(b) Ambystoma annulatum
(c) Ambystoma maculatum

drawn to scale, are shown in Fig. 3. Readily observable differences can be seen in all areas of the patterns obtained for all three species.

The pattern for A. annulatum is distinctive in showing poor resolution and low band mobilities, with single alpha, beta and gamma bands. The patterns for P. glutinosus and A. maculatum appear superficially similar although clearest differences exist in all areas of the patterns. In the far cathodal (gamma crystallin) region, resolution was better in the pattern for P. glutinosus, with three apparent bands opposed to two in A. maculatum. The nearest cathodal of the gamma bands of the two species appears to have similar mobilities. In the beta crystallin region, A. maculatum shows a very dense, slightly cathodal band absent in P. glutinosus. (Large amounts of beta crystallin are present in the same area in P. glutinosus, but the protein is diffuse.) Conversely, P. glutinosus shows an area of far anodal beta crystallin lacking in A. maculatum. The alpha bands of the two species appear to have identical mobilities; however, the clear presence of a pre-alpha (high mol. wt. alpha) band in A. maculatum (arrow, Fig. 2) distinguishes the two in this area. Although a pre-alpha band has been reported (McDevitt and Collier, 1975) in P. glutinosus, none could be resolved in these samples.

Resolution is generally best in the far cathodal (gamma crystallin) region of the total lens protein profile. The lack of resolution in the alpha, and to some extent in the beta, regions of the pattern reported by Brahma and van Djoorenmaalen (1969) is apparent in these samples. These resolution differences stem from the nature of the proteins themselves; gamma crystallins being single chain polypeptides with rather definite size, charge and mobility, and alpha and beta crystallins being aggregate proteins, with size, charge and mobility dependent upon a variable complement of subunits.

DISCUSSION

The potential value of a reliable test of speciation, especially in urodelans where meristic criteria are relied on heavily, is unquestionable. The lens proteins, which are direct gene products and therefore less susceptible to environmental modification than morphology, would be suitable for use in such a test. Their structural and nonenzymatic nature, by restricting observed differences to actual differences in protein structure, thus reflecting the actual gene makeup of the species with respect to lens proteins, also favors their use in such a test.

In reference to the species herein investigated, there is no difficulty distinguishing one from another on the basis of lens protein profiles alone. These results would tend to justify the conclusion of McDevitt and Collier (1975) that the lens proteins are potentially valuable in determining true speciation in urodelans. The apparent failure of this procedure to distinguish subspecies/intergrades and phases, as well as individual differences, as reported by McDevitt and Collier (1975) would be a further point in favor of the application of this procedure to taxonomic problems where the validity of a species is in doubt.
A Comparison of the Lens Protein Profiles of Three Species of Ozark Salamanders

It is of interest here to note that study of the lens proteins could possibly indicate evolutionary trends in certain urodelans, the observed lack of banding and low mobility of *A. annulatum* being a case in point. During dissection, trends in morphology were noted in this species similar to trends noted by previous workers (e.g., Besharse and Brandon, 1974) in troglobitic and highly fossorial species. The possibility that the unusual pattern observed in *A. annulatum* is indicative of degenerative evolution of the eyeball is certainly worth further investigation.

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LITERATURE CITED


The Fate of Some Common Radionuclides Found in Dardanelle Lake

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ABSTRACT

Four factors influence the concentrations of radionuclides in Dardanelle Lake water: injections due to fallout and discharge from Nuclear I coupled with losses due to decay, to dilution and to sedimentation. It is possible to estimate the first three factors and to measure monthly changes in the concentrations of $^{137}$Cs, $^{137}$Sr, $^{134}$Ce, $^{137}$Ce, $^{144}$Ce, and $^{134}$Ce during periods when the concentrations of these nuclides are abnormally high (after large releases or the Chinese weapons tests) or abnormally low (during reactor refueling).

By measuring the decrease in the concentrations of the affected nuclides immediately following each of these occasions, it was possible to get an estimate of the amount of each radionuclide that was removed by the process of sedimentation.

MATERIALS AND METHODS

The concentrations of $^{137}$Sr, $^{137}$Ce, $^{144}$Ce, $^{137}$Ce, and $^{134}$Ce - $^{144}$Ce were measured monthly from June, 1976 to August, 1977. The results of these measurements can be found in Chittenden (1978), and a summary found in Chittenden and McFadden (1979).

RESULTS

A. $^{137}$Sr and $^{137}$Ce: 10/29/76 - 2/18/77

The concentrations of $^{137}$Sr and $^{137}$Ce from the Chinese nuclear weapons tests, introduced into the water mainly by rainfall, are the simplest to treat. Although these nuclides are not found in reactor effluent, they provide a model to estimate the amount of long lived $^{137}$Sr and $^{137}$Ce that co-precipitate with sediment. Since the introduction of these nuclides into waters occurs over a wide area, we can assume them to be in the same concentration no matter what the source of the water. Thus, Factor (B) in the above equations = 0. The arithmetic becomes quite simple, and only concentrations need be considered. Table I summarizes the remaining factors for samples taken from October 29, 1976, to February 18, 1977.

Table 1. Fate of $^{137}$Sr and $^{137}$Ce Injected by Fallout.

<table>
<thead>
<tr>
<th>Date</th>
<th>$^{137}$Sr</th>
<th>Increase due to injection (D)</th>
<th>Increase due to decay (A)</th>
<th>Decrease due to dilution (B)</th>
<th>Decrease due to sedimentation (C)</th>
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</thead>
<tbody>
<tr>
<td>10/29/76</td>
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</table>

*Errors not specified in this and following tables are estimated to be ±30%.

B. $^{137}$Sr - $^{137}$Y and $^{137}$Ce: 1/23/77 - 3/27/77

A similar trend is exhibited by the $^{137}$Sr - $^{137}$Y and $^{137}$Ce concentrations after the reactor was shut down for refueling on January 27, 1977. For these nuclides, we will assume that Facu-
The Fate of Some Common Radionuclides Found in Dardanelle Lake

The values for \( V_{\text{flow}} \) for the months of July, 1976 to March, 1977 provided by the office of the Corps of Engineers at the hydroelectric power station are presented in Table 2. The volume used to calculate the dilution factor was a weighted average of the two months through which the period between collections ran.

The values for the amount of activity injectate that appear in Table 3 and 4 were derived from data on planned releases supplied by Technical Analysis, Arkansas Power and Light Company. It is assumed that extensive mixing takes place rapidly. It is also assumed, with reasonable justification, that releases of \(^{137}\text{Cs} \) and \(^{60}\text{Co} \) were spread out over the whole month rather than completed in a day or less and that there was minimal variation of radionuclide concentration in the effluent from day to day. Thus the following model can be proposed for the fate of \(^{137}\text{Cs} \), \(^{60}\text{Co} \) and \(^{90}\text{Sr} \) present in Dardanelle Lake.

1) The nuclides released by the Nuclear I facility are quickly mixed with lake water, \( C_v = \text{Injection (Ci)/} \left( \text{V}_{\text{lake}} \right) \) for \(^{137}\text{Cs} \) and \(^{60}\text{Co} \). Fallout contribution of \(^{137}\text{Cs} \) appears to be insignificant compared to injection from Nuclear I.

2) A fraction of the activity present in lake water was adsorbed onto sediment shortly after injection until the concentration reached \( C_s < C_b \). 

\[ C_s = \left( C_0 - C_v \right) \left( V_{\text{lake}} \right) \left[ \exp \left( -V_{\text{flow}} / V_{\text{lake}} \right) - 1 \right] \]

where \( A_s \) is the amount of each nuclide leaving the lake.

\[ A_s = \left( C_0 - C_v \right) V_{\text{lake}} + \text{Injection} - A_1 \]

where \( A_1 \) is the amount of each nuclide leaving the lake.

Table 3 summarizes the factors contributing to the decrease in the concentrations of \(^{90}\text{Sr} \), \(^{90}\text{Y} \) and \(^{137}\text{Cs} \) during the period of refueling.

To estimate the maximum error inherent in these assumptions, \( A_{\text{sed}} \) was calculated assuming all injected activity was released immediately after the initial collection. This extreme value of \( A_{\text{sed}} \) was within 38% of the values of \( A_{\text{sed}} \) that appear in the Tables 1, 3 and 4. In Tables 3 and 4, percent activity removed by sediment

\[ A_{\text{sed}}/(A_1 + A_{\text{sed}}) \text{ if } A_{\text{sed}} > 0 \]

\[ = A_{\text{sed}}/A_1 \text{ if } A_{\text{sed}} < 0. \]

C. \(^{137}\text{Cs} \) and \(^{60}\text{Co} \): 7/23/76-10/29/76

The release of \(^{137}\text{Cs} \) and \(^{60}\text{Co} \) on June 21, 1976, gave rise to abnormally high concentrations of these nuclides for several months after the release. Table 4 summarizes the factors which cause the decrease in the \(^{137}\text{Cs} \) and \(^{60}\text{Co} \) concentrations for the period of high concentrations.

DISCUSSION

For the most part, the process of sedimentation removes only a small fraction of the radionuclides present in the water of Dardanelle Lake. In many cases the value for the activity removed by sedimentation is negative, indicating that activity was de-adsorbed and re-entered solution.
Data supplied by Dr. Dale Swindle of the Arkansas Power and Light Company Technical Analysis Laboratory on the concentrations of $^{137}$Cs and $^{60}$Co in sediment samples collected semiannually, summarized in Figure 1, confirms that there has been no significant accumulation of these nuclides in sediment except for $^{137}$Cs at the mouth of the discharge canal (near the author's Station 1) where its concentration in the effluent water is at its greatest. The process of deposition at this point is probably not sedimentation but rather an exchange of ions between water and sediment.

Concentrations of these nuclides in sediment have generally been on the decline everywhere else during 1977 and 1978. This decline could be due either to a transfer of radionuclides back into the water or to the deposition of sediments with low specific activity.

It is not unreasonable to generalize these conclusions to include the rest of the radionuclides discussed herein. It is, thus, safe to conclude that a great percentage of the radionuclide load injected into Dardanelle Lake as a result of the operation of Arkansas Nuclear I is removed from the lake area in solution or suspension rather than being deposited with sediment.

ACKNOWLEDGEMENTS

Partial financial support for this study was provided by the Office of Water Research and Technology through the Arkansas Water Resources Research Center, project number A-037-ARK.

The author also wishes to thank Mr. Stan Stevens and the Radiochemistry group at the University of Arkansas-Fayetteville for supplying data on the $^{89}$Sr and $^{60}$Co concentrations in rainfall, to Dr. Dale Swindle and Dr. David Smelions of AP&L for data on the concentrations of radionuclides in the sediments of Dardanelle Lake and in released waste water, and to Mr. Jim Woodall of the U. S. Corps of Engineers for data on the volume of water passing through Dardanelle Lake each month of this study.

Special thanks go to Drs. John Rickett and Robert Watson at the University of Arkansas-Little Rock for their invaluable help.

LITERATURE CITED


Self-Perceived Health and Life Outlook Among the Rural Elderly

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Department of Agricultural Economics and Rural Sociology
University of Arkansas, Fayetteville 72701

ABSTRACT

Differences in life outlook and self-perceived health often attributed to age differences among the elderly were found to be more accurately explained by education. The young-old (62-74 years) and the old-old (75 years and older) were compared among 495 elderly in two rural counties in western Arkansas. The old-old were more likely than the young-old to perceive their health as better than that of others their age. But when six variables including age were entered into a predictive model for self-perceived health, differences were explained by education. That is, those with better educations rated their health more positively. There was no difference between the two age groups in sick days, although the old-old reported more days hospitalized and trips to the doctor. However, no predictive model for health status measured was statistically significant. On measures of life satisfaction, the old-old were slightly more pessimistic than the young-old. But the age difference in life outlook was explained by education when the data were controlled for other variables. The customary division of the elderly into young-old and old-old is questioned, and policy implications of the findings are discussed.

INTRODUCTION

The elderly represent a growing proportion of the United States population. In 1975, 15 percent of all persons in the U.S. were 60 years of age or older. This proportion is expected to increase during the remainder of the century. Thus, the status and special problems of the elderly have received increasing attention from researchers and policymakers and have become the target for a number of federally-funded programs such as income maintenance, preventive health care, and nutritional programs.

Some of the changes and problems associated with aging can be viewed as essentially inevitable, especially the gradual deterioration of bodily functioning and health. Others seem to be more closely associated with social, economic and cultural aspects of the aging process. Certainly, the institution of mandatory retirement forces major, and often traumatic, changes in the lifestyles of elderly people, especially among males. The fixed, low incomes of many elderly place them at a severe economic disadvantage, while low educational levels limit alternatives. Increased pessimism is said to develop as older people face many of these and other problems associated with aging.

Long-range planning for the elderly is fairly easy if one is addressing a homogeneous group of people, and if the problems faced by the current group of elderly are inevitable products of aging. However, if as suggested above, the problems are more acute among some segments of the elderly population than among others, or if many of the problems are more dependent on socio-economic status than on the aging process, per se, targeting programs becomes more difficult. Those who are middle-aged today may have different characteristics than those who are older. As today's middle-aged move into old age, programs may have to change to meet their needs. Problems faced by those who live in isolation from their families, those in poor health, those who are economically deprived or ill-educated, may differ from those faced by other segments of the population. If researchers can identify some of the socio-economic variables affecting the aging process and its concomitant problems, planning may be more effective.

In this paper the association of age to socio-economic characteristics, mobility, family dependence, health status, and self-perception is examined among the elderly of western Arkansas. Some of the changes which occur with age are pinpointed. Health and self-perception are examined to determine if characteristics other than age can better explain differences normally attributed to age.

METHODS AND STUDY POPULATION

Data for this paper were taken from one sample in a longitudinal evaluation of a Model Project for Senior Citizens in Franklin and Crawford Counties, located in west central Arkansas. Data were gathered in 1977 by questionnaires administered individually to 495 respondents aged 62 and older residing in two predominantly rural counties. The questionnaire addressed socio-economic conditions, health status, community participation, and life satisfaction among the elderly. Random samples of 100 elderly persons from each county were augmented with data from 295 persons who received examinations at a medical screening mobile unit that was associated with the Model Project. The respondents had a median annual household income of $3,600; they had a median educational level of 8.4 years, and 52 percent were female.

RESULTS

Socio-Economic Well-Being

Comparisons between the young-old and old-old were made on several socio-economic variables using Chi Square and t tests where appropriate. Pearson's correlations between age (expressed in years) and these variables were also computed.

As was expected, older people had significantly lower incomes than younger people. Whereas mean monthly per capita income for the young-old was $223, the old-old averaged only $198; and income was correlated -0.16 with age. Older people were also likely to report significantly fewer savings from their income than younger ones after monthly household expenses were paid, as shown both by the young-old/old-old comparison and by the correlation coefficient. Participation in government programs increases with age, perhaps partially compensating for declining income. However, rates of participation were low among all the elderly respondents, lower than income eligibility requirements would dictate. Increasing age was also associated with lower educational levels; and older people were

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https://scholarworks.uark.edu/jaas/vol33/iss1/1
less likely than the younger to be married, mostly due to a higher proportion who were widowed.

Health Status: Behavioral Indices

Three indicators of health status—number of physician visits, days sick in bed, and days in the hospital—were examined by age, and the results appear in Table 1. Comparisons between the young-old and old-old on the three indicators showed a tendency, although non-significant, for the old-old to report poorer health status. Correlations with years of age showed significant increases in physician visits and hospitalization days with increasing age. Still, these correlations were small, and we question the assumption that among the elderly failing health naturally accompanies the older ages. Physician visits, however, may not be a good proxy for health since they are difficult to interpret. The visits may represent only routine check-ups, or they may be made at the request of a physician in order to treat a diagnosed health problem. Neglected physician visits may cause health problems to accelerate to the point that they require hospitalization, hospital care that might have been unnecessary if a physician arrested a health malady.¹

Table 1

<table>
<thead>
<tr>
<th>Health Status Indicator</th>
<th>Age Category</th>
<th>Correlation with age (years)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Young-old</td>
<td>Old-old</td>
</tr>
<tr>
<td>Number of physician visits, 1977</td>
<td>4.4 (311)</td>
<td>3.9 (181)</td>
</tr>
<tr>
<td>Days in bed sick, 1977</td>
<td>7.6 (316)</td>
<td>11.9 (161)</td>
</tr>
<tr>
<td>Days in hospital, 1977</td>
<td>2.4 (315)</td>
<td>3.3 (164)</td>
</tr>
</tbody>
</table>

** p < .01

Table 2

<table>
<thead>
<tr>
<th>Self-Perceived Health Measure</th>
<th>Age Category</th>
<th>Correlation with age (years)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Young-old</td>
<td>Old-old</td>
</tr>
<tr>
<td>My health is much better than most people's</td>
<td>76 (276)</td>
<td>99 (160)</td>
</tr>
<tr>
<td>It is hard for me to get my regular housework done.</td>
<td>32 (306)</td>
<td>39 (165)</td>
</tr>
<tr>
<td>I have health problems that bother me.</td>
<td>57 (305)</td>
<td>49 (166)</td>
</tr>
</tbody>
</table>

** p < .01

¹Fryar (1977) in a related study of the effects of participating in Senior Citizens' Centers in Arkansas showed that with participation, days of hospitalization decreased and physician visits increased. She suggested that frequent physician visits can to some extent substitute for hospitalization.

Self-Perceived Health

Of three measures of self-perceived health, only one showed a significant association with age (Table 2). Older people were more likely to agree with the statement, "My health is much better than most people's", as shown both by the young-old/old-old comparison and by the correlation.

Social Participation and Mobility

The young-old were compared to the old-old on five different measures of mobility and social participation, and correlations with age were computed. Both analyses showed that the older groups were significantly less likely than the younger to do their own shopping, church and club attendance were not related significantly to age, nor was the tendency to get out of the house nearly every day, or to visit daily.

Dependence on Family

Although aging may bring physical ailments and frailty, older people did not appear to be more or less dependent upon their families than the younger ones. There were no statistically significant differences by age in the percentage of persons who saw their children weekly or more frequently, the percentage of those who felt they could count on family for support, or the percentage who said that they would go to their family if they had to seek a new living arrangement because of failing health.

Life Satisfaction

Five agree-disagree statements were used to assess well-being or life satisfaction. On two of these measures the old-old were significantly less satisfied with their life situation than the young-old (Table 3). Fewer of the old-old reported that they expected interesting things in the future, while more felt that life was getting worse instead of better. The same two items also had significant correlations with age. The pattern for life satisfaction was a consistent one, with older people expressing more pessimism than the younger ones on each measure.

Table 3

<table>
<thead>
<tr>
<th>Life-Satisfaction Measure</th>
<th>Age Category</th>
<th>Correlation with age (years)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Taking all things together, I'm very happy</td>
<td>36 (32)</td>
<td>27 (160)</td>
</tr>
<tr>
<td>The life of the average person is getting worse, not better.</td>
<td>44 (280)</td>
<td>56 (139)</td>
</tr>
<tr>
<td>Most people think I'm more friendly than others my age.</td>
<td>91 (269)</td>
<td>89 (136)</td>
</tr>
<tr>
<td>Most of the things I do are rather dull.</td>
<td>22 (396)</td>
<td>30 (159)</td>
</tr>
<tr>
<td>I expect interesting things to happen to me in the future.</td>
<td>82 (234)</td>
<td>77 (163)</td>
</tr>
</tbody>
</table>

* p < .05

** p < .01
Predictors of Health and Life Satisfaction

Self-Perceived Health

Preliminary examination had shown only a small positive association of self-perceived health to increasing age. The data were examined further to detect whether other socio-economic variables might be more important than age in explaining self-perceived health. Two multiple regression models were developed to predict self-perceived health. Sex, age, marital status, per capita income, years of school, and number of days sick in bed were used as independent variables in both models. One model treated age as a categorical variable (young-old/old-old), while the other treated age as a continuous variable. This process was used to test whether or not the traditional young-old/old-old dichotomy conformed to the social realities of the elderly population under study.

For the purposes of this study, self-perceived health was defined as the additive score of three questions: "Is your health better than others your age?", "Is it hard for you to get your housework done?" and "Do you have health problems that bother you?"

Not surprisingly, the most significant predictor of self-perceived health was the number of days a person was sick in bed during the year (Table 4). However, educational level also emerged as a significant predictor. Thus, even at the same levels of "objective" health, people with more education assessed their health more positively. Age did not show a significant association with self-perceived health in either model.

<table>
<thead>
<tr>
<th>Table 4</th>
<th>Predictors of Self-Perceived Health a/</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Independent Variable</td>
</tr>
<tr>
<td></td>
<td>Model 1 (Age in categories) b/</td>
</tr>
<tr>
<td></td>
<td>Standardized Beta</td>
</tr>
<tr>
<td>Per capita income</td>
<td>0.002</td>
</tr>
<tr>
<td>Years of school</td>
<td>0.25**</td>
</tr>
<tr>
<td>Sex (female)</td>
<td>0.077</td>
</tr>
<tr>
<td>Marital status (married)</td>
<td>-0.014</td>
</tr>
<tr>
<td>Days sick in bed, 1977</td>
<td>-0.231**</td>
</tr>
<tr>
<td>Age</td>
<td>0.023</td>
</tr>
<tr>
<td></td>
<td>Model 2 (Years of age)</td>
</tr>
<tr>
<td></td>
<td>Standardized Beta</td>
</tr>
<tr>
<td>Per capita income</td>
<td>0.05</td>
</tr>
<tr>
<td>Years of school</td>
<td>0.23***</td>
</tr>
<tr>
<td>Sex (female)</td>
<td>-0.10</td>
</tr>
<tr>
<td>Marital status (married)</td>
<td>0.04</td>
</tr>
<tr>
<td>Mobility (get out of house daily)</td>
<td>0.11</td>
</tr>
<tr>
<td>Family contacts (see children weekly)</td>
<td>0.08</td>
</tr>
<tr>
<td>Days sick in bed, 1977</td>
<td>-0.10</td>
</tr>
<tr>
<td>Age</td>
<td>0.00</td>
</tr>
<tr>
<td></td>
<td>Model Statistics</td>
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<td></td>
<td>Model F</td>
</tr>
<tr>
<td></td>
<td>df</td>
</tr>
<tr>
<td></td>
<td>Adjusted Model R²</td>
</tr>
</tbody>
</table>

Self-perceived health is an additive score of answers to the following three questions: Is your health better than others your age? Is your housework hard to do? Do you have bothersome health problems? Responses were: 1 = yes; 0 = no. On the questions followed by an asterisk (*), the answer "yes" indicates a more negative perception of health. These questions were recoded before computing the score, so that a "1" represents a more positive evaluation, while a "0" represents a more negative evaluation of one's health.

Age is expressed in two categories—young-old (62-74 years) and old-old (75 + years). Coefficient in the table is for the old-old.

*p < .05
**p < .001

Behavioral Indices of Health

As previously pointed out, there was only a slight association of age to physician visits, days in bed, or days of hospitalization. Multiple regression models were developed to predict each of the three behavioral health indicators, using sex, education, marital status, per capita income and age as independent variables. Again, age was treated both as a categorical, and as a continuous variable. The results of the regression analyses were nonsignificant. Therefore, health status does not appear to be closely related to socio-economic status, at least among the elderly population considered here. Whereas education did affect the way a person perceived his/her health, it was not associated with behavioral indices of health.

Self-Perceived Well-Being

Responses to five agree-disagree questions were added to develop a scale to measure self-perceived well-being or life satisfaction (Table 3). Multiple regression models used sex, education, per capita income, marital status, mobility, family contacts, age, and number of days sick in bed as independent variables. Age again was treated as both a categorical and a continuous variable. In both models, educational level was the only significant predictor of life satisfaction among the elderly (Table 5). Regardless of their income, age, etc., the more highly educated were more positive about their life.

<table>
<thead>
<tr>
<th>Table 5</th>
<th>Predictors of Well-being/Life Satisfaction a/</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Independent Variable</td>
</tr>
<tr>
<td></td>
<td>Model 1 (Age in categories) b/</td>
</tr>
<tr>
<td></td>
<td>Model 2 (Years of age)</td>
</tr>
<tr>
<td></td>
<td>Standardized Beta</td>
</tr>
<tr>
<td>Per capita income</td>
<td>0.05</td>
</tr>
<tr>
<td>Years of school</td>
<td>0.23***</td>
</tr>
<tr>
<td>Sex (female)</td>
<td>-0.10</td>
</tr>
<tr>
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<td>0.04</td>
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<td>Mobility (get out of house daily)</td>
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<tr>
<td>Family contacts (see children weekly)</td>
<td>0.08</td>
</tr>
<tr>
<td>Days sick in bed, 1977</td>
<td>-0.10</td>
</tr>
<tr>
<td>Age</td>
<td>0.00</td>
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<tr>
<td></td>
<td>Model Statistics</td>
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<td></td>
<td>Model F</td>
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<td></td>
<td>df</td>
</tr>
<tr>
<td></td>
<td>Adjusted Model R²</td>
</tr>
</tbody>
</table>

Well-being is an additive score of answers to the following five questions: Are you very happy? Is life getting worse? Are you friendlier than others? Do you think things are dull? Do you expect interesting things in the future? Responses were: 1 = yes; 0 = no. On the questions followed by an asterisk (*), the answer "yes" indicates a more negative outlook. These questions were recoded before computing the score, so that a "1" represents a more positive outlook, while a "0" represents a more negative evaluation of one's life.

Age is expressed in two categories—young-old (62-74 years) and old-old (75 + years). Coefficient in the table is for the old-old.

***p < .001

CONCLUSIONS

The elders were more likely than their younger counterparts to say they were in better health than others their age. On two other measures of self-perceived health, however, there was no association with age. A multiple regression model using a number of socio-economic and demographic variables showed that education was a better predictor than age for self-perceived health. Disability days, or days sick in bed, was the single best predictor variable in the model, but when persons with similar numbers of disability days were compared, those with more education viewed themselves as healthier. Although aging is generally associated with a gradual deterioration of bodily functioning, age was not associated with significant increases in the use of health practitioners, and hospitals, or with the number of days in bed. Furthermore, differences in education were more important than age in explaining differences in life-satisfaction among the elderly in western Arkansas. Those with higher educations tended to regard themselves as healthier and happier, regardless of their age.

There are a number of relevant policy implications apparent from these results. First, decreases in happiness and self-perceived health are not inevitable results of aging. Although the oldest persons in our sample were not as happy as the younger elders, this appeared to be due largely to educational differences, not to age differences, per se.
Better educated persons viewed their health and life as better than less educated persons, regardless of age, income, social isolation, mobility, marital status, sex, or behavioral health status.

Using age as a categorical variable, as is customary in much of the literature on aging, did not prove useful or illuminating. Indeed, changes which occur among the elderly tend to be gradual and to fit better as a linear function. These results cause us to question the widespread use of the categories of young-old and old-old in analyzing the elderly.

As educational levels improve, or as the better educated middle-aged population joins the ranks of the elderly, perhaps we can expect them to have an improved outlook on life. More than any of the other variables explored, education predicts life satisfaction and self-perceived health. Although a superior education does not guarantee against physical ailments and ill fate, it does appear to cushion their impact.

LITERATURE CITED


Electrophoretic Analysis of Blood Serum Proteins in Three Species of Water Snakes (Genus Nerodia)

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ABSTRACT

Serum from three species of water snakes (Nerodia rhombifer, N. erythrogaster and N. fasciata) from one geographic region was analyzed electrophoretically on cellulose acetate, and anodic mobility and relative concentration of the fractions were determined by a recording densitometer with an automatic integrator. Classification of fractions was based on mobility (Rf values), and for identification purposes, bands were labeled in order of decreasing mobility (albumin and alpha, alpha, alpha, beta, beta, gamma and gamma-globulins). Several fractions were identified in each species with alpha being absent from N. rhombifer and N. erythrogaster, and only one gamma fraction was observed in N. fasciata. In the three species, gamma globulin was the predominant protein (42-46%), and albumin levels were characteristically low; however, a distinct difference was observed in albumin concentration (N. fasciata, 7%; N. rhombifer and N. erythrogaster, 16-18%). The Rf values and relative concentrations of other globulins showed heterogeneity in the three species, with the protein pattern of N. fasciata being distinct from the other two species.

INTRODUCTION

According to present dogma, proteins are the products of gene action; thus, the analyses of proteins from different organisms have provided a means for studying the genetic similarities between various groups. Electrophoretic analysis of blood proteins has been a useful tool for demonstrating the distinctiveness of taxonomic groups of reptiles. The electrophoretic patterns of blood proteins of members of the family Colubridae have been compared by Voris (1967), Dessauer (1975, 1974), Dessauer and Fox (1956, 1958, 1964) and Deutsch and McShan (1949). These studies include generalized descriptions of the electrophoretic patterns of blood proteins for taxonomic comparison most often at the family level. The most inclusive description of species of Nerodia was provided by Dessauer and Fox (1964) with emphasis on the variations of the electrophoretic pattern of transferrins at different taxonomic levels. Senio (1963) and Dessauer and Pough (1975) described the electrophoretic pattern of certain blood proteins in the grass snake (Natrix natrix) and the kingsnake (Lampropeltis getula), respectively.

Taxonomic studies of snakes including species of Nerodia based on electrophoretic analysis of blood proteins have limitations due to variations in number, mobility, and/or concentration of some fractions that have been reported based on geographic separation, seasonal changes, and electrophoretic technique (Senio, 1963; Voris, 1967, Dessauer and Fox, 1956, 1958, 1964). Electrophoretic heterogeneity of some blood proteins (especially transferrins) has been noted in individuals of the same population, and in members of a species from different geographic populations (Dessauer and Fox, 1958, 1964); however, the heterogeneity increased as the geographic range was expanded. Variation in the number, mobility, and quantity of fractions parallels the degree of taxonomic separation of species and, thus, can be used for estimating degrees of divergence in taxonomic categories.

The purpose of the study was to describe and analyze the electrophoretic pattern and relative concentrations of serum proteins in three species of Nerodia, N. erythrogaster flavogaster (9 specimens), N. fasciata confusa (5 specimens) and N. rhombifer rhombifer (15 specimens) from a localized population. Both males and females were included in the study.

MATERIALS AND METHODS

Snakes were captured from minnow ponds near Lonoke, Lonoke County, Arkansas in June and transported to the University of Arkansas at Little Rock where they were maintained on a minimum diet of minnows. Starvation preceded collection of blood samples which was made from July through January. Snakes were anesthetized with chloroform, a ventral incision made to expose the heart and major vessels, and bled with a puncture of the aorta. Blood samples were allowed to clot at room temperature for one hour, then centrifuged, and sera collected. Fresh samples were subjected to electrophoresis immediately; the remaining serum was frozen and later analyzed again by electrophoresis. Seven to nine samples (1.5 µl each) were applied across a wide cellulose acetate strip (78 x 150 mm) and subjected to electrophoresis in a Shandon U77 Apparatus. A barbital buffer (pH 8.6; ionic strength 0.075) was used in the tank. Separation was carried out toward the anode for 1½ hr. at a constant current of 5 ma, and a mean of 150 v. Strips were then fixed in 5% trichloroacetic acid, stained with Amido Black 10B, and washed in a solution of mannitol/acetic acid. After visual analysis, strips were cleared with Sepra Clear (Gelman Company) and analyzed using a Helena recording densitometer with an automatic integrator. The Rf values for each fraction were determined by a ratio of the distance from the origin to the peak of the band and the distance from the origin to the anodic edge of the fastest migrating fraction. Relative concentrations of protein fractions were determined by optical density of each band.

Serum from each individual was subjected to several electrophoretic separations with only the clearest separations being used for comparisons. When several clear separations were available for a given individual, the mean Rf value and relative concentration of each component were recorded.

The different serum fractions were named according to the classification of human fractions applied by Tiselius (1973): albumin, alpha, alpha, alpha, beta, beta, gamma, gamma; globulin in order of decreasing mobility. Investigators using the mobility and names of human fractions as a frame of reference in describing blood proteins in snakes include Dessauer and Fox (1964), Dessauer (1974), and Senio (1963). Writers have used letters (Voris, 1967) or Arabic numerals (Dessauer and Fox, 1958; Deutsch and McShan, 1949) in identifying protein fractions or have in some cases simply identified the fastest migrating fraction as albumin and the slower ones as globulins. Simultaneous separation of human and Nerodia sera indicated that the mobilities of albumin, alpha, beta and gamma fractions of Nerodia are within the same range as equally named human fractions. Thus, this nomenclature is appropriate for serum proteins of Nerodia. Since the classification is based solely on mobility, one cannot assume that the serum fractions of snakes have the same physiological properties of equally named fractions of human serum. However, Baril et al. (1961) identified the fastest migrating fraction of alligator serum as albumin and the major component as alpha globulin based on physiochemical comparison to mammalian sera. In a review of the literature, Dessauer (1974) reported that reptilian immunoglobulins are similar to antibodies of the G and M classes in mammals and that the physiochemical properties of reptilian albumin are similar to human albumin.
RESULTS AND DISCUSSION

The serum proteins of Nerodia separated into eight electrophoretic bands: albumin (A1) and alphas (α1), alphas (α2), alphas (α3), betas (β1, β2), gammas (γ1), gammas (γ2), globulins (Fig. 1). Gamma was absent from N. fasciata, and alpha was absent in N. rhombifera and N. erythrogaster. The Rf values and relative concentration of each fraction in the three species are given in Table 1 and Table 2. No distinct variations were noted among individuals of a species. Hemoglobin, which was present in some samples due to hemolysis, added an additional band which was the slowest in migration. The mobility of isolated fractions of hemoglobin verified that the band nearest the origin was due to hemoglobin contamination. Further study of this protein was not pursued.

Table 1. Relative mobility of serum proteins in three species of Nerodia.

<table>
<thead>
<tr>
<th>Species</th>
<th>Albumin (A1)</th>
<th>Alpha (α1)</th>
<th>Alpha (α2)</th>
<th>Alpha (α3)</th>
<th>Beta (β1)</th>
<th>Beta (β2)</th>
<th>Gamma (γ1)</th>
<th>Gamma (γ2)</th>
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<tbody>
<tr>
<td>N. rhombifera</td>
<td>-</td>
<td>0.82</td>
<td>0.92</td>
<td>0.95</td>
<td>0.77</td>
<td>0.94</td>
<td>0.76</td>
<td>0.85</td>
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<tr>
<td>N. fasciata</td>
<td></td>
<td>0.84</td>
<td>0.92</td>
<td>0.95</td>
<td>0.77</td>
<td>0.94</td>
<td>0.76</td>
<td>0.85</td>
</tr>
<tr>
<td>N. erythrogaster</td>
<td></td>
<td>0.82</td>
<td>0.92</td>
<td>0.95</td>
<td>0.77</td>
<td>0.94</td>
<td>0.76</td>
<td>0.85</td>
</tr>
</tbody>
</table>

1. Number of individuals.
2. Mean Rf value defined as the ratio of the distance from the origin to the fraction peak to the total distance of the run.
3. Mean Standard Deviation.

The fastest migrating fraction, albumin, which is considered to have equal mobility in all three species, migrates slightly faster than human albumin. Seniow (1963) reported that the albumin of Natrix natrix migrated slightly slower than human albumin. The relative concentrations of albumin in N. rhombifera and N. erythrogaster are similar (16-18%), but the albumin concentration in N. fasciata is distinctly lower (7%), representing a minor component.

The concentation and Rf values of alphas and alphas in N. erythrogaster and N. rhombifera are very similar, the notable difference being that alpha and alpha fractions migrate slightly faster in N. rhombifera, thus serving as a distinguishable characteristic. Three alpha subfractions are present in N. fasciata with alpha and alpha having higher Rf values than in the other species; the relative concentration of alpha was also higher. A fraction, named alpha, due to its mobility between alpha and beta, is unique for N. fasciata and serves as a clearly distinguishable trait for this species.

The ranges of Rf values and relative concentration of the beta subfractions overlap between the species and thus are not considered to be distinguishing characteristics.

Gamma globulin clearly separates into two fractions with similar mobilities in N. erythrogaster and N. rhombifera. However, the relative concentration of the two gamma fractions in these two species is approximately inversely proportional. Gamma subtraction (30%) being predominant to gamma (16%) in N. rhombifera, and gamma (30%) being predominant to gamma (13%) in N. erythrogaster. There is no distinct difference in relative concentration of the total gamma fraction between these two species. Only one gamma fraction was observed in N. fasciata even when the time of electrophoretic separation was greatly increased. The mobility is similar to that of gamma, and the relative concentration (43%) of this one gamma fraction is not distinct from the total relative concentration of gamma globulin in the other two species.

The three species resemble each other in that the major component is the slowest fraction, gamma globulin. The ratio of globulin/albumin concentration is approximately 3:1 in N. rhombifera and slightly lower in N. erythrogaster but 6:1 in N. fasciata. A high ratio of globulin to albumin agrees with published reports for other species of snakes (Deutsch and MeShan, 1949; Seniow, 1963). Kahl (1963) compared the concentration of albumin in several species of snakes and found that the blood of aquatic snakes had a lower albumin concentration than that found in semidesert or desert species. Dessauer (1974) reported that albumin averaged 32% of the total blood protein in terrestrial snakes and only 11% in water snakes.

The number of electrophoretic studies of serum proteins in snakes is limited, and most reports are of a survey nature comparing higher taxonomic groups or geographic variations. Some studies include species of water snakes but only within collective groups. Furthermore, it is difficult to compare the electrophoretic mobility and concentration of serum proteins of Nerodia described in this study to other reports of snakes due to differences in buffers and supporting fluids.
Electrophoretic Analysis of Blood Serum Proteins in Three Species of Water Snakes (Genus Nerodia)


LITERATURE CITED


Mollusca of the Illinois River, Arkansas

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Fayetteville, Arkansas 72701

ABSTRACT

The Illinois River is in the Ozark region of northwestern Arkansas and eastern Oklahoma. A survey of the Illinois River in Arkansas produced nine species and one morphological sub-species of gastropods, three species of sphaeriid clams, and 23 species of unionid mussels. Museum records resulted in another two species and an ecophenotype of the Unionidae. This represents the first published survey of molluscan species from the Illinois River in Arkansas.

INTRODUCTION

The Illinois River is a southwestern Ozark stream. The Oklahoma portion is a component of the Oklahoma and National Scenic Rivers Systems. The Arkansas portion is presently under consideration for inclusion in the National Scenic Rivers System. The Northwest Arkansas Regional Water Quality Management Plan (Mitchell, 1974) has recommended addition of secondarily treated effluent into the Illinois. It has been noted that this may alter its environmental quality and biological composition (Kittle et al., 1974; Geihsler et al., 1975). Mollusks were collected by Kittle et al. (1974) but were not identified to species. Sublette (1956), Elick (1965), Kraemer (1970), and McCraw (1978) collected mollusks from the Illinois drainage in Arkansas. Isley (1925) and Branson (1964, 1973) listed mollusk species from sites in Oklahoma. This paper reports mollusks from the Arkansas portion of the river.

MATERIALS AND METHODS

The Illinois River is a major drainage of the southwestern Ozark Plateaus and a principle tributary of the Arkansas River. It originates in the Boston Mountains and flows through this physiographic region for about 16 km. It then flows through the Springfield Plateau to Lake Francis on the Oklahoma-Arkansas border. Summer surface flow begins in the vicinity of Hogeye. Washington County, Arkansas. The substrate is mainly chert gravel and rubble with areas of exposed bedrock. Mud substrate occurs in some areas due to agricultural abuses of the watershed.

Sixteen sites were sampled between Hogeye and Siloam Springs, Arkansas (Fig. 1). Qualitative collecting was done by gathering specimens from the river and banks by hand and by kick-net methods (Hynek and Hynes, 1975). Dead specimens were cleaned and stored dry. Live specimens were relaxed in Nembutal, fixed in formalin, and preserved in 70% ethanol (Kraemer, 1970). Specimens were verified by personal inspection and comparison (March 1979) with the collections at the University of Michigan Museum of Zoology, the Harvard University Museum of Comparative Zoology, and the National Museum of Natural History in Washington; D. C. Phylogeny and nomenclature follow a conservative system prescribed by Ortmann and Walker (1922), Clarke (1973), and Burch (1975). This is augmented by Ortmann (1919), Baker (1945), and Basch (1963). Vernacular names were taken from a variety of sources (e.g., Meek and Clark, 1912; Murray and Leonard, 1962; Sterki, 1910). A representative collection has been deposited in the University of Arkansas at Fayetteville Museum.

RESULTS

Nine species and one morphological subspecies of gastropods, three species of sphaeriid clams, and 23 species of unionid mussels were collected. Two species and an ecophenotype located in the University of Arkansas Museum (UAM) L. R. Kraemer collection were included. This makes a total of 39 species and forms of aquatic Mollusca from the Illinois River in Arkansas. Material in the collections at the University of Michigan Museum of Zoology, Harvard University Museum of Comparative Zoology, and the U. S. National Museum of Natural History confirm these findings. Headwater species were Goniobasis pustulosa plebeius, Carunculina glans, and Ligumia subrostrata. Commonly encountered species include Goniobasis pustulosa plebeius, Quadrula pustulosa, Amblocoma plicata, Actinonaias carinata, and Limopsis radiata niquiquidae. Only a single shell of Quadrula cylindrica was collected. Personal data from other nearby rivers suggests that Quadrula cylindrica is fairly rare in this area.

Class Bivalvia
Family Unionidae Fleming
Fusconaia flavus (Rafinesque) ................................ Wahash Pig-toe
Megalania gigantea (Barnes) (UAM 76-173-2b) ....... Washboard
Amblema plicata (Say) (=. A. costata) ............... Washboard, Rock mussel, Three-ridge, Blue point
Quadrula pustulosa (Lea) ................................ Warty pig-toe, Pimple-back
Quadrula quadrula (Rafinesque) (UAM 76-173-3c) ... Maple-leaf
Quadrula cylindrica (Say) ................................ Cob shell, Rabbit’s foot, Spectacle case
Trigonia verrucosa (Rafinesque) ......................... Fantail, Buckhorn, Pistol-grip
Pleurobema cordatum cocconeum (Conrad) .......... Round pig-toe
Ephippia dilatata (Rafinesque) ........................ Spike, Lady-finger
Lasmigona costata (Rafinesque) ......................... Sand mussel
Alasmidonta marginata Say .............................. Elks-Toe
Anodonta grandis Say .................................. Floater
Mollusca of the Illinois River, Arkansas

This is a keeled form of *M. dilatatus*. Identification is based upon information from Wu (pers. comm.) and Winslow (1918).

**DISCUSSION**

Previous papers dealing with the entire aquatic molluscan fauna of an Arkansas river do not exist. Wheeler (1914) studied the unionids of the Cache River, reporting 18 species, and conducted an in-depth survey of the mollusks of Clark County, Arkansas (Wheeler, 1918), which included a large portion of the upper Ouachita River and its tributaries. Meek and Clark (1912) collected 22 species of unionids from the Buffalo River. Recent unpublished collections increase this to 25 species. In the course of the field studies, it was observed that not only were the Buffalo and Illinois rivers similar in physiographic characteristics, but also that there were similarities in the unionid assemblages (Gordon, unpubl. data). Branson (1967) reported 29 unionid species and several subspecific forms from the Spring River in Missouri, Kansas, and Oklahoma (a portion of the Neosho [= Grand] River drainage basin, a principle tributary of the Arkansas River). In addition to similar unionid species, he also identified 13 species of sphaeriids and gastropods, eight of which are probably identical to species in the Illinois. Thus, regarding numbers of species, the Arkansas portion of the Illinois River appears to be comparable to other nearby Ozark streams. However, when species composition is compared, there are interesting differences.

The Ozarks region (including the Ouachita Mountains) has been considered to have a distinct molluscan faunal assemblage with endemic species (van der Schalie and van der Schalie, 1950). Several of these endemic species occur in drainages adjacent to the Illinois: *Goniobasis potoisien sis plebeius*, *Psychobranchus occidentalis*, *Fusconaia ozarkensis*, *Lampsilis ravena (= *L. brevicula*)*, and *Cypragena aberti*. Of these, only *Goniobasis* and *Psychobranchus* were found in the Illinois. The White River, to the east, contains five species. The Elk River fauna in Missouri, a tributary of the Neosho River, includes *F. ozarkensis* and *L. ravena*, the latter being apparently endemic to the Illinois and Neosho rivers drainages. These rivers are within 16 km of the Illinois. Frog Bayou, to the south, apparently holds none of these species (pers. data). Therefore, the Illinois River may represent the southwestern limit of the Ozark influence on the molluscan fauna of the Illinois River, with adjacent rivers to the south and west characterized by the Mississippian fauna. The limited information from the Oklahoma portion of the Illinois River (Isely 1925; Branson 1964, 1973), the situation in the Spring River (Branson, 1967), and Kansas records by Murray and Leonard (1962) support this observation.

**ACKNOWLEDGMENTS**

Appreciation is expressed to the following for their help, advice, and use of facilities at their respective institutions: Dr. Henry van der Schalie, Professor and Curator, Emeritus, and Dr. Alex S. Tompa, University of Michigan Museum of Zoology; Mr. Richard B. Johnson, Harvard University Museum of Comparative Zoology; Dr. Arthur H. Clarke, U. S. National Museum of Natural History; Dr. Nancy G. McCartney, University of Arkansas Museum; and Dr. Shi-Kuei Wu, University of Colorado Museum; and Mr. Ronald Osch, Glenegal, Missouri. A grant from the University of Arkansas Foundation, Inc., financed a trip to the first three institutions listed above. The manuscript was typed by Judy Zielinski.

**LITERATURE CITED**


Seasonal Abundance and Habitat Distribution Of Birds in Northeastern Arkansas

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Arkansas State University
State University, Arkansas 72467

ABSTRACT

Bird sighting records from 1964 through 1978 for 17 northeastern Arkansas counties were compiled according to the seasonal status, relative abundance and habitat distribution of each species. The five seasonal occurrence categories and their relative species composition were: transient visitor (46.6%), summer resident (20.3%), winter resident (14.8%), permanent resident (17.2%), and winter visitor (10.0%). The seven seasonal abundance categories and their relative species composition were: very rare (13.9%), rare (15.9%), uncommon (30.7%), fairly common (10.5%), common (25.8%), very common (1.7%) and abundant (1.7%). Eleven habitat categories were included: campestrian, abandoned fields, forest edge, lowland woods, upland woods, riparian woods, marshes, mud flats, flooded fields, lakes and ponds, and edificarian. A total of 268 species were recorded over the 15 year period.

INTRODUCTION

When Cook (1888) began the study of bird migration in the Mississippi Valley in 1882 only fragmentary notes on the birds of Arkansas had appeared in the literature. Coles (1877), Hollister (1902) and Pindar (1924) published lists of birds based on a few visits to eastern Arkansas.

Major ornithological works on the natural history and distribution of birds throughout Arkansas have been presented by Howell (1911), Wheeler (1924) and Baerg (1931 and 1951). Smith (1915) published on the birds of the Boston Mountains and Deaderick (1938) published a preliminary list of the birds of the Hot Springs National Park area. Callahan and Young (1955) reported on population densities of the Ozark Plateau in Washington County in northeastern Arkansas and Hanebrink and Shugart (1962) compiled a list of birds for south-central Arkansas. James (1960 and 1964) and James and James (1964) summarized more recent seasonal occurrences of the entire Arkansas avifauna.

Detailed studies of the avifauna of northeastern Arkansas have been limited. Collins (1960) and Hanebrink (1965) were first to study habitats and species composition of birds in this section of the state. Later a check-list was prepared (Hanebrink, 1972) of 10 counties in northeastern Arkansas. It is the purpose of this paper to update the check-list of birds for the northeastern quarter of the state with information concerning the seasonal status, relative abundance and habitat distribution of each species recorded and catalogued from 1964 through 1978. The counties included in this study are Fulton, Randolph, Clay, Izard, Sharp, Lawrence, Greene, Independence, Jackson, Craighead, Mississippi, Poinsett, White, Woodruff, Cross, St. Francis and Crittenden (Fig. 1).

DESCRIPTION OF AREA

All of eastern Arkansas is extensive delta with the exception of Crowley’s Ridge and the bordering Ozark counties (Fig. 1). The delta extends to the base of the Ouachita hills at the edge of North Little Rock and then continues north into Missouri and south into Louisiana without any natural break (Holder 1951). Crowley’s Ridge runs a distance of 200 miles from southeastern Missouri down the Mississippi River to Helena, Arkansas. In places the ridge is 12 miles wide but becomes very narrow at others and has a natural break at Marianna, Arkansas, where the L’Anguille River flows through the ridge. An excellent account of the geology of Crowley’s Ridge is given by Call (1981), and Magill (1985) summarized the theories concerning its origin.

Another prominent topographical feature of northeastern Arkansas is the famous “sunken lands” which are thought to have resulted from the New Madrid Earthquake of 1811-1813. A full account of this event is given by Fuller (1912). The so-called “sunken lands” are extensive areas of swamp and overflow bottom land occupying a large part of Mississippi County and portions of Clay, Greene, Craighead and Poinsett Counties. The largest “sunken” areas are those of Big Lake near Manila, Wapanocca near Turrell and the extensive St. Francis River basin. There are also lakes and sloughs in Mississippi County between Little River and the Mississippi River which were formed after the New Madrid Earthquake. In late summer and fall many of these areas shrink greatly in size or become entirely dry.

Extensive areas of inundated bottom lands are found in the valleys of the Black, White, Cache and St. Francis Rivers.

Habitat types found in northeastern Arkansas include: 1) campestrian (CA), which includes pastures, airports, plowed fields and stubble, 2) abandoned fields and fence rows (AF), 3) forest edges (FE), 4) lowland deciduous wood (LD), 5) upland deciduous woods (UW), 6) riparian woodland (RI), 7) marshes (MA), 8) mud flats (MF), 9) flooded fields in winter (FF), 10) lakes and ponds (LA) and 11) edificarian (ED) which includes residential areas, parks and all man made structures.

Favorable bird habitats in northeastern Arkansas can be found at sewage and catfish ponds and mud flats, Big Lake Wildlife Refuge, Wapanocca Wildlife Refuge, Claypool’s Reservoir near Weiner, Bayou deView Wildlife Management Area, Craighead Forest and Lake near Jonesboro, Lake Poinsett, Crowley’s Ridge State Park and Lake, Lake Hogue, Caney-Brake Wildlife Refuge, Village Creek, State Park, Jonesboro airport, the Burdette Herony and along the Mississippi River levee.

RESULTS AND DISCUSSION

A total of 268 avian species, 130 non-passerines and 138 passerines, were recorded and catalogued for northeastern Arkansas. Table 1 lists all species, their seasonal occurrence, relative abundance and habitat distribution.

Five seasonal categories were used in this study. They were: Transient Visitor (TV) - species that migrate through, Summer Resident (SR) - here at breeding season only, Winter Resident (WR) - here during winter only, Permanent Resident (PR) - here all year, Winter Visitor (VV) - irregular or occasional winter occurrence. An example of this last category would be the Snowy Owl.

Seven abundance categories were employed in this paper. They were:

- Very Rare (VR) - recorded 5 times or less in 15 years.
- Rare (R) - averaging about one sighting per year.
- Uncommon (U) - seen on less than 50% of the field trips.
Figure 1. Map of Arkansas showing the general topographic features, major forest types and the area covered by this study (modified from Foti, 1974).

Fairly Common (fc) - seen on 50-75% of the field trips.
Common (c) - seen on every field trip.
Very Common (vc) - seen often on every field trip.
Abundant (a) - seen in large numbers on every field trip.

Table 2 summarizes our findings on avian seasonal abundance and habitat distribution in northeastern Arkansas. The four most frequently occupied habitats were lowland woods, riparian woods, lakes and ponds, and upland woods. Over 25% of the species were common while nearly 31% were uncommon, with only about 2% being abundant. Transient visiants were the most abundant species (46.6%) while breeding species (permanent residents and summer residents) accounted for 37.5% (Table 2).

ACKNOWLEDGMENTS

We wish to thank Douglas James and Norman Lavers for their many beneficial suggestions on the original manuscript. Also, we thank many contributors who have provided much of the data used in this study.

Table 1. Seasonal occurrence and habitat distribution of avian species in northeastern Arkansas.

<table>
<thead>
<tr>
<th>Seasonal Abundance</th>
<th>Habitat Distribution</th>
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<tbody>
<tr>
<td>Abundant</td>
<td>Upland Hardwood</td>
</tr>
<tr>
<td>Rare</td>
<td>Mixed Pine Hardwood</td>
</tr>
<tr>
<td>Fairly Common</td>
<td>Pine</td>
</tr>
<tr>
<td>Common</td>
<td>Lowland Hardwood</td>
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<tr>
<td>Very Common</td>
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<td></td>
<td>Osage Flats</td>
</tr>
<tr>
<td></td>
<td>Coastal Plain</td>
</tr>
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<td>Interior Highlands</td>
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Table 2. (Cont'd.)
### Seasonal Abundance and Habitat Distribution of Birds in Northeastern Arkansas

#### Table 1 (Cont'd.)

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<thead>
<tr>
<th>Taxon</th>
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https://scholarworks.uark.edu/jaas/vol33/iss1/1
Table 2. Summary of avian seasonal abundance and habitat distribution in northeastern Arkansas.

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1 All scientific names are from Witham (1979), A.O.U. check-list of North American Birds, the thirty-second supplement to the A.O.U. check-list (1973) and the thirty-third supplement to the A.O.U. check-list (1979).
2 S = Summer months
3 W = Winter months

Arkansas Academy of Science Proceedings, Vol. XXXIII, 1979
Seasonal Abundance and Habitat Distribution of Birds in Northeastern Arkansas

LITERATURE CITED


Status of the Red-cockaded Woodpecker
At the Felsenthal National Wildlife Refuge in Arkansas

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INTRODUCTION

The Red-cockaded Woodpecker (Picoides borealis) inhabits southeastern pine forests and due to its status has been designated an endangered species by the United States Fish and Wildlife Service (U.S. Dept. Interior, 1973). In Arkansas, the Red-cockaded Woodpecker originally occurred as far north as the Ozark Province (Howell, 1911) but now is limited to the pine forests of the Ouachita Province and the West Gulf Coastal Plain (Jackson, 1971) as shown in Figure 1. Highest concentrations of the woodpecker occur in the pinelands of the southeastern part of the state.

Figure 1 shows a preliminary appraisal of the present county occurrences of the Red-cockaded Woodpeckers in Arkansas. It represents the findings of an ongoing comprehensive survey to determine the distribution of the woodpecker. Information concerning locations of cavity trees of the Red-cockaded Woodpeckers were received from timber companies, state and federal agencies, and several individuals in Arkansas.

The critical habitat factors of the Red-cockaded Woodpecker include adequate cavity trees for nesting and roosting and suitable forest conditions in the home range of the bird. The cavity trees must be live mature pine trees generally averaging 75 years in age or older with red-heart fungus (Fomes pini) present in the heart wood (Jackson, 1977a). Due to intensive forest management by wood products companies, mature stands of southern pines are diminishing thus reducing the availability of adequate cavity trees in the range of the woodpecker (Thompson, 1976). These and other practices account for the present endangered status of the Red-cockaded Woodpecker.

Similarly, timber management practices in pinelands in Arkansas are causing a reduction of suitable habitat, especially the availability of mature trees for roosting and nesting. In fact the federal endangered species statutes do not pertain to private holdings. Therefore, even in present centers of distribution, the future of the Red-cockaded Woodpecker on private lands is not bright. However, the federal statutes state that endangered species will be protected and encouraged on federal lands and projects. Thus it is fortunate that a new federal refuge, the Felsenthal National Wildlife Refuge, has been established in southeastern Arkansas. It is equally fortunate that the Red-cockaded Woodpecker is abundant in the pine lands on the refuge. The future existence of the Red-cockaded Woodpecker in southern Arkansas would seem to depend upon the continued presence of the refuge.

FELENSTHAL NATIONAL WILDLIFE REFUGE

The Felsenthal National Wildlife Refuge is located on the forested Gulf Coastal Plain along the Ouachita and Saline Rivers comprising parts of Union, Ashley and Bradley Counties in southeastern Arkansas. It lies within the Felsenthal Basin, a natural physiographic depression that once was a large lake extending southward to the site of Monroe, Louisiana. The refuge area totals 64,975 acres of which 9,482 are pine forests, mainly loblolly pines (Pinus taeda) with a scattering of shortleaf pines (Pinus echinata). The remaining refuge acreage is primarily various types of hardwood forests (50,493 acres) but also fields (271 acres) and open water (5,000 acres) in the form of an intricate system of rivers, creeks, sloughs, bayous and lakes.

The pineland habitat utilized by Red-cockaded Woodpeckers occurs on terrain that is higher than the 72 foot contour above mean sea level. This elevation is above the level of the river floodplain and is not subject to frequent flooding.

Federal land acquisition for the Felsenthal National Wildlife Refuge began in the early 1970s. It is an enhancement development in conjunction with the Ouachita and Black Rivers navigational pro-
Status of the Red-cockaded Woodpecker at the Felsenthal National Wildlife Refuge in Arkansas

A project, a lock and dam facility on the Ouachita River is included that will create a permanent navigational pool in the refuge totaling 15,752 acres at the 65 foot contour line, and a seasonal waterfowl pool totaling 37,686 acres of inundated land to the 70 foot contour level. The refuge lands were acquired from timber companies, private corporations, the State of Arkansas, and private landowners.

RED-COCKADED WOODPECKER POPULATIONS

Before refuge land acquisition began, pine timber was managed by private timber companies for use in production of forest products. Some of the sylvicultural practices resulted in mature pine forests with habitat suitable for the Red-cockaded Woodpecker. During federal land acquisition, provisions were made permitting timber companies to harvest 50 percent of all standing timber on their lands. Under these provisions merchantable timber was harvested in alternating 40-acre blocks and understory trees were left. Special efforts were made to locate and mark all cavity trees of Red-cockaded Woodpeckers in timber harvest areas. Care was taken to insure that these cavity trees were left standing following timber harvest activities.

Only the pinelands where refuge personnel have been active during preliminary refuge developmental activities, or areas where timber harvest has occurred, have been thoroughly searched for cavity trees of Red-cockaded Woodpeckers. A considerable area still remains to be surveyed. A map was prepared by the resident refuge forester showing locations of cavity trees. Using this map, cavity sites were visited during the present project. Information was gathered concerning the presence or absence of recent woodpecker activity, number of Red-cockaded Woodpeckers in the area, and general habitat conditions at each site. The existence of current cavity use was determined by the presence of fresh cambial peckings around cavity openings (Jackson, 1977b).

A total of 101 cavity trees were inspected. Of these, 42 (or 42%) were actively being used by Red-cockaded Woodpeckers as indicated by fresh cambial peckings. Only 15 birds actually were seen because they occur near cavity sites only at sunrise and sunset, and few birds were seen at cavity sites through the rest of the day. Cavity tree locations on the refuge are shown in Figure 2.

The legal obligations stipulated in the Endangered Species Act of 1973 (U.S. Dept. Interior, 1973) and its amendments direct all federal agencies to use their authority to promote programs that will preserve viable and endangered species such as the Red-cockaded Woodpecker. These agencies further are directed not to adopt policies that will jeopardize the existence of an endangered species nor destroy or modify critical habitats for such species. Therefore, the management of pinelands needed for the Red-cockaded Woodpecker at the Felsenthal National Wildlife Refuge will receive priority over all other considerations.

MANAGEMENT RECOMMENDATIONS

As stated previously, the future of the Red-cockaded Woodpecker in southern Arkansas is uncertain due to recent forestry practices. Therefore, in areas where the bird can receive priority attention, forest management for the woodpecker should be carefully applied. We recommend that this management policy include the following:

1. Annual surveys should be conducted to locate new cavity trees and to determine the status of cavity trees found previously. Special efforts should be made in areas designated for timber harvest.
2. The surveys should employ the standard procedure for determining if cavities are actively in use by Red-cockaded Woodpeckers.
3. To avoid harvest of cavity trees, such trees should be marked conspicuously with a broom ring of bright color. Dead cavity trees should not be harvested for several years to permit excavation of new cavities by resident woodpeckers.
4. Timber harvest operations should be terminated during the breeding season of the Red-cockaded Woodpecker. This applies to any area being managed for the species.
5. Pineland management units should be at least 200 acres to conform to the known home range size of the woodpeckers.
6. To insure an available supply of large trees for cavity construction, a 100-year cutting rotation of pines should be employed.
7. Timber cutting plans should be adopted that result in all age timber stands in woodpecker home ranges. If total harvesting of tracts of timber is unavoidable, the areas of harvest should be small, 30 acres or less, and adapted to the physiographic contours of the area resulting in long narrow patches, not circular or square ones.
8. Cavity trees should be isolated in the center of 12-acre plots in which selective cutting should be practiced, and where hardwood understory should be controlled. Ground litter should be removed from the bases of cavity trees before controlled burning to lessen the chance of igniting the cavity trees.
9. Timber cutting patterns should be designated so as not to force two clans to use the same foraging area. Thus each woodpecker clan should have its own 200-acre management unit.
10. To keep understory low and foraging space optimal, a 3 to 4 year cycle of controlled burning should be employed in woodpecker territories.

Figure 2. Felsenthal National Wildlife Refuge showing land elevations and cavity tree sites of the Red-cockaded Woodpecker. Pinelands occur in the upland areas (stippled).

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11. Since most of the information concerning proper management was obtained elsewhere, studies of the Red-cockaded Woodpecker should be made at the Felsenthal National Wildlife Refuge to determine if special management policies are needed there. This pertains particularly to studies of home range size and habitat preference.

ACKNOWLEDGEMENTS

This study was partially supported by the Arkansas Game and Fish Commission with grant-in-aid funds administered by the U. S. Fish and Wildlife Service under Section 6 of the Endangered Species Act of 1973 (PL 93-205). A grant from The Arkansas Audubon Society Trust provided funds to initiate the field work. Information concerning cavity tree locations off the refuge was provided by Georgia-Pacific Corporation, International Paper Company, Potlatch Lumber Company, the Arkansas Natural Heritage Commission, and by H. H. Shugart, Sr. and Tom Foti. Levi Davis of the Arkansas Game and Fish Commission was especially helpful in this regard and thus merits particular notice. Personnel at the Felsenthal National Wildlife Refuge deserve special recognition for providing information about the refuge and cavity tree locations there, and for assistance in the field in visiting and studying the cavity sites.

LITERATURE CITED


A Distributional Survey of the Fishes of Ten Mile Creek in Southeastern Arkansas

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ABSTRACT

A survey of the fishes of Ten Mile Creek was conducted during 1976 to 1979. The ichthyofauna of Ten Mile Creek is typical of lowland drainage systems in southeastern Arkansas. Fifty-three species representing 13 families and 23 genera were collected. Etheostoma parvipinne was locally abundant in the headwaters, and other vulnerable or rare species included Notropis maculatus, Fundulus notti, Fundulus chrysotus, Erimyzon sucetta, Moxostoma poecilurum, and Lepomis punctatus. Eight specimens of Notropis hubbii were collected.

INTRODUCTION

During the past decade extensive surveys of the fishes of the lower Ouachita River system including its two principal tributaries, the Saline River and Bayou Bartholomew have been conducted. Reynolds (1971) conducted a survey of the fishes of the Saline River, and Thomas (1976) completed a study of the fishes of Bayou Bartholomew. Investigations at Northeast University and Southern Arkansas University of the fishes of the Ouachita River system are in the final stages of completion. Robison (1975) reported on new distributional records from the lower Ouachita River system.

A survey of the fishes of the Saline River by Reynolds (1971) did not include any sampling within the Ten Mile Creek drainage. Discovery of the largest known population of goldstripe darters Etheostoma parvipinne in the headwaters in 1976, and designation of the Warren Prairie Site located within the drainage basin as a Natural Area by the Arkansas Natural Heritage Commission necessitated a more intensive survey of the fishes of Ten Mile Creek. Also, additional data on the distributions and abundances of rare or vulnerable species in Arkansas including Fundulus chrysotus, Fundulus notti, Erimyzon sucetta, Lepomis punctatus, Lepomis symmetricus, Moxostoma poecilurum, Notropis maculatus, and Etheostoma parvipinne were needed to ascertain their status in Arkansas.

MATERIALS AND METHODS

Eleven sampling stations were established at representative areas along Ten Mile Creek (Fig. 1) and were designated as: Station 1 (S27, T12S, R7W), Station 2 (S13, T13S, R8W), Station 3 (S12, T13S, R8W), Station 4 (S16, T13S, R8W), Station 5 (S7, T13S, R8W), Station 6 (S5, T13S, R8W), Station 7 (S12, T13S, R9W), Station 8 (S32, T12S, R8W), Station 9 (S1, T13S, R9W), Station 10 (S14, T13S, R9W), and Station 11 (S24, T13S, R9W). Twenty-eight collections were taken with 10-ft and 20-ft wide mesh seine, an 1100 watt generator, and aquatic dip nets. Specimens were identified with the keys of Pflieger (1975), Miller and Robison (1973), Douglas (1974), and Buchanan (1973). The use of common and scientific names is in accordance with Bailey et al. (1970). A total of 1,548 specimens was retained and is housed in the UAM Collection of Vertebrates in the Turner Neal Museum of Natural History. Many specimens of the most abundant species were not retained.

DESCRIPTION OF THE DRAINAGE BASIN

Ten Mile Creek, a small tributary to the Saline River, is located in Drew and Bradley Counties, Arkansas. The principal branch of Ten Mile Creek is 19 miles long, and 57.6 miles of tributaries drain approximately 60 square miles of predominantly commercial pine and hardwoods timberland. The headwaters are located at 270 ft above mean sea level (msl), and the elevation at the confluence of Ten Mile Creek and the Saline River is 100 ft above msl, representing an average gradient change of about 20 ft per mile.

Stream width varies from 4.0 to 30.0 ft, but it is typically less than 10.0 ft wide except in some of the larger pools in the lower sections which are periodically flooded by the Saline River. Water depth is typically less than 3.0 ft except in the larger pools at Station 9 and in some other areas during the winter and spring floods. During late summer and early fall Ten Mile Creek is usually intermittent with the larger pools being found at Station 9. Sand is the predominant substrate type in the headwaters, but silt and clay are more prevalent in the lower regions. Shallow and deep pools also contain substantial amounts of leaves and decaying debris. There is a limited diversity of habitats throughout the drainage, and stream velocities approach zero except during late winter and spring. The typical riffle areas characteristic of high stream gradient system are absent from Ten Mile Creek. Numerous shallow pools with luxuriant growths of aquatic vascular plants along the Warren Prairie are habitats for uncommon or rare species of Arkansas fishes.

RESULTS AND DISCUSSION

Fifty-three species representing 13 families and 23 genera were collected in Ten Mile Creek. A species list and the occurrence of each species at the sampling stations are shown in Table 1. The number of individuals of the uncommon or rare and endangered species is included in the discussion of the ichthyofauna. The most common species in Ten Mile Creek included Gambusia affinis, Notropis atherinoides, Lepomis macrochirus, Notemigonus crysoleucas, Centrarchus macropterus, Lepomis gulosus, Elliptoma zonatum.
Lepomis marginatus. Fundulus olivaceus, Pomoxis nigromaculatus, and Aphredoderus sayanus. Vulnerable or rare species included Fundulus notti, Fundulus chrysotus, Etheostoma parvipinne, Erinymyson suetca, Lepomis punctatus, Notropis maculatus, and Moxostoma poecilurum. Relative abundance and distribution of each of these unique species are discussed. Eight specimens of Notropis hubbsi were collected and represent a new distributional record for the Saline River.

Fundulus notti (Agassiz). Starhead topminnow

Forty-two specimens were collected in the weed-choked pools scattered throughout the Warren Prairie in the lower regions of Ten Mile Creek at Stations 7, 9, and 10. Reynolds (1971) reported only two specimens from the entire Saline River drainage. Buchanan (1973) listed only four localities in Arkansas. The Warren Prairie site is one of the best known habitats for Fundulus notti, and it is locally abundant in the area. Robison (1975) collected 79 specimens from Hazel Creek on Hwy. 8, five miles south of the junction of State Hwys. 8 and 4. These data verify that Fundulus notti is a common inhabitant of the Saline River drainage.

Fundulus chrysotus (Gunther). Golden topminnow

Five specimens of Fundulus chrysotus were collected at Station 7. Reynolds (1971) did not report Fundulus chrysotus from the Saline River drainage, but Robison (1975) reported four specimens from Hazel Creek, a tributary to the Saline River that is approximately two miles south of the Ten Mile Creek drainage basin. These are the only known specimens from the Saline River system and establish Fundulus chrysotus as a rare inhabitant in the drainage. Buchanan (1973) listed five other localities in Arkansas, and Robison (1975) reported five other localities in the Ouachita River system.

Etheostoma parvipinne Gilbert and Swain. Goldstripe darter

Prior to 1971 Etheostoma parvipinne was known in Arkansas only from two records reported by Black (1946). Robison (1977) described the typical habitat as being small, spring-fed, shallow streams with low to moderate gradient surrounded by riparian vegetation and with sandy substrates. Twenty-six localities and 41 specimens have been reported for Arkansas (Robison 1977). Thirty-seven of these individuals were collected from the Ouachita River system. The goldstripe darter was locally abundant at Station 1 in Ten Mile Creek where 19 specimens have been collected since 1976. One individual was collected from a shallow pool in the Warren Prairie near Station 10. Nine specimens have been collected from Clear Creek, a tributary to the Saline River, and Reynolds (1971) had reported a single specimen from Clear Creek in his survey of fishes of the Saline River. A population of goldstripe darters was discovered in a shallow farm pond on the UAM campus in 1979 by Tim Scott, John Loose, and Steve Shores. A total of 20 specimens was collected from the pond, and several specimens were left in the pond for observations of the life history. The total population in the pond will probably exceed 50 individuals. This is the first record of Etheostoma parvipinne from a pond, and specimens collected from the pond are more heavily pigmented than those collected from Ten Mile Creek and Clear Creek. A study of meristic variations and temperature tolerances of the pond population has been initiated. It can be concluded that Etheostoma parvipinne is locally abundant in Drew County where more specimens have been collected than in all other counties in Arkansas combined.

Erinyzon suetca (Lacepede). Lake chubsucker

The lake chubsucker is a rare inhabitant in Ten Mile Creek, and only one specimen was reported at Station 9. Reynolds (1971) did not find Erinyzon suetca in the Saline River, but Robison (1975) reported two specimens from Hazel Creek. The authors collected six specimens from a roadside pool adjacent to the Saline River along Hwy. 8 one mile east of Warren.

Lepomis punctatus (Valenciennes). Spotted sunfish

Reynolds (1971) collected 35 individuals in the Saline River system. Buchanan (1973) cited 24 localities from which the spotted sunfish has been collected. Lepomis punctatus was collected at Station 9 in Ten Mile Creek where three specimens were taken from a weed-choked pool. Two additional specimens were collected at Station 7. The spotted sunfish was considered an uncommon inhabitant of the Ten Mile Creek drainage.

Lepomis marginatus (Holbrook). Dollar sunfish

The dollar sunfish was one of the most common sunfishes in Ten Mile Creek, and 46 individuals were collected at Stations 3, 5, 7, and 9. Lepomis marginatus was most common at Station 7. Reynolds (1971) did not report the dollar sunfish from the Saline River system. The authors also collected six specimens from a roadside pool along Hwy. 8 approximately one mile east of Warren near the Saline River bridge. Robison (1975) found Lepomis marginatus in Hazel Creek and considered the species to be an uncommon inhabitant of the lower Ouachita River system. Based on this study, the dollar sunfish is much more common than previously recognized, probably because of the confusion with Lepomis megalotis.

Notropis maculatus (Hay). Taillight shiner

Robison (1974) and Buchanan (1974) regarded the taillight shiner to be rare in Arkansas. Black (1946) reported two specimens from the Saline River, but Reynolds (1971) did not collect any Notropis maculatus in a more intensive survey of the fishes of the Saline River. One specimen was collected in the Saline River by the authors at Hwy. 172 (S14, T14S, R9W) in 1976. Nine specimens were collected at Station 9 in Ten Mile Creek in a shallow pool near the Hwy. 8 bridge (S1, T13S, R9W). Notropis maculatus was an uncommon inhabitant in Ten Mile Creek.

Moxostoma poecilurum (Jordan). Blacktail redhorse

Five specimens of Moxostoma poecilurum were collected in the deep pools at Station 9 in Ten Mile Creek. Reynolds (1971) collected 20 individuals in the lower Saline River. The blacktail redhorse is common at Station 9 in Ten Mile Creek because numerous other individuals have been observed but were not collected. Buchanan (1974) considered Moxostoma poecilurum to be rare in Arkansas.

Notropis hubbsi Bailey and Robison. Bluehead shiner

Bailey and Robison (1978) described the habitat and summarized the distribution of Notropis hubbsi. Numerous localities for the bluehead shiner were cited in the Ouachita River system, including two localities near Bayou Bartholomew, Notropis hubbsi was not reported from the Saline River area, and Reynolds (1971) did not collect any specimens. Eight specimens were collected in the vicinity of Station 7 in Ten Mile Creek. A single specimen was collected in the flooded backwaters along Hwy. 8 near the Hwy. 4 intersection in April 1975. Seven additional specimens were collected in March 1979 at the first concrete bridge on Hwy. 8 (S12, T13S, R9W). These are the first known records of Notropis hubbsi from the Saline River drainage.

ACKNOWLEDGEMENTS

The authors are grateful to Greg Calaway and Tim Scott for assistance with the field collections. Members of the Taxonomy and Natural History of Lower Vertebrates classes at UAM also assisted in the collection of specimens. Dr. Henry Robison kindly verified Notropis hubbsi, Notropis maculatus, and Lepomis marginatus.

LITERATURE CITED

A Distributional Survey of the Fishes of Ten Mile Creek in Southeastern Arkansas


Table 1. Species list and distributions of the fishes in Ten Mile Creek, Drew County, Arkansas.

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TOTALS 1548
Lithostratigraphy of the Cane Hill Member of the Hale Formation (Type Morrowan), Northwest Arkansas

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University of Arkansas
Fayetteville, Arkansas 72701

ABSTRACT

The Hale Formation (lower Morrowan Series) is a sequence of sandstones and shales divided into the Cane Hill (lower) and Prairie Grove Members. In Washington County, Arkansas, the type Cane Hill consists predominantly of interbedded fine-grained, noncalcareous sandstones and siltstones. The member rests unconformably on Chesterian strata of either the Pitkin Formation or underlying Fayetteville Formation, and it is unconformably overain by the Prairie Grove Member. In Washington County, the Hale Formation exhibits a slight thickening trend to the south and east. Interpretation of sedimentary structures indicates that the Hale Member was deposited in an offshore, tidal current-dominated environment throughout the type region. Eastward from Washington County, the Cane Hill thickens both southward and eastward to nearly 160 feet in southcentral Newton County. The sandstone content of the unit increases markedly in Madison County, then decreases again into eastern Newton County, where the Cane Hill is dominated by shales. Basal conglomerates are extremely rare in Madison County, but appear occasionally in Newton County. Thick linear sandstone bodies, apparently related to fluvial processes, occur in southeastern Carroll County and eastern Madison County, but the bulk of Cane Hill deposits are still of tidal origin.

INTRODUCTION

Morrowan age sediments outcrop throughout northern Arkansas along the trend of the Boston Mountains. Lithostratigraphy of the units within the Morrowan Series is complex. The units are similar lithologically, boundaries are gradational or unconformable, and lateral changes in lithology are common. Although the lowest Morrowan unit, the Hale Formation, has been recognized for nearly 75 years (Taff, 1905; Adams and Ulrich, 1905), little progress has been made toward understanding the lithostratigraphy of the unit. In western Arkansas the Hale Formation has been divided into two members (Henbest, 1953, 1962): an upper Prairie Grove Member and a lower Cane Hill Member. The Prairie Grove Member is composed of medium grained calcareous sandstones and bioclastic limestones, while the Cane Hill Member is a sequence of interbedded noncalcareous, fine-grained sandstones, siltstones, and shales.

LITHOSTRATIGRAPHY

In western Arkansas the Cane Hill Member of the Hale Formation unconformably overlies either the Pitkin Formation or the Fayetteville Formation both of upper Mississippian age. These variable positions reflect the amount of pre-Morrowan erosion on the underlying Mississippian beds. Generally, the member over the Pitkin Formation south of the latitude (36°04′ N) of Fayetteville, Arkansas, and the Fayetteville Formation north of Fayetteville. The Cane Hill is unconformably overlain by the Prairie Grove Member of the Hale Formation throughout northwest Arkansas.

A regional isopach (Fig. 1) of the Cane Hill shows general thickening of the unit to the south and east. In outcrop, the Cane Hill thickens from about 40 feet at its type section in southwestern Washington County to nearly 160 feet in southcentral Newton County. Well data indicates that in the subsurface the unit continues to thicken southward to about 250 feet in southern Franklin and Pope Counties.

Throughout its type region, Washington County, the Cane Hill is a sequence of interbedded sandstones, shales, and siltstones, commonly with a conglomerate at its base (Fig. 2, sections A and B). In the type area sandstones are present as both locally continuous medium beds of ripple marked fine-grained quartzarenite, and as very fine-grained quartzarenite thinly interbedded with finer shale beds. In thin section, these sandstones are fine to very fine-grained, micaeous, supermature quartzarenites. The sandstones are dominated by siliceous cement in the form of quartz overgrowths, but locally may contain one to two percent calcareous or limonite cement. Chert and shale fragments generally compose about one to two percent of the rock, and feldspar makes up one percent of the grains. In cross section the sandstones are composed of small scale trough cross-stratification often with silty or muddy troughs. Shales found in the type area occur as thin to thick beds that are micaeous and silty. Siltstones are commonly thinly bedded and micaceous. Randomly occurring carbonate units are found in the Cane Hill within Washington County. These carbonates are generally thin, lenticular, bioclastic limestones with as much as 50 percent quartz sand.

Eastward from the type area in Washington County marked changes take place in the sandstone and shale content of the Cane Hill. Throughout Madison County the Cane Hill is dominated by a sequence of medium bedded sandstones as much as 70 feet thick (Fig. 2, sections B and C). Typically this sequence of sandstones is bounded by shales above and below. The sandstones seen in Madison County show siltstone partings, lunate or asymmetrically ripple marked upper surfaces and, in cross section, small scale trough cross-stratification. Petrographic study by Wiggins (1978) indicates that the sandstones found in Madison County are very similar to those sampled in Washington County. The shales which bound this thick sandstone interval are silty and commonly contain thin lenticular or wavy beds of siltstone or very fine-grained sandstone. Basal conglomerates analogous to those found in Washington County are extremely rare in Madison County, but often siltstone pebble conglomerates are present within bedded sandstone intervals well above the base of the member.

In the western half of Newton County the Cane Hill Member is dominated by thick shale intervals (Fig. 2, sections E and F). These shales, though rarely well exposed, are silty and micaeous, often containing thin lenticular beds of siltstone or very fine-grained sandstone. Bedded sandstones analogous to those found in Madison County are present in the lower part of the member, but are reduced in thickness. Limestone pebble basal conglomerates similar to those exposed in Washington County are commonly found in southwestern Newton County when the base of the unit is exposed.

Thick linear sandstone bodies that rest on the Fayetteville Formation are commonly present in southeast Carroll County, northeastern Madison County, but less commonly in Washington County (Fig. 1). Thickness ranges from 20 feet to more than 100 feet of medium to fine grained quartzarenite. Some of these sand bodies show a fining upward sequence, and most are conglomeratic at their basal contact.
Lithostratigraphy of the Cane Hill Member of the Hale Formation (Type Morrowan), Northwest Arkansas

Interpretation of sedimentary structures found within the Cane Hill Member indicates that the bulk of Cane Hill sediments were deposited in a near-shore, tidal current-dominated environment. Ripples, wave, and lenticular bedding following the classification of Reineck and Wunderlich (1968), are common within the unit, and are associated with bipolar dip directions on small scale trough cross-strata (Wiggins, 1978). Such structures indicate alteration of tidal current bedload transport with suspension settling during slack water periods and bipolar reversals of flow direction (Klein, 1977). Black (1975) reported the presence of mudcracks from the northernmost extirpation of the outcrop belt. This occurrence of mudcracks may indicate that a belt of intertidal sediment at one time existed to the north of the outcrop belt, but has subsequently been stripped off by erosion. The thick carbonates found associated with lower Cane Hill strata are apparently relic fluvial channels developed on the Mississippian surface prior to the initial Morrowan transgression. As the Morrowan Sea transgressed the Ozark Platform, these fluvial channels were still active but became tide dominated and reworked as evidenced by reports of bipolar dip directions for some of the cross-stratification (Black, 1975).

CONCLUSIONS

Regional studies of the Cane Hill indicates that the member is a viable and recognizable unit throughout northwestern Arkansas. The consistent occurrence of fine-grained supermature sandstones, silty shales, and micaceous siltstones provide adequate criteria for recognition of the unit and its separation from strata lying above and below it. Typically the unit is composed of interbedded sandstones and shales in Washington County, dominated by medium bedded sandstones in Madison County, and dominated by shales in western Newton County. The bulk of Cane Hill sediments were probably deposited in a shallow tidal current dominated environment as evidenced by sedimentary structures which indicate alteration of tidal current bedload transport with suspension settling during slack periods and bipolar reversals of flow direction.

The relationship of the Cane Hill Member to units occupying the same stratigraphic interval in northcentral Arkansas, such as the Imo Formation of Gordon (1965), is problematic. Units corresponding to those found in northcentral Arkansas do not occur within the study area with the possible exception of a thin shale and limestone interval found in southwestern Newton County (Fig. 2, section E). This thin interval may be the western-most extremity of late Mississippian strata that unconformably wedge between presumed Cane Hill strata and the Mississippian Pitkin Limestone to the east. However, further studies to the east must be initiated in order to tie the two areas together.

LITERATURE CITED

The Effects of Channelization on Fish Populations Of the Cache River and Bayou DeView

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ABSTRACT
This study was designed to better understand the possible effects of channelization by comparing natural and previously channelized sections of the Cache River and Bayou DeView. Forty-five fish species were collected in natural reaches, but only 24 species were collected in channelized reaches. Cyprinus carpio and Dorosoma cepedianum constituted 40 and 20 percent of the total fish biomass in channelized reaches, respectively, but only 22 and 2 percent of the total biomass in natural reaches. The mean weight of total fishes and game fishes only per surface ha in natural sections were 276 and 48 kg, respectively, but these values in channelized sections were 213 and 2 kg, respectively. Mean species diversity indices for natural and channelized sections of the Cache River were 3.1 and 1.8, respectively, and mean redundancy values for these sections were .30 and .55, respectively. Species diversity indices and redundancy values for Bayou DeView followed this trend.

INTRODUCTION
In recent years the public has become increasingly aware of the multiple ramifications of projects resulting in environmental alteration. The simplistic view that stream channelization will result in flood control and increased land productivity is not so readily embraced. It is now more widely recognized that certain political, sociological, economic, and aesthetic considerations may reduce or completely negate the immediately envisioned benefits of a given project. Assessment of the overall impact of stream channelization is still hampered because the environmental interrelationships are not well understood. This is due primarily to a paucity of data and inadequate methodology for obtaining it. The Cache River basin provides a unique opportunity for impact assessment because the opposing forces of conservationists and developers have so clearly polarized and because part of the basin has been channelized previously in the interest of flood control.

Initial channelization of upper reaches of the Cache River and Bayou DeView was done by local landowners in the 1920's. Efforts to obtain public funds for flood relief in this basin began in the 1930's. Two studies addressing the feasibility and desirability of Federal participation in major flood control works, the first completed on 4 December 1941 and the second on 19 October 1945, recommended no improvement. A third report was submitted to the Corps of Engineers on 4 February 1949 and recommended improvement of the main channels of the Cache River and Bayou DeView. This report resulted in authorization by the Flood Control Act of 17 May 1950.

Subsequent to authorization, the project was reviewed as part of the Mississippi River and Tributaries Project. That portion of the report pertaining to the lower White and Cache River basin was forwarded to the Memphis District, Corps of Engineers on 11 December 1959. Included was a report from USD'd Fish and Wildlife Service, dated 2 September 1959, evaluating the effects of the proposed project and recommending adoption of specific mitigation measures. Their input was authorized by the Fish and Wildlife Coordination Act of 1958. The Corps recommended against mitigation measures, as they were not considered economically feasible. Based on the 1959 report, the Flood Control Act of 27 October 1965 authorized improvement measures (U.S. Army Corps of Engineers, 1973). In preparing a pre-construction report in 1966, the Corps found that woodlands in the basin were being cleared at such a rapid rate that they asked the Fish and Wildlife Service to reevaluate the Project and submit another report. The reevaluation report was submitted in 1969, but was deemed to be too general in nature. The Corps asked for another report, which was submitted to them in 1970. It recommended water control structures for oxbow lakes and 30,000 A (12,000 ha) for public use. In October 1971, environmental groups filed a civil suit in U.S. District Court at Little Rock, and in May 1972, the Court dismissed the case, ruling that the Government of 1969 in their environmental impact statement (EIS). This EIS and the Corps evaluation, which became known as the "mitigation report", were forwarded to Congress in 1972 (U.S. Army Corps of Engineers, 1973).

Dredging on the lower Cache River was begun during July 1972. In the fall of 1972 Senator John McClellan introduced a bill providing 30,000 A (12,000 ha) of woodlands for public use with an additional 40,000 A (16,000 ha) to be preserved by environmental easements, with or without public access. He introduced another bill which provided $1 million for purchase of mitigation lands. Congressman Bill Alexander introduced similar legislation in the House. Congress passed both bills. President Richard Nixon vetoed the Rivers and Harbors Omnibus Bill, which contained the authority to start the mitigation program, but signed the appropriation bill that contained the $1 million for land acquisition (U.S. Army Corps of Engineers, 1973).

Construction stopped on the lower Cache River in December 1972 because of high water. Also at this time the 8th Circuit Court of Appeals ruled the 1972 EIS inadequate. In February 1973, environmentalists filed a motion with the U.S. District Court at Little Rock for an injunction to stop construction. The Court ruled that construction must stop but allowed for completion of the section which was started. In May 1973, the construction contract was terminated (U.S. Army Corps of Engineers, 1973).

A more thorough EIS was released in November 1973, and a series of public hearings were held in the Cache River basin. Also during 1973 several states and additional environmental groups joined the original plaintiffs in the suit to block the Cache River Basin Project, primarily because of alleged adverse impact on waterfowl populations. The various parties could not find an area of compromise, and a special task force was appointed to this end. Based on their recommendations, in October 1978 Congress approved a $2.8 million appropriation for work in the Cache River basin, with half of this amount to be spent immediately for the purchase of mitigation lands. No channelization can take place until the Environmental Protection Agency approves, however. The current plan restricts channelization to the lower 14 mi (22.5 km) of the Cache River. The upper 140 mi (225 km) of the Cache River, channelized in the 1920's, would be cleared of silt, debris, and vegetation to improve flow, but the
The Effects of Channelization on Fish Populations of the Cache River and Bayou DeVev

channel would not be enlarged. Further, "green belt" strips would be acquired along the midsections of the Cache River and Bayou DeVev. Several alternatives for dealing with this portion of the waterways would be considered, including constructing a leveed floodway, digg\ig a bypass channel or clearing the channel without enlarging it. As of the summer of 1979, the Environmental Protection Agency has not approved channelization work.

STUDY AREA

The Cache River basin drains southward along the western edge of the Mississippi Embayment. It extends from Butler County, Missouri, near the Arkansas line, to White River near Clarendon, Monroe County, Arkansas. With a length of about 229 km and a maximum width of 29 km, the Cache River basin has a total area of about 5,227 sq km. Except for a portion of the headwaters draining off the western slope of Crowley's Ridge, the basin is a long, narrow alluvial plain. The recent alluvium overlays Tertiary sediments (Fisk, 1944) and consists of a substrate of about 40 m of coarse sands and gravels deposited in the early stages of valley fill by streams with heavy loads and finer-grained top layers deposited later when the carrying capacity of the streams decreased (Krinisky and Wire, 1964). The surface layer consists of a very dense, relatively impervious, dark reddish-brown clay one to three m thick interlayered between varicolored clays and silts. In some areas sand overlayers the clay (Krinisky and Wire, 1964).

Land use in the basin is predominantly agricultural, with soybeans, cotton, and rice being the major crops. Natural vegetation in the basin includes such wetland types as Tupelo gum, cypress, cottonwoods, oaks, river birch, and willows. Annual rainfall is approximately 122 cm, with the heaviest amounts falling from December to June (U. S. Army Corps of Engineers, 1973). Because of the flat terrain, streams in the area are sluggish, and runoff is slow, which aids recharge of the ground water reservoir (Albin et al., 1967).

The upper reaches of the Cache River have been channelized by local authorities or land owners to State Hwy 18.16 km E of Grubbs, Jackson County, Arkansas. Below this point it follows a fairly well-defined course through the floodplain. The top bank of the channel is 27-152 m wide with depths of 1-8 m. Bayou DeVev, the main tributary of the Cache River, arises on Crowley's Ridge north of Jonesboro, Arkansas. It parallels the Cache River until it joins it 17 km upstream from the mouth of the Cache River. Its total length is 172 km. This stream has been channelized by local people from its headwaters to the U. S. Hwy 64 crossing. Areas adjacent to the channelized portion are intensively farmed except for Bayou DeVev State Game Area and lands owned by private hunting clubs. The lower 68 km of Bayou DeVev flow naturally through swamplands such as the Dagmar Wildlife Management Area, having a rather poorly-defined channel. These areas contain dense stands of Tupelo gum and cypress trees (U. S. Army Corps of Engineers, 1973).

METHODS AND MATERIALS

Nine stations were established in the Cache River basin. Of the three stations located on Bayou DeVev, the headwater station was channelized, and the two lower stations were located in natural reaches. Six stations were located on the Cache River; the upper three were channelized, and the lower three stations were in natural sections (Fig. 1). Selected physiocochemical determinations were made at each station, and values varied within comparable ranges in channelized and natural sections (Mauney, 1974).

During 22-30 June and 31 August fishes were collected from the nine stations by the use of various seine and rotenone. Classification was accomplished with the keys of Ricker (1955), Pfieger (1968), and Moore (1968). Nomenclature is in accordance with Bailey et al. (1970). In calculating number and weight of vs total fishes the following 12 species were considered game fishes: Esox americanus, E. niger, Centrarchus macropterus, Lepomis cyanellus, L. gulosus, L. humilis, L. macrochir, L. microlophus, Micropterus punctulatus, M. salmoides, Pomoxis annularis, and P. nigromaculatus.

Total number of individuals (n), number of individuals per species (n), and number of species present (s) were used to calculate diversity per individual (d), and redundancy (R) (Willm and Dorris, 1966). Sterling's approximation for factorials was used in all calculations. Computations were made with an IBM 360 computer. Coefficient of condition, ksL (Lagler, 1956), was determined for Ictiobus bubalus collected from the Cache River. They were divided into size classes of 5.0 cm intervals. Coefficient of condition was equal to the weight of a fish in g times 100,000 divided by the cube of the standard length in mm. Data pertaining to weights and numbers of fish at Station B-1 were not used in computations because of the bias introduced by a small dam and rock riprap, which was not present at any other sampling station.

RESULTS

Forty-seven species of fishes were collected in the Cache River basin. 32 from the Cache River proper and 42 from Bayou DeVev (Table 1). The channelized reaches of the two rivers yielded a total of 24 species, while a total of 45 species were taken from natural sections. Three species of fishes were taken only from channelized sections, but 23 species occurred only in the natural reaches.

Large numbers of Cyprinus carpio and Dorothea cepedianum were found in both natural and channelized sections. C. carpio constituted 40 and 22 percent and D. cepedianum constituted 20 and 1.5 percent by weight of the total fish biomass in channelized and natural sections, respectively. The mean weight of total fishes per surface ha in channelized sections was 88 kg, and in natural sections the value was 276 kg. The mean weight of game fishes per surface ha in channelized portions was 1.5 kg, or 3.3 percent of that found in natural reaches (46 kg). The mean weight of non-game fishes per surface ha was also greater in natural sections (230 kg) than in channelized sections (86 kg). The number of harvestable game fishes (15+ cm in total length) per surface ha was reduced by 99.5 percent in channelized sections. The mean number of all fishes per kg was 16 for natural sections and 197 for channelized sections.

Figure 1. The Cache River Basin. Study stations are designated by C (Cache River) or B (Bayou DeVev). Dashes represent channelized stream sections. Solid perimeter line represents the watershed divide.

https://scholarworks.uky.edu/jaas/vol33/iss1/1
Table 1. Species list of the fishes of Cache River and Bayou DeView

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<th>Scientific Name</th>
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<td>Shortnose Gar</td>
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<tr>
<td>Prairie perch</td>
<td>Aphredoderus saurus (Gil. &amp; B.)</td>
</tr>
<tr>
<td>Northern shadfinish</td>
<td>Fundulus notatus (Storer)</td>
</tr>
<tr>
<td>Blackspotted hindfin</td>
<td>Fundulus corynus (Storer)</td>
</tr>
<tr>
<td>Brook silverside</td>
<td>Etheostoma nigrum (Cope)</td>
</tr>
<tr>
<td>Mosquitofish</td>
<td>Gambusia affinis (Baer &amp; Girard)</td>
</tr>
<tr>
<td>Flathead</td>
<td>Pimelodus notatus (Raf. &amp; B.)</td>
</tr>
<tr>
<td>Green shadfinish</td>
<td>Pimelodus nigromaculatus (Raf. &amp; B.)</td>
</tr>
<tr>
<td>Wampour</td>
<td>Pimelodus nemoralis (Raf. &amp; B.)</td>
</tr>
<tr>
<td>Orangepointt sunfish</td>
<td>Pimelodus nigromaculatus (Raf. &amp; B.)</td>
</tr>
<tr>
<td>Longear shadfinish</td>
<td>Pimelodus spectabilis (Girard)</td>
</tr>
<tr>
<td>Spotted bass</td>
<td>Micropterus salmoides (Raf. &amp; B.)</td>
</tr>
<tr>
<td>White crappie</td>
<td>Pomoxis annularis (Raf. &amp; B.)</td>
</tr>
<tr>
<td>Black crappie</td>
<td>Pomoxis nigromaculatus (Raf. &amp; B.)</td>
</tr>
<tr>
<td>Mud darter</td>
<td>Etheostoma agenon (Forbes)</td>
</tr>
<tr>
<td>Bighead darter</td>
<td>Etheostoma occidentale (Harp)</td>
</tr>
<tr>
<td>Slaugh darter</td>
<td>Etheostoma viridescens (Harp)</td>
</tr>
<tr>
<td>Harlequin darter</td>
<td>Etheostoma nigrum (Girard)</td>
</tr>
<tr>
<td>Guppies darter</td>
<td>Etheostoma longirostris (Harp)</td>
</tr>
<tr>
<td>Logperch</td>
<td>Perca canadensis (Raf. &amp; B.)</td>
</tr>
<tr>
<td>Blackside darter</td>
<td>Perca microlepis (Girard)</td>
</tr>
<tr>
<td>Dusky darter</td>
<td>Perca macrochirus (Raf. &amp; B.)</td>
</tr>
<tr>
<td>Sauger</td>
<td>Stizostedion canadense (Smith)</td>
</tr>
<tr>
<td>Perch darter</td>
<td>Aplocheilus melanotus (Raf. &amp; B.)</td>
</tr>
</tbody>
</table>

*C denotes Cache; B denotes Bayou DeView; CB denotes both.

Mean species diversity indices for natural and channelized sections of the Cache River were 3.1 and 1.8, respectively. Mean redundancy was 45 percent lower in natural reaches than in channelized reaches, 0.30 vs 0.55. These values were of comparable magnitude in Bayou DeView (Table 2). Due to limitations caused by imposed experimental design, species diversity indices were calculated for Jenkins and Harp's (1971) data for Big Creek, the headwaters of Bayou DeView (Table 3). Individual coefficients of conditions were determined for 27 species in benthic macroinvertebrates from natural sections and 22 from channelized sections. The Student's t test showed no significant differences between mean condition coefficients of populations in natural vs channelized reaches (Table 4).

Table 2. Community structure of channelized and natural stream sections of Cache River and Bayou DeView.

<table>
<thead>
<tr>
<th>Station</th>
<th>n</th>
<th>S</th>
<th>N</th>
<th>H</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Natural</td>
<td>16</td>
<td>367</td>
<td>2.095</td>
<td>0.50</td>
<td></td>
</tr>
<tr>
<td>Natural*</td>
<td>17</td>
<td>653</td>
<td>2.846</td>
<td>0.31</td>
<td></td>
</tr>
<tr>
<td>Natural*</td>
<td>35</td>
<td>645</td>
<td>3.702</td>
<td>0.28</td>
<td></td>
</tr>
<tr>
<td>Channelized</td>
<td>13</td>
<td>998</td>
<td>1.683</td>
<td>0.58</td>
<td></td>
</tr>
<tr>
<td>Channelized</td>
<td>15</td>
<td>995</td>
<td>1.666</td>
<td>0.59</td>
<td></td>
</tr>
<tr>
<td>Natural</td>
<td>19</td>
<td>548</td>
<td>3.517</td>
<td>0.16</td>
<td></td>
</tr>
<tr>
<td>Natural</td>
<td>17</td>
<td>509</td>
<td>2.316</td>
<td>0.46</td>
<td></td>
</tr>
</tbody>
</table>

* Denotes stations located on Bayou DeView.

Table 3. Total number of species and species diversity indices for stations located on Bayou DeView, arranged in a downstream sequence.

<table>
<thead>
<tr>
<th>Station</th>
<th>n</th>
<th>S</th>
</tr>
</thead>
<tbody>
<tr>
<td>JB-1* Natural</td>
<td>8</td>
<td>2.394</td>
</tr>
<tr>
<td>JB-2 Natural</td>
<td>9</td>
<td>2.401</td>
</tr>
<tr>
<td>JB-3 Natural</td>
<td>10</td>
<td>2.165</td>
</tr>
<tr>
<td>JB-4 Natural</td>
<td>10</td>
<td>2.807</td>
</tr>
<tr>
<td>JB-5 Channelized</td>
<td>13</td>
<td>1.613</td>
</tr>
<tr>
<td>JB-1 Channelized</td>
<td>17</td>
<td>2.096</td>
</tr>
<tr>
<td>JB-2 Natural</td>
<td>17</td>
<td>2.946</td>
</tr>
<tr>
<td>JB-3 Natural</td>
<td>38</td>
<td>3.702</td>
</tr>
</tbody>
</table>

* JB denotes stations studied by Jenkins and Harp (1971). B denotes stations utilized in the present study.

Table 4. Mean condition coefficient (kl) of Ictiobus bubalus in natural and channelized sections.

<table>
<thead>
<tr>
<th>Sex</th>
<th>Channelized</th>
<th>Natural</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male</td>
<td>2.603</td>
<td>3.080</td>
</tr>
<tr>
<td>Female</td>
<td>2.806</td>
<td>3.093</td>
</tr>
<tr>
<td>Mean</td>
<td>2.812</td>
<td>3.096</td>
</tr>
</tbody>
</table>

n = sample size

DISCUSSION

The greater diversity of fish species in natural reaches and the differences in species composition in natural vs. channelized reaches were apparently related to the greater degree of silting in channelized sections, since other factors (e.g. stream order [Horton, 1945], physicochemical characteristics) were basically comparable. Silitation negatively affects the survival rate of eggs, spawning and nesting grounds, number of food organisms, visibility of sight feeders, number of habitats, and substrate stability (Ritchie, 1972). Any one or combination of these factors could cause the observed results.

The marked reduction in mean weight per surface ha for total fishes, game fishes, and non-game fishes at channelized stations may be attributed in part to a reduction in numbers of macroinvertebrate organisms. Latimer (1975) reported that the numerical standing crop of benthic macroinvertebrates in this basin was reduced by 55 percent in channelized sections. She also observed a reduction in macroinvertebrate diversity in channelized sections. The resulting simplified food web could logically result in less weight per individual in higher trophic levels. Restricted nesting areas could further contribute to reduced biomass of fishes in channelized reaches (Ritchie, 1972). The reduction in biomass of all fish species in channelized sections of the Cache River basin was 68 percent. Other studies have reported reductions of 32-85 percent in channelized stream sections (Congdon, 1971; Mitchell, undated; Tarplee et al., 1971).

Channelization appears to affect game fishes, particularly those of harvestable size, more severely than non-game fishes. Game species are characterized less hardy, and they are primarily sight feeders (e.g. Micropterus spp.) as opposed to taste or touch feeders (e.g. Cyprinus carpio). The mean weight reduction of game fishes in chan-
The Effects of Channelization on Fish Population of the Cache River and Bayou DeVew

Channelized sections of the Cache River basin was 96.7 percent, and reduction in the number of harvestable individuals (15+ cm in length) was 99.5 percent. Other investigators have reported the numbers of game fishes exceeding 15 cm in length to be reduced by 77-99 percent in channelized environments (Bayless and Smith, 1962; Congdon, 1971; Tarplee et al., 1971).

The negative effects of channelization on the Cache River basin are emphasized upon studying Gray's (1955) data. He collected Allosa chrysochroa, Morone chrysops, M. mississippiensis and Lepomis gulosus from the Cache River and A. chrysochroa, Carpiodes cyprinus, M. mississippiensis and Micropterus punctulatus from Bayou DeVew. The absence of these species in our collections may be due in part to sampling bias, but the impact of channelization and subsequent siltation, as well as pesticides and other agriculturally oriented stresses, cannot be ignored.

Two important features of good game fish habitat are the presence of deep backwater areas with little or no current and the presence of adequate cover (Buchanan, 1976). Indeed presence of these features increases the total fish species diversity. Reduced environmental heterogeneity in the channelized portions of the Cache River basin is indicated by the species diversity indices (mean 1.8 vs 3.1 in natural reaches) and redundancy values (0.55 vs 0.30 in natural reaches). High redundancy values reflect dominance by a few species, whereas low redundancy values indicate a more even distribution of fishes among species (Wilhm and Dorris, 1968). Channelization results in a straight channel with near constant depth and width. This homogeneity contributes to reduced competition for some species through extirpation of those species unable to cope.

Due to imposed experimental design, effects of channelization vs longitudinal zonation were difficult to evaluate, because upper stations were channelized and lower ones were not. Species diversity would be expected to increase in down stream increments if longitudinal zonation alone were operating. Analysis of species diversity indices for a natural, channelized, then natural section sequence would best elucidate what effect, if any, channelization might have. To this end, species diversity indices were calculated for Jenkins and Harp's (1971) data for Big Creek, the headwaters of Bayou DeVew (Table 3). The reduction in species diversity indices at the two channelized stations, JB-5 and B-1, clearly indicate the effect of channelization in this stream.

The lack of significant differences in mean condition coefficients of Ictiobus bubalus populations between channelized vs natural sections of the Cache River (Table 4) may reflect the migratory behavior of this species, extensive flooded conditions during this time (which may have provided ample detrital foods in all stream sections), sample size, or any combination of these phenomena.

LITERATURE CITED


MICHAELSON, S. M. Undated. Fish populations in channelized and unchannelized sections of the Platte River, Missouri. Pages unnumbered.


https://scholarworks.uark.edu/jaas/vol33/iss1/1
Hydrogeologic Investigation of a Landfill Site in Washington Co., Arkansas

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ABSTRACT

A proposed landfill site near Wheeler, Washington Co., Arkansas, was investigated for its hydrogeologic suitability. The site is located on the highly fractured, cavernous, and cherty Boone Limestone. The site is a small upland valley 4500 ft. north of Clear Creek. The valley containing the proposed site is a karst dry valley in which precipitation rapidly infiltrates, recharging the water table and local springs.

The water table around the site was mapped to determine the hydraulic gradient and direction of ground-water movement. The water table slopes in a SE direction from the landfill towards Clear Creek with a steep hydraulic gradient of an average 200 ft/mile. Water levels in wells near the site are 17-80 ft. below the surface of the valley. Specific capacity values of 0.54 and 0.94 gpm/ft. and transmissibility values of 257 and 301 gpd/ft. were determined from two pumping tests in the unconfined and semi-confined Boone-St. Joe aquifers. These values indicate a relatively high permeability of the aquifer. The cherty soil to be used as a liner is adequate due to its high variable permeability. Therefore, the site as designed, is judged unsuitable. One large spring and five wells in the area were monitored for Cl⁻, NO₃⁻, and SO₄²⁻ and found uncontaminated according to health standards. Since the Arkansas DPCE has granted permission for the landfill, these same sites will be monitored through time to detect any leachate contamination.

INTRODUCTION

A new landfill site for the Fayetteville area was chosen near the community of Wheeler, Arkansas, as the old landfill at Johnson filled. Controversy over the proposed new site began. The landfill at Johnson is on similar soils and rock types as the proposed new site, and leaks leachate to the ground water. Therefore, concerned residents in the area requested that a hydrogeologic investigation be performed around the proposed site to test its suitability for waste disposal. The area was investigated by the authors, and a report was presented at a hearing of the Arkansas Department of Pollution Control and Ecology in January 1978. This paper presents the data and conclusions of this investigation.

LOCATION, GEOLOGY, AND SOILS

The Wheeler sanitary landfill site is located in the northwest part of section 23, T17N, R31W (Figure 1) Washington Co., Arkansas. Topographically, the area consists of a gently undulating uplands surface that is dissected by ephemeral tributaries that lead to the floodplain valleys of Clear and Little Wildcat Creeks. The landfill site is at the head of one of these tributaries.

The geology of the landfill is relatively simple. It is underlain by highly fractured, cherty, and cavernous Boone Limestone of Mississippian age (Figure 2). The Boone is over 250 feet thick at the site, as indicated by nearby water wells. Structurally, the site is along the axial trace of the "Wheeler Anticline" (Evans, 1952). Subsequent field examination has not demonstrated the existence of this structure (Konig, pers. comm.). The rocks have a regional dip of less than one degree in the southeast. Solution enlarged joints are common in bedrock exposures in the area.

The residual soils covering the Boone Limestone are characterized red and are silty-clay and clay in texture, with a high content of chert fragments. The site is primarily on the Baxter and Clarksville cherty silt loam of 12-60% slope (Harper et al., 1969). Borings made by McClelland Eng. Inc. (1977) at the landfill site were made up to a depth of 31 feet. The McClelland's (1977) report states the following about the soils at the site:

"Due to the nature of the weathering and the presence of broken and fractured chert seams and layers, mass vertical and horizontal permeabilities of the strata are highly variable."
This report further says that:
“due to the inherent variability of the residual deposits of the Boone Formation, it is not possible to pinpoint exact areas with high or low potential for leachate seepage.”

The U.S. Soil Conservation Service at Fayetteville, Arkansas, drilled several test holes at the site in April 1976. These borings showed soils of moderate to high permeability and high percentages of chert (Gaston, 1978). This report states:

“The alluvial layer of gravelly silt loam in the bottom of the narrow drain, transmits water too rapidly for good pollution control.”

A study by Ransom et al., (1975) which characterized the Clarksville soils as to their suitability for septic tanks, found that the Clarksville Soil Series has a moderate to rapid rate of dye percolation from septic tanks.

### Hydrogeology: Direction and Rate of Water Movement

Carbonate rocks are known by geologists to have zones of extremely high permeability due to solution in favorable lithologies, jointed and faulted regions, and along bedding planes. Such factors have caused a variety of researchers to recommend that carbonate rock areas not be used as landfill sites (Lessing et al., 1971; Parizek et al., 1971).

Three important questions that must be asked when constructing a landfill that has the potential for producing leachate are:
1. What is the lithology of the underlying aquifer?
2. How permeable is the aquifer?
3. What direction does the ground water move in the area?

Recent investigations in northwest Arkansas have shown that the Boone-St. Joe aquifer is primarily unconfined with local semi-confined by dense chert and limestone beds (Willis, 1978; Rezaie et al., 1979; Ogden et al., 1979). Wells commonly intersect caves and enlarged fractures. This secondary permeability is found in wells 1 and 2 (Figure 3) located down slope from the landfill site. The caves that were intersected by these wells are waterfilled primarily during the wet season, thereby supplying some water to the wells. Springs along Clear Creek (Figure 3) are believed to be the ultimate discharge points for this water.

The site is located in a karst: dry valley that has flowing water only after very hard rains. This indicates the high permeability of the soil and rock in the area. To further investigate the permeability, pumping tests were performed on two wells downslope from the site (Figure 3, wells 1 and 3). The wells were pumped for 30 min. and allowed to recover for 1 hr. The coefficient of transmissibility (T) and specific capacity (C) were then calculated using the methods of Jacob (1963). Specific capacity values of 0.54 and 0.94 gpm/ft and transmissibility values of 257 and 301 gpd/ft were found for wells 1 and 3, respectively. A comparison of these values to the median C and T values (0.29 gpm/ft and 176 gpd/ft, respectively) from 32 pumping tests performed in the Boone-St. Joe aquifer of Benton and Washington Counties (Rezaie et al., 1979), indicates that the permeability at the landfill site is high. The direct implication of this is that the water, and thus the leachate that may be produced from the landfill, will rapidly move through the soil and rocks with little chance for purification.

In an unconfined aquifer such as the Boone-St. Joe, it is expected that the water table will conform somewhat to the topography. Water levels were measured in wells in the area and the data used to construct a water table map in order to determine the direction of ground-water flow and slope of the water table. Water levels in the wells range from 17-80 feet below the land surface with greater depths occurring in upland wells. The water level data indicate that the water table slopes in a southeast direction from the landfill towards Clear Creek with a steep hydraulic gradient of up to 200 ft/mile.

### Ground-water Chemistry

Five wells and one spring were monitored to determine the degree of contamination that existed in the ground water prior to the emplacement of the landfill (Figure 3). Figure 4 shows the concentrations of chloride, nitrate, and sulfate that existed in the sampling sites during several sampling periods. All concentrations were found to fall within limits set by the U.S.E.P.A. (1976). This data will prove useful for later comparisons of water quality, now that the landfill is in operation.

**Figure 3.** Location of the pumping tests and sampling sites in T17N, R31W and their proximity to the Wheeler Landfill.

**Figure 4.** Concentrations of sulfate, chloride, and nitrate at the sampling sites.

### Summary and Conclusions

This investigation was performed prior to construction of the Wheeler landfill at the request of concerned local residents. Soils are highly variable in permeability and depth. The high chert content in the soil and soil liner, along with the moderate to high permeability, suggests that any leachate produced will infiltrate into the water table. Surface karst features and pumping tests, further substantiate the relatively high permeability of the soil and cherty limestone beneath. A relatively shallow depth to water exists, and the local water table map produced from collected data shows a southeast direction of movement, and discharge probably via springs along Clear Creek. The high transmissibility and specific capacity values and the steep hy-
Albert E. Ogden and Carlos J. Quintana

Hydraulic gradient of the water table indicates a rapid flow rate of the ground water. Therefore, the site, as designed, is judged by the authors to be unsuitable and likely to contaminate local wells, springs, and ultimately, Clear Creek.

Monitoring of several wells and springs for water quality indicates that the ground water presently is not contaminated and falls within limits set by U.S. E.P.A. (1976) with respect to chloride, sulfate, and nitrate. Future monitoring of these samples sites will show if and when the leachate enters and moves into the ground water system.

LITERATURE CITED


A Preliminary Investigation of Rural-Use Aquifers Of Boone, Carroll, and Madison Counties, Arkansas

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ABSTRACT

Approximately 500 water wells having driller's lithologic logs were plotted in Boone, Carroll, and Madison Counties, Arkansas. Three aquifers were found to be used by the rural residents and smaller communities. The most shallow of these is the Mississippian Boone-St. Joe aquifer. This aquifer is generally the least productive having a range of .25 to 63 gpm but a median productivity of only 5 gpm. Well depths for the Boone-St. Joe range from 46 to 464 ft and have a median depth of 225 ft. The Boone-St. Joe aquifer is unconfined to semi-confined and yields sufficient quantities of water only when there is an adequate saturated thickness (generally >100 ft) and/or a fracture or water-filled cave is intersected.

The next aquifer is the first sand below the Chattanooga Shale which can be composed of one or three of the following sandstones: upper Evrot, Clifty, and Sylamore. The range in yield for this newly designated aquifer is 1 to 70 gpm with a median productivity of 10 gpm. Well depths for the aquifer range from 150 to 824 ft with a median depth of 460 ft. An isopach map was made for this sandstone aquifer zone. There is a rapid thinning trend to the north from 250 ft in central Madison County to 0 ft near the Missouri border. If there is insufficiency of permeability or this aquifer, residents must drill deeper to the Cotter Dolomite.

The Cotter-Jefferson City Dolomite is the next aquifer below the Sylamore-Clifty-Evrot aquifer. This aquifer zone has a range in yield of 1.5 to 200 gpm and a median yield of 15 gpm. Well depths range from 130 to 1010 ft with a median depth of 475 ft.

A statistical correlation procedure was made among well yield (gpm), photo-lineament proximity, and regolith thickness for all these aquifers in Boone County. The results indicate that more water can be obtained in areas of deep weathering and that deeper weathering is found closer to photo-lineaments. A strong relationship between lineament proximity and yield exists when the aquifers are combined but not for each of the individual aquifers.

INTRODUCTION

Ground water is extensively used by rural residents and communities of Carroll, Madison, and Boone Counties, Arkansas. Few detailed hydrogeologic reports have been written about the study area. Purdue and Miser (1916) first mentioned ground water in Carroll and Boone Counties, but only in an cursory manner. A short list of water well depths and estimated yields was made by Bannan (1937) in the study area. Isopachous and structural contour maps of some of the formations discussed in this report were made by Caplan (1957). A reconnaissance survey by Lamonds (1972) used sparse data to produce a piezometric surface map for Roubidoux Formation and Gunter Sandstone member of the Gasconade Formation.

Numerous hydrogeologic theses have been produced at the University of Arkansas, but none pertain directly to the study area of this report. Water chemistry of the Boone-St. Joe aquifer has been investigated by Grubbs (1974). Coughlin (1975), and Brooks et al. (1979) in Washington and Benton Counties. A water table map of the Boone-St. Joe aquifer was produced along the western edge of Beaver Lake by Hunt (1974). Hanson (1973) and Gaines (1978) have performed a fracture analysis of northern Arkansas and compared fracture proximity to well yield for the Boone-St. Joe and Roubidoux aquifers, respectively. A recent detailed analysis of the Boone-St. Joe aquifer in Benton County by pumping tests, water analyses, and fracture mapping has been performed by Brooks et al. (1979) and Rezaie et al. (1979).

This investigation presents the results of a preliminary investigation of three important aquifers used by a large majority of the people of Carroll, Boone, and northern Madison Counties.

LOCATION AND GEOLOGY

The study area is located in Carroll, Boone, and northern Madison Counties, Arkansas (Figure 1). Mississippian, Devonian, and Ordovician rocks are exposed at the surface. The generalized stratigraphy of the study area is shown in Figure 2. Unconformities are common in the stratigraphy, sometimes making it difficult to determine the exact formations present in a well. The study area is composed of portions of several physiographic provinces. There are three dissected plateau surfaces, and two major escarpments separating the plateaus (Figure 2). The rocks in the study area dip gently on the southeastern flank of the Ozark Dome with slight deformation. Normal faults are found, but they are not a common structural feature. There is extensive karst developed in the carbonate rocks such as the Boone, St. Joe, Powell, Cotter, and Jefferson City formations. Caves, springs, dolines, and losing streams are common landforms. Joints have been enlarged by solution, thus enhancing the permeability and increasing groundwater storage and movement within the carbonate formations.

METHODS

Records of water wells were obtained from the Arkansas Geologic Commission for Carroll, Madison, and Boone Counties. Approximately 500 wells were accurately plotted with the aid of county plat books and rural directories. From the gross lithologic log reported on each record, it was possible to determine the aquifer(s) that supplied water to each well. The occasional absence of formations due to unconformities generally did not significantly hamper determination of the studied aquifers since they are usually composed of more than one geologic formation that is easily distinguished by marker horizons. Other important information provided by each well record was: (1) the depth to water, (2) driller's estimate of yield (gpm), and (3) the depth to bedrock.

Photo-lineaments were drawn from 1:20,000 BXW aerial photographs of Boone County. The Spearman-Rank Correlation Coefficient test (Siegel, 1956) was then used to make preliminary tests among the following parameters: (1) well yield, (2) photo-lineament proximity, and (3) depth to bedrock.

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Results

Three important aquifers were found to be used by rural residents in the study area. The most shallow aquifer is the Mississippian Boone-St. Joe Limestone aquifer. Although different formations, the Boone and St. Joe limestones behave collectively as an aquifer. This aquifer is generally the least productive with a range in yield of 0.25 to 60 gpm, and a median productivity of only 5 gpm (Table 1).

Depths for drilled wells in the Boone-St. Joe aquifer range from 40 to 464 feet and have a median depth of 235 feet (Table 1). These figures represent only wells in which drilling began in the Boone. Wells beginning in Pennsylvanian rocks and penetrating the entire thickness of the Boone-St. Joe aquifer indicate that the aquifer achieves a maximum thickness of 476 feet in southern Carroll and Boone Counties. This aquifer is unconfined where exposed at the surface.

The second important aquifer zone is a group of sands below the Chattanooga Shale where the Chattanooga is present, or below the St. Joe Limestone if the Chattanooga is not present. This aquifer can be composed of one to three of the following sandstones: Sylamore, Clifty, and upper Everton (Figure 2). In the western part of the study area where the Chattanooga is present, ground water is obtained commonly within the first 50 feet of the aquifer and is primarily from the Clifty and/or Sylamore. In Boone County, the Clifty and Sylamore are absent, and the upper Everton sandstone beds become the dominant water bearing units. Locally, occasional thin beds of limestone and dolomite are found within this upper section of the Everton.

Table 1. Summary of measured hydrogeologic parameters in the study area.

<table>
<thead>
<tr>
<th>Aquifer</th>
<th>Depth (ft)</th>
<th>Yield (gpm)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Range</td>
<td>Median</td>
</tr>
<tr>
<td>Boone-St. Joe</td>
<td>46-464</td>
<td>225</td>
</tr>
<tr>
<td>Sylamore Clifty Everton</td>
<td>150-824</td>
<td>460</td>
</tr>
<tr>
<td>Cotter Jefferson City</td>
<td>130-1010</td>
<td>475</td>
</tr>
</tbody>
</table>

(Suhm, 1970). East of the study area, the St. Peter Sandstone overlies the Everton and becomes part of this aquifer zone.

The range in yield for the Sylamore-Clifty-Everton aquifer is 1 to 70 gpm with a median productivity of 10 gpm (Table 1). It should be noted that many of these yields include water contributed by the overlying Boone-St. Joe aquifer. Generally, this contribution is slight or else drilling would have ceased in the overlying aquifer. Well depths for the aquifer range from 150 to 824 feet with a median depth of 460 feet (Table 1). These depths most commonly include thicknesses of the Boone-St. Joe formations since the Sylamore-Clifty-Everton is only exposed as a thin band along the Eureka Springs Escarpment (Figure 2). Many of the wells drilled on the Boone covered Springfield Plateau surface go into this second aquifer zone for sufficient quantities of water.

An isopachous map was prepared for the Sylamore-Clifty-Everton aquifer for Boone, Carroll, and northern Madison Counties (Figure 3). There is a rapid thinning trend to the north from 250 feet in central Madison County to 0 feet near the Missouri border. The base of this aquifer zone was defined by the first carbonate unit (usually within the Everton) encountered. If there is insufficient thickness of the aquifer, and/or it is inadequately fractured, drilling must continue to the Cotter and Jefferson City formations. A small number of
A Preliminary Investigation of Rural-Use Aquifers of Boone, Carroll, and Madison Counties, Arkansas

wells obtain water from carbonate units within the Everett and Powell Formations.

The Cotter and Jefferson City Formations make up the third major aquifer in the study area. This aquifer is primarily dolomite and is used mostly where the Cotter Dolomite is exposed on the Salem Plateau surface (Figure 2). The aquifer has a range in yield of 1.5 to 200 gpm with a median yield of 15 gpm (Table 1). Well depths range from 130 to 1010 feet with a median depth of 475 feet. The greater depths represent the few wells that begin in the Boone. Yield values for a few wells contain water contributions from overlying aquifers, but this is generally insignificant.

**GEOSTATISTICAL RELATIONSHIPS**

The relationships among yield, regolith thickness, and photo-lineament proximity were determined for the hydrologic data accumulated for Boone County, Arkansas, as a means for better well site location. The Spearman-Rank Correlation Coefficient was used for the comparisons with the aid of computer SAS (Barr et al., 1976) procedures.

The first relationship tested was between well yield (gpm), estimated by drillers, and photo-lineament proximity. Parizek (1976) has found a relationship between these two for dolomites in central Pennsylvania which he attributes to photo-lineaments representing zones of fracturing that cause higher aquifer permeabilities and thus greater well yields. Using the data from each aquifer individually in Boone County, a relationship was not found at an alpha = 0.1 probability level. This may be due to sparse data within an individual data set. When grouped together, the aquifers showed a relationship, but the authors do not feel this is of strong geologic significance.

A comparison between well yields for wells in bedrock and regolith thickness was made. The regolith thickness ranged from 1 to 217 feet with a median of 28 feet. One hundred and sixty-three yield and regolith values from Boone County wells were used in this test. A relationship indicating higher yields for wells drilled in thicker regolith was found at an alpha = 0.1 significance level for the Boone and Sylamore-Clifty-Everton aquifers individually, and the combined well data. In carbonate rocks, weathering takes place deeper along fractures than along unfractured areas, often yielding an irregular regolith-bedrock contact of pinnacles and cutters (Sweeting, 1973). Therefore, a linear relationship between greater yield and thicker regolith is expected since water can more easily move along the more weathered fracture zones.

Finally, a comparison was made between regolith thickness and photo-lineament proximity. A significant relationship was found at an alpha = 0.005 significance level utilizing all the aquifer data. There are two important implications of this significant relationship. The first is that most of the mapped photo-lineaments are accurately representing fracture zones along which deeper weathering has taken place compared with unfractured zones. The second is that by drilling a well where regolith is thicker in a given area, the yield can be expected to be higher even if a photo-lineament cannot be found near a well site. Regolith thicknesses can be determined from exploration drilling and seismic and resistivity techniques to utilize this well site selection method.

**SUMMARY AND CONCLUSION**

Three important aquifers representing combinations of pre-Pennsylvanian geologic formations exist in Boone, Carroll, and northern Madison Counties. Ranged from oldest to youngest, most productive to least productive, and deepest to shallowest, they are: (1) Cotter-Jefferson City, (2) upper Everett-Clifty-Sylamore, and (3) Boone-St. Joe aquifer zones. The upper Everett-Clifty-Sylamore aquifer zone is commonly used on the Springfield Plateau when the Boone-St. Joe aquifer lacks adequate production. The Cotter-Jefferson City is used throughout the Salem Plateau of Arkansas, and it is occasionally penetrated on the Springfield Plateau where the Boone-St. Joe and Sylamore-Clifty-Everton are unproductive.

Geostatistical correlations show that greater yields can be found where there is thicker regolith. Increased regolith thickness along photo-lineaments indicates that most of the photo-lineaments accurately represent fractures along which weathering is more extensive than in unfractured areas. Although not statistically confirmed, an increase in yield is also expected along photo-lineaments.

**LITERATURE CITED**


CAPLAN, W. M. 1957. Subsurface geology of Northwestern Arkan-


HANSON, B. C. 1973. A fracture pattern analysis employing small scale photography with emphasis on groundwater movement in

60 Arkansas Academy of Science Proceedings, Vol. XXXIII, 1979


HUNT, M. C. 1974. The geohydrology of an area near Beaver Reser-
voir in Northwest Arkansas. Unpubl. M.S. Thesis, University of Ar-
kanas, 100 p.

LAMONDS, A. G. 1972. Water resources reconnaissance of the Ozark Plateau Province, Northern Arkansas. Hydrologic In-

PARIZEK, R. R. 1976. On the nature and significance of fracture traces and lineaments in carbonate and other terranes. Karst Hy-
drology and Water Resources, Vol. 1. Water Resources Publica-
tions, Fort Collins, Colorado, p. 3-1 to 3-62.


REZAIE, M. N. A. E. OGDEN and W. H. WILLIS. 1979. Aquifer charac-
teristics of the Boone-St. Joe aquifer in NW Arkansas (ab-


SUHM, R. W. 1970. Stratigraphy of the Everett Formation (Early Med-

Time Course of PR of UV-Induced Chromosomal Aberrations and Lethal Damage in S and G2 Xenopus Cells

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Siloam Springs, Arkansas 72761

ABSTRACT

S and G2 phase cells were exposed to 150 ergs mm$^{-2}$ UV and their ability to photoreactivate the induced cell killing (loss of colony forming ability) and chromosomal aberrations was determined as a function of time following the UV exposure. In S phase cells, the lesions leading to cell death and those leading to aberrations were both converted to a non-photoreactivable state shortly after the UV exposure. A significant fraction of the lesions induced in G2 cells, that led to cell death, were converted to a non-photoreactivable state before the progeny of the exposed cells reached the next succeeding S phase. Few, if any, lesions were induced in G2 cells that were expressed as aberrations at the first mitosis following exposure. Some of the lesions induced in G2 cells led to aberrations that were observable in the progeny that progressed to the second mitosis following exposure. These lesions were converted to a non-photoreactivatable state as the progeny of the exposed G2 cells progressed through the first S phase following exposure.

INTRODUCTION

Due primarily to its unusually efficient photoreactivation (PR) mechanism, the A8W243 Xenopus tissue culture cell line has proven to be a superior system for the study of many UV-induced effects in vertebrate cells (Griggs and Bender, 1972, 1973; Orr and Griggs, 1976). Recently Payne and Griggs (1977) reported a study with G$_2$ phase Xenopus cells in which this PR mechanism was used to examine the extent of overlap of UV-induced lesions that lead to chromosomal aberrations (aberrational lesions) and UV-induced lesions that lead to cell death (lethal lesions). Synchronous cultures of G$_2$ cells were irradiated with 120 ergs mm$^{-2}$ UV. As the cells progressed through the cycle to the first succeeding mitosis (M1), the extent of PR of induced lethal and aberrational damage was determined as a function of time. A significant fraction of the lethal lesions was converted to a non-photoreactivable state while the cells were in G$_1$ phase, but most of the aberrational lesions were converted to a non-photoreactivable state as the cells entered S phase, indicating that many of the lethal lesions were not identical to those that were formed and that different intracellular mechanisms were responsible for their expression. We report here two sets of experiments which constitute an extension of these time course of PR studies with Xenopus cells: the first set was performed to examine the overlap of UV-induced lethal and aberrational lesions in G$_2$ phase cells.

MATERIALS AND METHODS

The A8W243 Xenopus line used by Payne and Griggs (1977) was also utilized in this study. Routine procedures such as incubations, irradiations, DNA labelling with tritiated thymidine (HTdR), mitotic index determination, survival determinations, colcemid treatment, preparation of metaphase spreads, and chromosome scoring were the same as described earlier (Griggs and Bender, 1972, 1973; Wolff, 1981).

Experiments performed to describe the degree of overlap of lethal and aberrational damage induced in S cells by UV were carried out in essentially the same manner as the time course of PR experiments with G$_2$ cells reported by Payne and Griggs, 1977.

The procedures used in experiments to examine overlap of lethal and aberrational lesions induced in G2 cells by UV differed somewhat from those employed in experiments with S cells. Since no method was available for obtaining synchronous cultures of G2 cells, the starting point of these experiments was UV irradiation of vigorously growing log phase cultures. As the progeny of the G2 cells (in the exposed log phase cultures) progressed through M1 and the following cell cycle, attempts were made to describe the degree of overlap of lesions by time course of PR techniques. Synchronous cultures of G$_1$ cells, which were progeny of the exposed G2 cells that progressed through M1, were required in a number of experiments. These cultures were obtained by the following technique. Half the members of a set of vigorously growing log phase monolayers were labelled with HTdR and, immediately afterwards, the entire set was exposed to 150 ergs mm$^{-2}$ UV. Periodic agitation of these monolayers with a mechanical agitator yielded suspensions of cells with mitotic indices ranging from 50-70 percent. Autoradiographs prepared from suspensions obtained from labelled monolayers indicated that 99 percent of the mitotic cells were devoid of label, and thus derived from exposed G2 cells. The suspensions that contained no labelled cells were seeded into a large glass petri plate which contained BSS and fetal calf serum (Icc serum / 100cc BSS). At room temperature the cells quickly settled to the bottom of the plate but remained detached, and each cell which completed mitosis formed two small G$_1$ cells that remained in close proximity (double). These doubles could be identified and separated from other components of the suspension with the aid of a stereomicroscope and micropipette. New suspensions of early G$_1$ cells which exhibited a high degree of synchrony were thus obtained.

RESULTS AND DISCUSSION

Results of the time course of PR of lethal damage are shown in Table 3. Experiments 1-5 were performed to determine whether lethal damage was converted to a non-photoreactivatable state during the first 3 hours following UV irradiation. No method was available for obtaining suitable samples of G2 and mitotic cells for the survival determinations in these experiments. However, the labelling and mitotic index data of Figure 1 indicate that virtually all of the G2 cells in the UV exposed log phase cultures progress to M1 without significant delay. Furthermore, routine mitotic index determinations of cell
Time Course of PR of UV-Induced Chromosomal Aberrations and Lethal Damage in S and G2 Xenopus Cells

Table 1. Time course of PR of lethal damage induced in early S phase cells by UV. UV was administered at a dose rate of 5 ergs mm\(^{-2}\) sec\(^{-1}\) and PR light was administered at a dose rate of 100 ergs mm\(^{-2}\) sec\(^{-1}\).

<table>
<thead>
<tr>
<th>Experiment number</th>
<th>UV dose rate</th>
<th>PR dose rate</th>
<th>PR time</th>
<th>Number cells isolated</th>
<th>Number colonies assessed</th>
<th>Surviving fraction</th>
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<td>2000</td>
<td>19</td>
<td>0.01</td>
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</tbody>
</table>

*Metaphase cells were collected by colcemid treatments that spanned the indicated time ranges.

suspensions obtained by agitation of UV exposed log phase cultures, coupled with stereomicroscopic determinations of the fractions of cells in these suspensions that form "doubles," indicated that more than 98 percent of the mitotic cells progressed to M1. Thus, since practically all the UV exposed G2 cells progressed through M1, suitable sets of cells for the survival determinations in experiments 1-5 could be obtained from sets of early G2 cells which were progeny of the treated G2 cells that progressed through M1. Progeny of the treated G2 cells that completed M1 were also the source of sets of cells isolated for survival determinations in experiments 6-12. The data of experiments 1-5 and Figure 1 indicate that little, if any, of the lethal damage can be photoreactivated as cells progress through G2 phase and early M1. The data of experiments 6-12 closely parallel results of the time course of PR of lethal damage in G2 cells (Payne and Griggs, 1977), indicating that much of the lethal damage is converted to a non-photoreactivable state as progeny of the UV exposed G2 cells progress through the first G1 phase following the exposure.

Results of the time course of PR of aberrational damage induced in G2 cells by UV are shown in Table 4. The data of experiments 1 and 2 indicate that the amount of aberrational damage expressed when the UV exposed cells reach M1 is negligible, as compared with the amount expressed when the progeny of the exposed cells reach M2. The data of experiments 3-11 closely parallel results of the similar study with G1 phase cells (Payne and Griggs, 1977). Data of experiments 3-6 strongly suggest that aberrational damage could be photo-reactivated in the progeny of the UV exposed G2 cells as these progeny progressed through the first G1 phase following M1, while the data of experiments 7-11 suggest that aberrational damage is converted to a non-photoreactivable state as the progeny progress through the first S phase following M1.

A suitable explanation for the observation that G2 cells have little, if any, PR ability cannot be deduced from the data presented here. Further elucidation of the manner in which PR related to chromosome structure appears to be required. One might conjecture at this point, however, that the chromosome supercoiling and condensation processes operating in G2 cells (Prescott, 1970) might significantly decrease PR ability by somehow preventing normal complexing of PR enzyme with UV-induced dimers in DNA.

Table 2. Time course of PR of aberrational damage induced in early S phase cells by 150 ergs mm\(^{-2}\) sec\(^{-1}\) UV. PR light was administered at a dose rate of 100 ergs mm\(^{-2}\) sec\(^{-1}\).

<table>
<thead>
<tr>
<th>Experiment number</th>
<th>UV dose rate</th>
<th>PR dose rate</th>
<th>PR time</th>
<th>Cell population</th>
<th>Number cells isolated</th>
<th>Chromosomal aberrations</th>
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<td>0</td>
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<td>30-50</td>
<td>500</td>
<td>20</td>
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</tr>
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<td>3</td>
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<td>500</td>
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Table 3. Time course of PR of lethal damage induced in G2 cells by UV. A UV dose rate of 5 ergs mm\(^{-2}\) sec\(^{-1}\) and a PR dose rate of 100 ergs mm\(^{-2}\) sec\(^{-1}\) were used.

<table>
<thead>
<tr>
<th>Experiment number</th>
<th>UV dose rate</th>
<th>PR dose rate</th>
<th>PR time</th>
<th>Number cells isolated</th>
<th>Number colonies assessed</th>
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*In experiments 2-4, UV irradiated G2 cells were photoreactivated before they reached M1, and the sets of cells isolated were subsets of the populations of early G1 cells, which were produced as the UV exposed cells completed M1. In experiments 5-10, progeny of UV exposed G2 cells that progressed through M1 were photoreactivated at the times indicated, and cells were isolated immediately after PR.

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https://scholarworks.uark.edu/jaas/vol33/iss1/1
Table 4. Time course of PR of aberrational damage induced in G2 cells by 150 ergs mm$^{-2}$ UV. PR light was administered at a dose rate of 100 ergs mm$^{-2}$ sec$^{-1}$.

<table>
<thead>
<tr>
<th>Experiment</th>
<th>PR time (hrs after UV)</th>
<th>PR dose (ergs)</th>
<th>Cell collection time range (hrs after UV)**</th>
<th>Number of cells scored</th>
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<td>500</td>
<td>141</td>
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</tbody>
</table>

*M1 metaphase cells were analyzed in experiments 1, while M2 metaphase cells were analyzed in experiments 2-10.

**Metaphase cells were collected by colcemid treatments that spanned the indicated time ranges.

LITERATURE CITED


Genic Variation in White-tailed Deer From Arkansas

PHYLLIS K. PRICE, MICHAEL CARTWRIGHT, and MITCHELL J. ROGERS

ABSTRACT

Liver and kidney samples of 33 white-tailed deer (Odocoileus virginianus) representing three populations in Arkansas were examined with horizontal starch gel electrophoresis. Of 17 loci examined, only PGM-1 and ES-2 exhibited polymorphism. Average individual heterozygosity, ranging from 2.3% to 4.7% with a mean of 3.1%, was much lower than that reported for white-tailed deer in other parts of its range. The three populations examined in this study were highly similar based on Rogers' genetic similarity coefficient.

INTRODUCTION

Several investigators have used electrophoretic techniques to study the genetics of white-tailed deer, Odocoileus virginianus. Cowan and Johnston (1962), Weinberger (1964), Miller et al. (1965), Harris et al. (1973), and others have examined blood proteins with a major emphasis on hemoglobin. Manlove et al. (1975), Baccus et al. (1977), Johns et al. (1977), and Ramsey et al. (1979) studied liver and kidney proteins in addition to blood proteins and extensively examined relationships between heterogeneity and age, sex, and/or reproductive rate; spatial subdivisions of populations based on single locus gene frequencies were also examined.

Harris et al. (1973) included deer from two Arkansas counties (Stone and Desha) in an analysis of hemoglobin variation over the southeastern United States. However, at this time, there is still relatively no published genic information concerning white-tailed deer from Arkansas. Smith et al. (1976) have noted the use of such data in wildlife management practices. Since genic information may have important management application, the purpose of our study was to: (1) examine the genic composition of deer from Arkansas and (2) compare enclosed and non-enclosed populations.

MATERIALS AND METHODS

Two populations occupied Caney and Big Springs enclosures which encompass 243 and 273 hectares, respectively. The enclosures, located within the Sylamore District of the Ozark National Forest in north-central Arkansas, are separated by approximately 402 meters and have been maintained since 1962. Background information on the enclosures has been given by Segelquist and Green (1968) and Segelquist et al. (1969). A non-enclosed population was represented by deer in the Sylamore Wildlife Management Area (Sylamore WMA) surrounding the enclosures.

Liver and kidney samples of 33 white-tailed deer were obtained from the enclosures and the surrounding Sylamore WMA between January and March 1978. Information as to age and sex was available for 29 of 33 animals. Ages ranged from 0.5 to 15.5 years, with the majority of animals between 1.5 and 5.5 years. Number of known males and females for each sample are given in Table 1.

Tissues were subjected to horizontal starch gel electrophoresis. Apparatus, tissue preparation, buffer systems, and staining procedures were similar to those of Selander et al. (1971) and Manlove et al. (1975). The following 14 protein systems encoded by 19 loci were examined: albumin (ALB), esterases (ES-2, ES-4), glutamate dehydrogenase (GDH), glutamate oxalate transaminase (GOT-1, GOT-2), a-glycerophosphate dehydrogenase (a-GPD), indophenol oxidase (IPO), isocitrate dehydrogenase (IDH-1, IDH-2), lactate dehydrogenase (LDH-1, LDH-2, LDH-3), malate dehydrogenase (MDH-1, MDH-2), malic enzyme (ME), 6-phosphogluconate dehydrogenase (6-PGD), phosphoglucomutase (PGM-1), phosphoglucomerase isomerase (PGI), and sorbitol dehydrogenase (SDH). PGI was scored as a single allele although Manlove et al. (1975) has hypothesized the presence of two loci for this protein in white-tailed deer. Scoring of the remaining systems followed the method of Manlove et al. (1975). ME and SDH were not consistently scorable and, thus, not included in subsequent analysis. Allele frequencies and average individual heterozygosity (H = number of individuals x number of loci) were determined from genotype counts. Comparisons of paired combinations of populations were based on allele frequencies analyzed by Rogers’ (1972) coefficient of genetic similarity. The resulting matrix was subjected to the unweighted pair-group method using arithmetic averages of cluster analysis from NT-SYS programs (Rohlf, 1969).

RESULTS AND DISCUSSION

Of 17 scorable loci, only ES-2 and PGM-1 exhibited polymorphism (Table 1). Two alleles were present at the ES-2 locus. The homozygous state of the fast allele (designated a) appeared as a fast-migrating band, while the homozygous state of the slow allele (designated b) appeared as a slow-migrating band. The heterozygote was expressed as a triple-banded pattern. Manlove et al. (1975) noted three alleles at ES-2. In their study, cathodal subbanding for homozygotes of two alleles and anodal subbanding for homozygotes of their slowest allele gave the appearance of an intense band and a light subband for homozygotes. Heterozygotes were expressed as two intense bands and one or two light subbands depending on allelic composition. In the present study, two ES-2 alleles were expressed at equal frequencies in the sample from Sylamore WMA and at near equal frequencies in the sample from Caney enclosure. Animals from Big Springs enclosure showed a predominance for the slower allele.

Variation at the PGM-1 locus was limited to a single heterozygote in the Sylamore WMA sample. The heterozygote, expressed as two bands, indicated the presence of a slow allele (designated b in Table 1). The homozygous state of the fast allele appeared as single fast-migrating bands. This locus is probably the same as the PGM-2 locus of Manlove et al. (1975). They noted the presence of three alleles at PGM-2 in homozygous and heterozygous states.

Although SDH was not consistently scorable, this locus did indicate polymorphism. Manlove et al. (1975), Baccus et al. (1977), Johns et al. (1977), and Ramsey et al. (1979) also noted variation at GDH-1, LDH-2, and MDH-1 which were monomorphic in our samples.

Cowan and Johnston (1962), Miller et al. (1965), Tets and Cowans (1966), and Seal and Erickson (1969) have noted very limited significant differences between sexes, age classes, or seasons in mobility of blood proteins. Ramsey et al. (1979) have observed significant differences between herds, sexes, or age classes for gene frequencies at the hemoglobin and ES-2 loci using large samples of white-tailed deer. Also using large sample sizes, Johns et al. (1977) noted a positive correlation between reproduction and H, indicating a higher frequency for females with two fetuses vs. females with one fetus. Of 17 known females in the present study, 11 had two fetuses, and three
Genetic Variation in White-tailed Deer from Arkansas

were not pregnant. N0 trend was apparent for the reproductive data as well as the age and sex data.

Values of $H$ obtained in the present examination of white-tailed deer were quite low in comparison to those from other areas. As seen in Table 1, $H$ ranged from 2.3% for the Caney sample to 4.7% for the Sylamore WMA sample with a mean of 3.1%. The low $H$ values may be partially accounted for by the kind of loci examined. Harris et al. (1973) observed beta-hemoglobin polymorphism in their samples of white-tailed deer from Arkansas. Hemoglobin and SDH loci may be additional sources of variation. Studies including kidney, liver, and blood proteins yielded $H$ values averaging 12.1% (Smith et al., 1976), 9.1% (Johns et al., 1977), and 12.7% (Ramsey et al., 1979) with SDH, hemoglobin, and ES-2 as major contributors.

The two enclosed population samples had similar $H$ values which were lower than those for the non-enclosed population sample (Table 1). The lower values could be indicative of inbreeding within the enclosures which reduces genetic variability (Smith et al., 1976). The Caney sample represents that entire population which has been terminated. Within such a small population, inbreeding would be expected. Smith et al. (1976) have noted that the effects of inbreeding in natural populations are not really known; however, unfavorable consequences of inbreeding have been well illustrated in laboratory and domestic animals. Genic variability may also be reduced due to genetic drift which would occur when only a few animals are introduced into a small population (Smith et al., 1976). After the cessation of restocking, Caney enclosure had very limited change in population size; such conditions would favor genetic drift (Smith et al., 1976). A similar situation was probably present for Big Springs enclosure.

The biochemical matrix obtained from Rogers’ genetic similarity coefficient shows all samples to be highly similar (Table 2). These relationships are depicted in the resulting dendrogram (Figure 1). The high degree of similarity for the three population samples may be due to the initial stocking of the enclosures and subsequent restocking of the enclosures until approximately 1969 from the surrounding Sylamore WMA. Each enclosure may have had similar genetic input. Caney enclosure has suffered high fawn mortality at least in recent years with a similar situation probably present at Big Springs enclosure. Thus, similarity between the three population samples could be partially explained by the lack of opportunity for new combinations of genes to occur. Since few fawns were reaching an age to become part of the effective breeding population and since the deer being stocked into the enclosures were probably genetically similar to those already present, little new genetic input into the population was occurring.

The current study has shown a reduction in genetic variability in deer probably due to inbreeding, genetic drift, and/or lack of change in the effective breeding structure of the populations. Since there was little new genetic input into the enclosed populations, opportunity for genetic change was limited. Smith et al. (1976) pointed out that mutation is the only way new genetic material may be developed from within a population but is an insignificant source of variation during time intervals that are meaningful in a management context. Selection and emigration will alter gene frequencies of population but do not add new material. New genetic information must come from additional introductions or immigrations. Therefore, in the re-introduction of species into areas, the investigator should introduce the maximum number from a variety of sources to found new populations (Smith et al., 1976). The significant genetic considerations for stocking of species is discussed by Smith et al. (1976).

Additional work is needed to better understand the genic structure of Arkansas deer. Future works may well show how genic studies can be of use in discriminating breeding units, assessing degree of inbreeding, and increasing herd productivity in deer.

ACKNOWLEDGEMENT

We wish to thank Michael L. Kennedy for critically reading this manuscript.

LITERATURE CITED


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Abundance, Diversity and Distribution of Benthic Macro-Invertebrates in the Flat Bayou Drainage Area, Jefferson County, Arkansas

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ABSTRACT

The main ditch of Flat Bayou Drainage in north central Jefferson County carries water southward into Plum Bayou which then shortly empties into the Arkansas River. Flat Bayou proper flows northward into Wabbaseka Bayou which in turn flows into the Arkansas River in northeastern Lincoln County. Two sites on the main ditch and tributaries and acreage north central Arkansas are sampled for physico-chemical characteristics and benthic macroinvertebrates on 9 September, 7 October and 11 November 1978. No visible detrimental effects were attributed to physico-chemical characteristics. Thirty-one below-family taxa and 19 families were found in abundance from zero at one site and date to 3580 per m² at one site and date. Corbicula was by far the most numerous taxon whereas several taxa (e.g. Placiocella, Piscicola, Lampsilis, Unio, Merostomata) were less abundant and were found in abundance from zero at one site and date. Dominance indices were generally greater, and distribution values indicated stronger clumping at Site 1 whereas diversity values were generally greater at Site 2. These indicated the substrate at Site 2 was more suitable for community development.

INTRODUCTION

The main ditch of Flat Bayou is a small tributary of Plum Bayou, Jefferson County, Arkansas (Fig. 1). Both drainages originate in north central Jefferson County and flow generally southward to join about 0.8 km (0.5 mi) before Plum Bayou joins the Arkansas River about 4.9 km (3 mi) upstream from Lock and Dam No. 4. In this area much acreage is cultivated for commercial production of soybeans and cotton. Relatively thin strips of bottomland hardwoods line the bayou tributaries and drainage ditches making suitable but sparse cover for wildlife. A series of constructed ditches lateral and upstream to the bayou proper originates near the town of Altheimer and flows northward about 11.3 km (7 mi) to Wabbaseka Bayou. However, because of the proximity of the main ditch to the Flat Bayou, the former apparently handles most of the area’s drainage. This study was funded by the Soil Conservation Service (SCS) and will be used to plan methods of reducing damage from floodwater, drainage and erosion.

MATERIALS AND METHODS

A. Description of sites. Site 1 was about 0.4 km (0.25 mi) above its confluence with Plum Bayou (T5S.R8W.S6). A levee between the sample site and Plum Bayou and flood gates help protect the nearby farmland. The substrate at Site 1 included numerous large rocks and concrete fragments near the end of a large culvert. Beyond 6 m (20 ft) made up of “pebbly” clay (when sieved the clay would roll up into pebble-like balls 3-10 mm diameter). Algae covered about 5% of the bottom. Site 2 was 2.4 km (1.5 mi) north of U.S. Highway 79 (T4S.R8W.S29) 0.4 km upstream from the entrance of lateral ditch no. 1. The substrate here contained much finely divided and very soft silt and organic matter. The organic matter was an evenly distributed mixture of sticks and leaves. Algae covered about 95% of the bottom.

B. Physico-chemical measurements. Weather data (percent cloud cover, precipitation and air temperature), physical characteristics of the water (temperature, flow, width, depth and turbidity) and chemical parameters (dissolved oxygen, pH, alkalinity, carbon dioxide, nitrate and phosphate) were recorded on 9 September, 7 October and 11 November 1978. Stream flow was measured with a General Oceanics Model 2031 impeller-type flowmeter. Chemical parameters were measured in the field with a HACH DR-EL “Engineer's Laboratory.”

C. Benthos. Five benthic samples using a 6 x 6-inch (232 cm²) standard Ekman grab were taken at each site on each date. Each sample was rinsed in a sieving bucket having a mesh size of approximately 0.5 mm, transferred to a wide-mouth glass jar and transported to the lab. The first series (9 Sep) was frozen until sorting and identification could be done, but this was unsuitable because a few oligochaetes were apparently lost. Samples in the other two series were preserved in 5% formalin immediately upon collection. After sorting, the specimens were put into 70% Ethanol. Identifications to genus, except Oligochaeta and Chironomidae, were made using keys in Edmondson (1959), Pennak (1953), Ussing (1958) and Merritt and Cummins (1978). Finally the specimens were counted, dried and weighed (EPA 1973). Not all the organisms in the family Chironomidae and the families of Oligochaeta were identified to genus because these groups present serious taxonomic problems; they were labelled “A”, “B”, etc.

Abundances of individual taxa were compared between the two sites using the Wilcoxon two-sample test of rank values. Single values for community dominance were calculated according to the formula, c = X(N) where ni is the numerical importance value for each taxon in turn, and N is the total of individual m's (Odum 1971). Diversity (d) values were calculated by the formula, d = -Σni/Nlog(N), where ni and N are the same as in the previous calculation (Odum 1971). Distribution of individuals with respect to one another was judged by observing the variance, v = Σ(iX-NX²)/(N-I) of the subsamples (Odum 1971).

There is room for error because a few subsamples, but these should not be ignored.

RESULTS AND DISCUSSION

A. Physico-chemical. Physico-chemical measurements were usually well within the range of expectation and caused no visible detrimental effects on the benthos within the study period (Table 1). Stream flow was not measurable on 7 Oct and 11 Nov, dissolved oxygen was somewhat low at Site 1 on 9 Sep, and phosphate was...
Abundance, Diversity and Distribution of Benthic Macro-invertebrates in the flat Bayou Drainage Area

Table 1. Physico-chemical Characteristics of Water, Sites 1 and 2.

<table>
<thead>
<tr>
<th>Site</th>
<th>Date</th>
<th>T</th>
<th>ch</th>
<th>pH</th>
<th>TEMP</th>
<th>DO</th>
<th>NO₃</th>
<th>PH₈</th>
<th>PO₄</th>
<th>SOR</th>
<th>T</th>
<th>O₂</th>
<th>B.O.D.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Site 1</td>
<td>9 Sep</td>
<td>10</td>
<td>15</td>
<td>23</td>
<td>20</td>
<td>4</td>
<td>0.2</td>
<td>5.6</td>
<td>0.8</td>
<td>0.1</td>
<td>10</td>
<td>60</td>
<td>15.0</td>
</tr>
<tr>
<td>Site 2</td>
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<td>10</td>
<td>15</td>
<td>23</td>
<td>20</td>
<td>4</td>
<td>0.2</td>
<td>5.6</td>
<td>0.8</td>
<td>0.1</td>
<td>10</td>
<td>60</td>
<td>15.0</td>
</tr>
<tr>
<td>Site 1</td>
<td>11 Nov</td>
<td>10</td>
<td>15</td>
<td>23</td>
<td>20</td>
<td>4</td>
<td>0.2</td>
<td>5.6</td>
<td>0.8</td>
<td>0.1</td>
<td>10</td>
<td>60</td>
<td>15.0</td>
</tr>
</tbody>
</table>

*Began sprinkling rain about 1230, lasted about 20 minutes.

Figure 1. Jefferson County, Arkansas showing sample Sites 1 and 2. A = Pine Bluff; B = Arkansas River; C = Plumb Bayou; D = Flat Bayou; E = Wabbaseka Bayou; F = Bayou Meto.

Figure 2. Arrangement of drainage ditches with locations of sample sites. Arrows mark direction of flow.

quite high at Site 2 on 7 Oct. I was not able to determine if the large concentration of phosphate was correlated with the application of fertilizer.

B. Benthos. Thirty-one species representing 19 families of invertebrates were present (Table 2). Some taxonomic review of Plecoptera is currently in progress but incomplete at the time of manuscript preparation (Mr. Mark Gordon, pers. comm.). Table 3 gives a summary of numbers and weights per m², whereas Figure 3 shows changes with time in numbers of the five most abundant groups.

Oligochaeta and Hirudinea were more abundant at Site 2, while Mollusca were generally more abundant at Site 1. Diptera increased with time at Site 1 and decreased with time at Site 2. Naididae "B" was the most abundant oligochaete, Helobdella the most abundant leech, Corbicula the most abundant pelecypod, Amnicola the most abundant gastropod and chironomid "A" the most abundant dip-teran. Several groups could be considered incidental, having occurred only once (Tubificidae, Placobdella, Piscicolaria, Lampsilis, Campeloma, Berrosus and Patapomya). Branchiobdellidae, Naididae "C" and Unionoides were found in two samples on the same date, whereas Laguncula and chironomid "B" were found twice in different dates, and chironomid "D" was found twice at different sites.

The total benthic abundance was greater at Site 1 than at Site 2 on all dates because of the large numbers of Corbicula, but abundance of individual taxa was generally greater at Site 2. On 7 Oct the difference in abundance was significant at $a = 0.05$ but not significant at $a = 0.10$ on 9 Sep and 11 Nov.

Dominance values range from zero to one, the larger indicating a greater degree of dominance in the community (Table 4). The dominant taxa appeared to be Naididae "B", Corbicula, Amnicola and Chironomidae "A." By number, Site 1 exhibited greater dominance on 9 Sep and 11 Nov., but by weight Site 1 showed greater dominance on all dates. Dominance is generally stronger in communities subject to harsh climates, poor habitat or in subclimatic stages of ecological succession (Odum 1971).

Table 4 also gives diversity values. Lower values indicate lower diversity and generally greater dominance. Obviously these are relative and used only for comparison of two or more communities. Of 16 paired diversity values, 14 were larger at Site 2 indicating the environment was more suitable for community development. At Site 1 gastropods were more diverse than pelecypods and insects more then mollusks. At Site 2 pelecypods were more diverse than gastropods, while mollusks were more diverse than insects. Change in diversity with time was variable, Site 1 exhibiting a general increase for all benthos, while Site 2 showed a decrease. Oligochaete diversity decreased at Site 1, while pelecypods increased at both sites. Insect diversity at Site 2 showed a sharp rise on 7 Oct but dropped again to the initial value on 11 Nov. There seems to be no clear distinction between the two sites regarding changes in diversity.

A variance of one indicates random distribution, but if greater than one it tends to be clumped. Table 4 shows that most of the groups are highly clumped. Of the 13 paired values the variance was larger at Site 1 nine times, indicating the benthic substrate was more highly variable causing clumped distributions (this varied substrate was also directly observed). Plecoptera were the most highly clumped at Site 1 whereas oligochaetes were at Site 2. Diptera were least clumped at both sites. Change in clumping with time was highly variable, both sites showing a general increase for all benthos, but within there was considerable variation. Pelecypods at Site 1 exhibited reversal ending with greater clumping and at Site 2 showed a uniform increase. Gastropods at Site 1 exhibited reversal ending with less clumping but at Site 2 showed a uniform increase. Diptera increased at Site 1 and decreased at Site 2. This seems to indicate the substrate at Site 2 was more variable and consistent with time (seasonal change).

While this drainage system is man-made and probably would not resemble a natural southeastern Arkansas bayou in every respect, there are similar characteristics because several years have elapsed since the most recent maintenance effort. Year round sampling would probably yield additional taxa and possibly seasonally variable diversity and dominance. Also, different sampling techniques would probably have yielded additional taxa, but SCS specifications called

https://scholarworks.uark.edu/jaas/vol33/iss1/1
for Ekman sampling only. On 28 July 1978 I visited Site 1, captured Pantala flavescens and Erythemis simplicicollis and observed Plathemis lydia, Libellula luctuosa and Pachydiplax longipennis. At Site 2 I caught E. simplicicollis, L. luctuosa and P. longipennis. All of these were adult dragonflies (Odonata). Callahan and Harp (1976) reported two species of Isopods, numerous mayflies including the genera Hexagenia and Stenonema and several species each in the orders Odonata, Hemiptera. Trichoptera and Diptera in Big Creek, a typical delta stream. Many of these would probably be found in Flat Bayou area upon further investigation.

**SUMMARY**

Both sites on the main ditch of Flat Bayou appear to be marginally suited for healthy aquatic populations but possess a surprising variety of benthic invertebrates — 31 species representing 19 families. Most of the invertebrates were herbivores or detritivores. Substrate at Site 1 was less uniform and suitable as indicated by clumping and diversity values. It was mostly rigid clay whereas at Site 2 it was finely divided silt with much semi-decomposed vegetation embedded. Values for physico-chemical parameters were somewhat variable but apparently not detrimental during the study period. Diversity was greater at Site 2, whereas abundance and clumping were greater at Site 1. Changes in diversity and clumping with time were variable with no trends readily seen or correlated with seasonal change. Site 2 appeared to be slightly more suitable for community development.

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Table 3. Summary of Numbers (per m²) and Weights (g/m²) of Benthos, Flat Bayou Drainage area, 1978

<table>
<thead>
<tr>
<th>Date</th>
<th>Site 1</th>
<th>Site 2</th>
<th>Site 1</th>
<th>Site 2</th>
<th>Site 1</th>
<th>Site 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>9 September</td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Phasmatoda</td>
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<td></td>
</tr>
<tr>
<td>Branchiobdellidae</td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Naiadina “A”</td>
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<td>.516</td>
<td>120</td>
<td>.086</td>
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<tr>
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<td>.467</td>
<td>318</td>
<td>.301</td>
</tr>
<tr>
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<td>.172</td>
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<td></td>
</tr>
<tr>
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<td></td>
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<tr>
<td>Dina</td>
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<td>.172</td>
<td>17.2</td>
<td>.172</td>
<td>68.9</td>
<td>.315</td>
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<td>Lampsilla</td>
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<td>Ulorusmus</td>
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<td>97.0</td>
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<td>.040</td>
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Table 4. Diversity indices, Variances and Dominance values, Flat Bayou Drainage area, 1978.

<table>
<thead>
<tr>
<th></th>
<th>Diversity Indices</th>
<th>Variances</th>
<th>Dominance Values</th>
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Literature Cited


The Effect of Turf Fungicides on Earthworms

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University of Arkansas
Fayetteville, Arkansas 72701

ABSTRACT

Numerous turf fungicides were tested under various conditions for possible deleterious effects upon the earthworm Eisenia fetida. Earthworms treated by immersion for one minute in 0.1% solutions of 10 different fungicides died in significant numbers after benomyl and thiophanate methyl treatments. After 1% fungicide treatments, there was significant mortality from benomyl, ethazole, Kromad, and thiophanate methyl fungicides. With 2% fungicide solutions, significant numbers died after benomyl, cadmium succinate, ethazole, thiophanate methyl, and thiram treatments. Earthworms fed bermudagrass clippings treated with 10 different fungicides showed a significant decrease in longevity from clippings treated with benomyl, dinocap, ethazole, and thiophanate methyl.

Earthworms reared for 84 days in soil treated with 15 different turf fungicides showed a significant decrease in longevity from soil treated with anyazine, benomyl, chlorothalonil, Duosan, ethazole, fenaminozulf, Kromad, mancozeb, PCNB, thiabendazole, thiophanate methyl, and thiram. Cadmium succinate, dinocap, and RP 26019 did not cause a decrease in longevity. There was no reproduction by worms in soil treated with Duosan, PCNB, thiophanate methyl, and thiram, and only trace amounts in soil treated with chlorothalonil, ethazole, and Kromad.

The toxicity of benomyl, thiabendazole, and thiophanate methyl to earthworms was confirmed in the present study, and additional fungicides used for turf disease control were also found to cause significant amounts of mortality.

INTRODUCTION

Certain pesticides are known to be toxic to earthworms, and the toxicity of some insecticides and herbicides is well-documented (Edwards and Lofty, 1972). Information on fungicides is more limited, however, and the relative toxicities of many fungicides to earthworms are not fully known.

Copper fungicides were among the first materials reported as being toxic to earthworms (Raw and Lofty, 1962, 1963). Dinocap and thiram were reported as causing 0 to 48% and 0 to 35% reductions in earthworm populations, respectively, depending upon the time of year and soil moisture content in field tests (van der Drift, 1963). Captain has been reported as being non-toxic (Edwards and Lofty, 1972, 1973; van der Drift, 1963; Kennel, 1972), and earthworm populations in Kentucky bluegrass (Poa pratensis L.) turf treated with phenyl mercuric acetate were not significantly different from those in untreated plots (Randell, et al., 1972).

In tests which included systemic fungicides, Kennel (1972) reported that very little grass mulch was eaten by earthworms in plots treated with benomyl, thiophanate methyl, or thiabendazole. Under unspecified conditions he reported that dodine and steered sulfur apparently had no ill effect on earthworm activity. Edwards and Lofty (1973) reported no significant effect upon earthworms in field tests in which formaldehyde, captain, quintozene, thiram, or dicloran were cultivated into soil; benomyl, however, was very toxic. Stringer and Wright (1973) and Wright and Stringer (1973) conducted extensive tests upon the toxic effects of benomyl, methyl benzimidazole-2-yl carbamate (MBC), thiophanate methyl, and thiabendazole upon earthworms under various conditions. They recently reported that benzimidazole and its 2-amino analogue were nontoxic to Lumbricus terrestris when administered orally (Stringer and Wright, 1976). The fungicidal 2-substituted benzimidazoles (benomyl, carbendazim, furididorazole, and thiabendazole) and 1-(benzimidazole-2-yl)-3-buty1urea, however, were highly and equally toxic.

Stringer and Lyons (1974) reported a drastic reduction in ten resident earthworm species in orchard plots sprayed with benomyl and thiophanate methyl. Only L. terrestris and Allolobophora chlorotica failed to recover to normal levels following a two-year non-treatment period following a single year's treatment with benomyl. Black and Neely (1975) similarly observed that soon after injection of soils with benomyl there was a significant reduction in earthworm populations. Within months the populations increased substantially and in plots treated with benomyl one or more years previously the earthworm populations did not differ significantly from untreated plots.

A reduction in earthworm casta, an indirect measurement of decline in earthworm activity, has been observed locally in bentgrass plots treated with various turf fungicides (King and Dale, 1977). Some of these fungicides had not previously been tested or reported as being harmful to earthworms. Since a wide range of fungicides are used on turf, and since the activity of many of these materials against earthworms is unknown, research was conducted to determine whether they might show differential toxicity to earthworms when simultaneously tested under controlled conditions. The fungicides which were tested are used for turf disease control, but some of them are increasingly being utilized or being considered for use on field crops where their effects on earthworm populations could possibly be of ecological importance.

MATERIALS AND METHODS

The earthworms used in the study were commercially grown Eisenia fetida Savigny (kindly identified by Dr. Walter J. Harman, Department of Zoology and Physiology, Louisiana State University). In the tests the earthworms were housed in 940 ml plastic containers covered with lids containing a 33 mm hole covered with 50-mesh plastic screening for ventilation. The containers were half-filled with a steam-sterilized soil mixture consisting of 4 parts soil and 1 part sand, except where noted. Water was added periodically to maintain a moisture content of approximately 55%. The worms were normally fed a finely ground mixture of equal parts of corn and oats. Each 454 g of feed contained 11 g of bone meal. The surface feeding worms were usually fed every seven days by sprinkling a small amount of feed on the soil in each container. This feeding schedule adequately maintained untreated worms during the experiments. All worms were held in a temperature controlled room maintained at 24°C. All treatments consisted of four replications of ten worms each. Mortality of
the earthworms was determined from counts made at approximately seven day intervals. The data were statistically analyzed as randomized complete blocks.

The turf fungicides used in the tests, with designated common names and trade names were: 50% 2,4-dichloro-6-(o-chloroanilino)-s-triazine (anilazine) (Dyrene); 50% methyl 1-(butylcarbamoyl)-2-benzimidazolecarbamate (benzamide) (Tercel; 1991; c.g. and thiram), containing 29% total cadmium (Cadmine 60W); 75% tetra-chloro-isopropylthionate (chlorothalonil) (Daconil 2878); 18.25% 2,4-dinitro-6-ctlyl phenyl crotonate and 2,6-dinitro-4-ctlyl phenyl crotonate, 1.25% nitroctyl phenols (dinocap) (Karathane); 75% Duxon, a dactyon; Malathion inotro experiment(al) surf ace fungicide MF-598; 35% 2-ethoxy-3-trichloromethyl-1,2,4-thiadiazole (ethazole) (Kordak); 70% sodium /4-(dimethylamino) phenyl/ diazene-sulfonate (fenamzin-sulf) (Dexon); 5% cadmium sebacate, 5% potassium chromate, 1% malachite green, 16% thiram (Kromad); zinc and manganese, ethylenebisdithiocarbamate 80%, coordination product of 16% manganese, 2% zinc, 62% ethylenebisdithiocarbamate (mancozeb) (Fore); 75% pentachloronitrobenzene (PCNB) (Tercel); 50% 1-isopropylcarbamoyl-3 (3.5 dichlorophenyl) hydanto, Rhodia, inc. experimental surf ace fungicide RP 26019; 25% 2-(4-thiazolyl) benzimidazole, 1.5% malachite green (thiadiazol) (Tobaz); 50% dimethyl 4,4-phenylenebis (3-thiophenanate) (thiophanate methyl) (Fungitrol); and 75% bis (dithiobis Carbamoylb) disulfide (thiram) (Thiramad). All weights and concentrations in tests are expressed in terms of the commercial preparations listed above, and not on the basis of active ingredients.

Earthworm immersion in fungicide solutions.—For each treatment ten adult worms of similar size were placed into a cylindrical metal container (7.5 cm x 6.5 cm diameter) having a bottom covered with 16-mm galvanized screening. The container with worms was dipped and hung for 2 min in 500 ml of 0.1, 1.0, or 0.1% concentrations (w/v) of the aqueous fungicide solutions or suspensions in a 600 ml glass beaker. After treatment, excess fungicide solution was removed from the screened bottom of the container by blotting on clean paper toweling and the worms were then placed into soil in individual containers.

Earthworms fed fungicide-treated grass clippings.—Since turf thatch is a component of the diet of some earthworms in nature, this test was conducted to determine whether the ingestion of fungicide-treated grass clippings was deleterious to earthworms. Clippings from a pesticide-free plot of Bermudagrass (Cynodon dactylon (L.) cv. 'Common') were air dried and finely ground in a Wiley mill with a sieve of 1 mm porosity (approximately 25 mesh). For fungicide treatments, 15 g samples of this bermudagrass feed were stirred into 100 ml of 0.1% concentration solutions of fungicides. Control bermudagrass was treated with water. After 16 hr saturation, excess fungicide solution on water was removed from the bermudagrass by vacuum filtration on Whatman No. 2 filter paper using a 9 cm diameter Buchner funnel. The worm's diet consisted of only the bermudagrass feed.

Earthworms in soil containing fungicides.—The fungicides tested were mixed with 4719 cm3 of soil to simulate the dosage applied to 929 cm2 with an assumed uniform distribution to a 5.08 cm depth. The amount of fungicide mixed in the soil was the cumulative amount which would be applied to 929 cm2 of turf from five applications at the recommended dosages, except for PCNB where the amount was comparable to the amount applied from three applications. The fungicide dosages normally recommended in g/92.9 m of turf, and the amounts mixed in the soil were: anilazine, 170.10 g, 0.849 g; benomyl, 28.35 g, 0.142 g; cadmium succinate, 14.18 g, 0.071 g; chlorothalonil, 170.10 g, 0.849 g; dinocap, 7.09 g, 0.035 g; Duxon, 113.40 g, 0.566 g; ethazole, 113.40 g, 0.566 g; fenamizin, 113.40 g, 0.566 g; Kromad, 113.40 g, 0.566 g; mancozeb, 170.10 g, 0.849 g; PCNB 226.80 g, 0.679 g; RP 26019, 28.35 g, 0.142 g; thiadiazol, 5.70 g, 0.283 g; thioate, 28.35 g, 0.142 g; and thiram, 85.05 g, 0.426 g. The fungicide used in each test was mixed with 10 g of talc to aid in thorough dispersal in the soil mixture. Worms were added to the surface of the fungicide-treated soil: control treatment consisted of worms added to soil treated with 10 g of talc.

### RESULTS

#### Earthworm immersion in fungicide solutions.—With earthworms dipped in fungicide solutions for 1 min, at the 0.1% concentration, only benomyl and thiophanate methyl caused a significant reduction in longevity (Table 1). Treatment with 1% fungicide solutions resulted in significant earthworm mortality from benomyl, ethazole, Kromad, and thiophanate methyl treatments. Ethazole was most toxic with all worms being killed within seven days. Treatment at the 2% level resulted in significant mortality from treatments with benomyl, cadmium succinate, ethazole, thiophanate methyl, and thiram. Ethazole again killed all worms within seven days, whereas 75 days elapsed before benomyl and thiophanate methyl caused total mortality. Cadmium succinate and thiram caused lesser but significant amounts of mortality after 101 days.

#### Table 1. Longevity of earthworms as affected by 1 minute of immersion in different concentrations of aqueous solutions of turf fungicides.

<table>
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<tr>
<th>Treatment</th>
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<tr>
<td>Dinocap</td>
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</tr>
<tr>
<td>Kromad</td>
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<td>9.2</td>
<td>1.5</td>
<td>6.2</td>
</tr>
</tbody>
</table>

*Fungicides tested at the three concentrations included anilazine, benomyl, cadmium succinate, chlorothalonil, ethazole, Kromad, mancozeb, PCNB, thiophanate methyl, and thiram; only those materials which caused a significant increase in mortality are shown in the table.

*Figures represent average earthworm survival in trial of four replications, ten worms per treatment.

#### Earthworms fed fungicide treated grass clippings.—Earthworm populations which were fed bermudagrass clippings treated with several fungicides showed a significant increase in mortality from benomyl, ethazole, and thiophanate methyl treatments (Table 2). Worms fed grass clippings treated with thiophanate methyl were most severely affected and died in significant numbers within nine days. Worms fed the benomyl and ethazole treated clippings died in significant amounts within 34 and 84 days, respectively. After 101 days the mortality from benomyl, ethazole, and thiophanate methyl treatments was similar. Worms fed grass clippings treated with cadmium succinate showed a significantly greater longevity than control earthworms fed untreated grass clippings. In a second test, which lasted only 59 days and the results of which are not shown, a significant amount of mortality also occurred when worms were fed dinocap-treated grass clippings.

Visual observations indicated that worms fed benomyl, dinocap, and thiophanate methyl treated grass clippings ate moderate to small amounts of the clippings at the beginning of the tests, and after 2-3 weeks consumed only trace amounts. Worms fed the clippings treated with the other fungicides ate amounts comparable to that eaten by control worms fed untreated grass clippings.

#### Earthworms in soil containing fungicides.—There was a significant increase in mortality from all fungicide treatments except cadmium succinate, dinocap, and RP 26019 (Table 3) when earthworms were reared in soil. Duxon and PCNB soil treatments caused total earth-
Por E
El.

Figures represent average earthworm survival in trials consisting of four replications, ten worms per treatment.

Table 3. Longevity of earthworms when reared in soil containing different turf fungicides.

<table>
<thead>
<tr>
<th>Fungicide</th>
<th>Elapsed Time, in Days</th>
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<tr>
<td>Benomyl</td>
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<tr>
<td>Calcium carbonate</td>
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<tr>
<td>Chlorothalonil</td>
<td>9.8</td>
</tr>
<tr>
<td>Dinocap</td>
<td>10.0</td>
</tr>
<tr>
<td>Duocan</td>
<td>9.8</td>
</tr>
<tr>
<td>Eusolase</td>
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</tr>
<tr>
<td>Fenamidox</td>
<td>9.8</td>
</tr>
<tr>
<td>Grindas</td>
<td>7.6</td>
</tr>
<tr>
<td>Thiram</td>
<td>7.9</td>
</tr>
<tr>
<td>Control, no treatment</td>
<td>9.8</td>
</tr>
</tbody>
</table>

*Amounts of fungicide mixed in the soil are given in the text.

**Figures represent average earthworm survival in two trials consisting of four replications per trial, ten worms per treatment.

Worm mortality within 29 days, and thiram caused death of all worms within 64 days. The other fungicides which caused significant decreases in earthworm numbers did so after varying periods of time. Although not shown in the condensed data in Table 3, all fungicides which caused significant amounts of mortality did so within 37 days after initiation of the tests.

Earthworms in soil treated with Duocan, PCNB, and Thiram showed little feeding activity in the tests. Worms in soil treated with benomyl and thiophanate methyl fed only slightly throughout the tests. Worms in soil containing fenamidox fed normally and then stopped feeding near the end of the tests. Worms in soil treated with the other fungicides consumed feed amounts similar to that eaten by control worms in untreated soil.

There was no reproduction by worms in soil treated with Duocan, PCNB, thiophanate methyl, and thiram, and only trace amounts by worms in soil containing benomyl, fenamidox, and thiabendazole. There was an intermediate amount of reproduction by earthworms subjected to chlorothalonil, ethazole, and Kromad treatments. Worms in soil treated with the other fungicides reproduced in numbers comparable to the worms in untreated soil.

**DISCUSSION**

Of various fungicides which have previously been tested for possible deleterious effects upon earthworms, benomyl, thiabendazole, and thiophanate methyl rather consistently have been demonstrated as being toxic. Other fungicides have been reported as being non-toxic or of variable toxicity, depending upon test conditions. In the present study using E. foetida, the earthworm toxicity of benomyl, thiophanate methyl, and chlorothalonil was confirmed, and additional fungicides used for turf disease control were also found to cause significant amounts of mortality. With the two testing procedures most closely resembling conditions which could occur in nature, rearing of earthworms in fungicide-treated soil generally affected worms more adversely than when they were fed fungicide-treated feed.

Since the tests were conducted with only one earthworm species, it can only be speculated whether or not the results might be representative of the activity of the tested fungicides against other earthworms found in nature. For example, a comparison of the toxicity of benomyl mixed in soil in the present study and the toxicity observed by Stringer and Wright (1973) when benomyl was used as soil drench treatments indicates benomyl was more toxic to L. terrestris in their tests than it was to E. foetida in the present work. The amount of benomyl mixed in soil in the present study was comparable to the 7.75 kg al/ha rate of benomyl they used as one of their soil drench treatments. At this concentration 100% mortality of L. terrestris occurred within 14 days, which was the length of their experiment. Although not shown in the condensed data in Table 3, only a 65% mortality of E. foetida was observed after 19 days in the present study; after 52 days and also at termination of the test after 84 days, approximately 10% of the worms still survived. The results from the soil treatments, however, indicate that accumulations of various turf fungicides in soil possibly could affect other earthworms by direct toxicity, by affecting their feeding habits, or by causing a decrease in their reproduction.

The toxicity of turf fungicides to earthworms creates an anomalous situation with regard to turf culture. On golf course greens and fine playing surfaces, earthworms are undesirable due to roughness caused by casts formed on the surface by some species. Since earthworms are usually eliminated from greens by applications of insecticides, the toxicity of fungicides to earthworms in greens is usually not noticeable. The general elimination of earthworms from grass-covered soil, however, results in the accumulation of a layer of undecomposed plant material known as thatch which is undesirable in turfgrass culture (Beard, 1973). Although thatch on putting greens is normally removed by mechanical means, this procedure is not practical on large areas of turf. It has been reported that applications of certain insecticides and herbicides to Kentucky bluegrass turf reduced or eliminated earthworms and resulted in thatch accumulation with accompanying deterioration of turfgrass quality (Randell, et al., 1972; Turgeon, et al., 1975). The presence of earthworms could be considered a desirable attribute in maintaining turf quality with turf areas that are not closely mowed and where earthworm casts and activity are not objectionable.

The results of this and other studies suggest that some fungicides used on turf cause a reduction in earthworm numbers, especially on putting greens where fungicides are applied repeatedly during a growing season. Fortunately, on an average golf course only about 4% of the grass area is composed of putting greens which receive regular and numerous applications of fungicides. On golf course fairways, home lawns, or areas that are not closely mowed, it is problematical whether occasional applications of turf fungicides have a term effect on earthworm populations. Even though occasional applications of fungicides may not have a pronounced effect on earthworm numbers in turf or a crop area, if such areas are also subjected to treatment with insecticides and herbicides, the fungicides would constitute an additional factor of stress in the earthworm’s environment. The ecological effects of different fungicides upon earthworms in various environments merit additional consideration.

**LITERATURE CITED**


The Effect of Turf Fungicides on Earthworms


GENERAL NOTES

THE GOLDEYE IN THE BLACK RIVER

The goldeye, *Hiodon alosoides* (Rafinesque) has previously been abundant in the Hudson Bay drainage of Manitoba and is distributed from the Mississippi Valley as far west as Yellowstone and as far south as Mississippi and Alabama (Moore, George A., 1968. Fishes. In Blair, W. Frank, Albert P. Blair, Pierce Brodkorb, Fred R. Cagle, and George A. Moore. Vertebrates of the United States, McGraw-Hill Book Company, Inc., New York. IX + 616 pp. Part II, p. 53). On 2 November 1978, a single specimen was collected on an artificial spinner near Lynn, Arkansas (T15N R2W S3), by Charles Clark, and was deposited in the Arkansas State University Fish Collection (No. 8688). The specimen was an adult female, 33.1 cm in total length, 26.7 cm in standard length; it possessed 9 principal dorsal fin rays, 33 anal fin rays, 12 pectoral fin rays, 7 pelvic fin rays, and 56 scales in the lateral line.

This female specimen represents the first definite record of *H. alosoides* occurring in the Black River. Buchanan (Buchanan, Thomas M., 1973. Key to the Fishes of Arkansas, Arkansas Game and Fish Commission, Little Rock, Arkansas 72201) reported past collection sites in Arkansas at four places on the Arkansas River and one on the White and Little Red Rivers, respectively. Yeager and Beadles (Yeager, Bruce E. and John K. Beadles, 1976., Fishes of the Cane Creek Watershed in Southeast Missouri and Northeast Arkansas. Proceedings Arkansas Academy of Sciences XXX:100-104) reported catching a single specimen in the channelized portion of Cane Creek, over a sandy bottom, which represented the first record for the goldeye in the Black River System.

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NOTES ON THE DISTRIBUTION OF THE ORNATE BOX TURTLE (*Terrapene ornata ornata*) IN ARKANSAS

The ornate box turtle, *Terrapene ornata ornata*, is found in the grasslands of the Great Plains of North America, ranging from southern Wisconsin, to southeastern Wyoming, southward to the Gulf Coast of west Louisiana and Texas and westward to south Arizona and southeast Sonora (Ward, 1978).

In Arkansas, there are few records of occurrence for the ornate box turtle, and those which do exist are inconsistent and confusing. The first record of the ornate box turtle in the state was Columbia County (Huron and Strecke, 1905). schwartzi (1938) listed Garland, Lafayette, Perry, Prairie, and Washington Counties; however Delinger and Black (1938) recorded only Fulton County. Dowling (1957) felt that further confirmation was needed before the turtle was included as a native species, thus he did not include the ornate box turtle in his listing of reptiles for Arkansas. Legler (1960) mapped only one location in Arkansas where the ornate box turtle occurred and the exact location was not given in his account. Reagan (1974) included only Boone, Benton, and Prairie Counties in his discussion of the ornate box turtle in Arkansas. He did not include earlier distributional records because he felt they were not representative of the turtle’s distribution at the time of his writing (Pers. comm., 1979). Ward’s 1978 map illustrating the distribution of the ornate box turtle noted seven known and two uncertain localities where the turtle occurred in Arkansas. However, no specific locations were given for these occurrences. Unpublished records for the ornate box turtle include sightings in Prairie County (Tom Foti, 1972 and David Hunter, 1974).

In an effort to better delineate the turtle’s range in Arkansas, various prairie areas were visited by the Arkansas Natural History Commission staff from early spring to late summer in 1978. Counties and approximate acreage studied included Arkansas (40), Benton (15), Boone (65), and Franklin (300). Searches for the turtle took place on these areas from sunrise to noon. Special emphasis was placed on areas near natural breaks in vegetation as populations are found to be higher in these areas (Legler, 1960). When captured, identification of the turtles was made using Cagle (1957), Conant (1975), and Legler (1960). Specimens were captured, examined, photographed, and released at the point of their capture.

Figure 1: Arkansas counties in which occurrences of the ornate box turtle were reported from 1909 to 1978.
This survey resulted in the finding of three specimens. Two specimens were captured in May on a 65-acre prairie in Boone County (Marsh, 1978), and the third specimen was captured in July on a 40-acre prairie in Franklin County, representing the first record for this county. Thus from 1960 to 1978 there are reports of the ornate box turtle in ten counties- Benton, Boone, Fulton, Washington, Franklin, Perry, Garland, Prairie, Lafayette, and Columbia (Figure 1). Being a species which is restricted by habitat availability, the ornate box turtle has been greatly affected by the changes in land use practices occurring in Arkansas, and has been considered a rare species (Reagan, 1974). Conversion to more productive agricultural use has reduced the amount of native prairie and undisturbed grassland available to the ornate box turtle, and this may be the most important factor limiting the ornate box turtle, and this may be the most important factor limiting the ornate box turtle’s range in Arkansas. In addition, the Arkansas highway system has taken a toll because the turtle seems to exhibit a certain affinity for roadways and a great number are killed by motor vehicles (Legler, 1960 and Reagan, 1974). To properly assess the status of the ornate box turtle (*Terrapene ornata ornata*) and to eliminate confusion concerning its distribution in Arkansas a detailed study is obviously needed.

The author expresses appreciation to the following for various types of assistance during the course of this project: Dr. R. Baldauf, Dr. R. V. McDaniel, and Valerie Thwing. Dr. M. V. Plummer is gratefully acknowledged for his assistance with literature and for his confirmation of species. Special thanks is extended to the Arkansas Natural Heritage Commission and staff, for continued support and cooperation.

**LITERATURE CITED**


**MODIFICATIONS AND IMPROVEMENTS IN THE FORMAX METHOD OF PREPARING SMALL AVIAN STUDY SPECIMENS**

Traditional methods of preparing study skins of small avian specimens are often not feasible due to time and expertise required. This may be especially true when large numbers of specimens, as in the case of tower kills, need to be prepared. Sheridan (Am. Biol. Teacher, January, 1978) reported a method of preparing small avian specimens which entailed injecting formaldehyde saturated with sodium borate (Formax) into the specimen. However, he did not present the proportions of the mixture, pinning procedure, or injection amounts in the different areas of the specimen. This paper describes improvements and standardization of Sheridan’s technique.

The Formax used in our laboratory consists of 1 gram of sodium borate to 125 ml of standard (37%) formaldehyde. This mixture is easily injected into the muscles and internal organs where it diffuses throughout the tissues, drying and preserving them in place. Materials needed for preserving the specimen are minimal, requiring only syringe, needles, pins, pinning board, ruler and specimen tags. Thus, the preparation of specimens is as easy in the field as in the laboratory.

Prior to injection, standard measurements of the specimen should be taken (e.g. see Pettingill, Ornithology in laboratory and field, p. 447, 1970). Formax is then injected into the flight muscles on each side of the keel, into the abdominal cavity, and into the cranial cavity next to the eye. Larger birds require additional injections in the nape, feet, wings, and/or other parts of the body depending upon specimen size. Table 1 summarizes the amounts of Formax injected into various areas for birds of representative sizes. For additional support of the head, an elongated S-shaped wire hook is inserted down the mouth and throat (Fig. 1). The use of this wire and the drying factor of Formax increases the usefulness of the teaching specimen as it is not as fragile as one preserved by the traditional skinning method. To prevent seepage of Formax from the mouth with matted feathers as a result, a small piece of cotton is inserted in the mouth. The cotton is usually placed in the mouth prior to injection of the cranial cavity and then replaced by a fresh piece after injection.

Figure 1 illustrates proper positioning and pinning of the specimen for drying. In some cases, additional support for the wings may be necessary. During the pinning process, feathers, especially on the dorsal side, may be moved out of place. This can be corrected by pushing a pin under the specimen from the anterior to posterior, several times. By modifying the pinning procedure, mounted specimens may also be prepared using this method.

Formax-prepared specimens have been particularly useful for teaching purposes. Birds dissected after a one year period still retain excellent preservation properties, and the Formax-prepared specimens appear to be much more durable than traditional bird skins. This last factor is particularly important in the classroom where the specimen is handled a great deal by a large number of students.

**Arkansas Academy of Science Proceedings, Vol. XXXIII, 1979**
TRICHOMES OF SOME MEMBERS OF THE LOASACEAE, A SCANNING ELECTRON MICROSCOPE STUDY

The plant family Loasaceae contains herbs, shrubs, and some woody vines. The leaves are alternate or opposite, entire or variously divided,
and generally covered with rough bristly or barbed hairs. Fifteen genera of about 250 species are native to the Americas, and one species to
Southwest Africa.

Metcalfe and Chauk (1950) have presented a summary of the known trichome types; however, most of this seems to have been from the work
Thompson (1963) and his co-workers (Davis and Thompson, 1967; Ernst and Thompson, 1963; Thompson and Roberts, 1971; and Thompson and Zavor-
tink, 1968) have supplied taxonomic data on species of Loasa of the United States; they have done only limited work with trichome morphology.
They worked with trichomes on all parts of the plant, and provided an illustration of the dendritic or candelabra type as described by Payne
(1978), Hill (1975, 1976, 1977) worked with the seeds, and Jensen et al (1978) have recently worked with protein chemistry and chromosome
numbers of the group.

This report provides some new morphological data concerning the types of trichomes, employing the scanning electron microscope.

One species of Mentzelia was examined from live material, four species of Mentzelia and one of Loasa were rehydrated from herbarium
material, and all other specimens were from pressed herbarium materials. The living leaf samples were fixed in Craf V solution, dehydrated with
acidified DMP, and critical point dried from CO₂. The rehydrated specimens were prepared by placing them in water which was then heated until
the sample dropped to the bottom of the container. After soaking there for one week, they were dehydrated with DMP and critical point dried
from CO₂. All specimens were then mounted onto stubs and coated with approximately 50 Å of carbon and 50 Å of 40/60 gold palladium by
vacuum evaporation. They were then examined and photographed in a Cambridge S-600 using Polaroid 665 P/N film.

The trichomes observed during this work which appear to be different from those described in the literature are numerically listed below
along with the genus from which they were observed:
1. An anchor trichome with elongated, downwardly directed barbs alternately arranged on the stalk. Eucnide. Fig. 1.
2. Very elongated, pointed trichome covered with small, oppositely or whorled upwardly directed spines. Mentzelia. Fig. 2.
3. Short conical-shaped with straight barbs in whorls, and anchor-like cap, and a raised, apparently multicellular base. Mentzelia. Fig. 3.
4. Long tapering trichome with spines pointing straight out and seemingly randomly arranged. Petalonyx. Fig. 4. There may be two different
sizes within this group.
5. Long tapering trichome with elongated horizontal protuberances randomly arranged. Loasa. Fig. 5.
6. Thin tapering trichome with outward pointing spines which do not extend to the apical end. This type is attached to a large, flat basal or
accessory cell. Mentzelia. Fig. 6.

These types give only a partial presentation of the data gathered. Figures 7-10 illustrate apical portions of trichomes seen on otherwise similar
trichomes. Further investigation must be completed before a clear understanding of these observations can be achieved.

Although Loasaceae trichome morphology has been organized into groups of six unicellular forms and one multicellular form, this examination
using the scanning electron microscope has revealed trichome morphology that does not satisfy previous criteria.

Several other modifications not presented here also have been observed, but it is not yet known whether these are developmental stages or
distinct forms. A study utilizing living specimens is in progress from which it is anticipated that the developmental stages of some of these trichomes
can be determined. From current morphological data, it appears that a classification system dividing Loasaceae trichomes into at least
the following four (4) major categories would be more appropriate:
1. Stinging emergences
2. Simple acerate to attenuate, of variable length, with or without tuberous swelling
3. Branching or candelabra type
4. Attenuate anchor hairs, with categorization based upon:
a. Apex form
b. Barb type and arrangement on shaft
c. Length of shaft
d. Base type
Figures 1-10. Trichome types. Fig. 1. Anchor type with alternate downward pointing barbs from Euclidean (X300). Fig. 2. Very elongated type with small upward barbs from Mentzelia (X500). Fig. 3. Conical capped form with straight barbs and raised base from Mentzelia (X500). Fig. 4. Long tapering trichome with straight spines from Petalonyx (X500). Fig. 5. Elongate trichome with horizontal protuberances from Louis (X500). Fig. 6. Tapering barbed trichome and flat basal cell from Mentzelia (X2000). Fig. 7. Smooth anchor type apex. Mentzelia (X2000). Fig. 8. Sunken anchor type apex. Mentzelia (X2000). Fig. 9. Pointed anchor type apex. Mentzelia (X2000). Fig. 10. Hooked type apex. Mentzelia (X2000).
LITERATURE CITED


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A NOTE ON THE FOOD HABITS OF SELECTED RAPTORS FROM NORTHEASTERN ARKANSAS

Early work in ornithology was, by necessity, almost entirely observations on the natural histories of species. During the first third of this century many studies were devoted to the food habits of avian species with special emphasis on the dietary constitutents of raptors (Allen, 1924; Bailey, 1905; Brodkorb, 1928; Cahn and Theodore, 1930; Errington, 1930, 1932a and 1932b; Steidl, 1928; Sutton, 1929; and others). Although in recent years ornithological emphasis has been focused on the more quantitative aspects of avian biology such as energy budgets, competition, habitat structure and niche relationships, there still is a need to update and augment our knowledge of the feeding habits of raptors. This is particularly true as the amount of suitable habitat dwindles, due to expanded agricultural practices, and more emphasis is placed on biological control in agriculture.

This report is based on the stomach contents from 10 species and 38 individual raptors found dead in northeastern Arkansas during the past ten years. Table 1 lists the raptor species and the food items collected from each. Three of the species require further comment. The most numerous species collected was the Screech Owl (Otus asio) which was primarily insectivorous, with insects constituting 84% of all food items, followed by small mammals (6%), birds (6%) and amphibians (3%) (Table 1). This agrees closely with Pearson et al. (1936) who reported insects to be the major food item for the species, with birds accounting for 17% of the diet. Allen (1924), however, reported birds to be the most abundant food brought to young in the nest, with insects ranking second. All of our specimens were collected in the fall and winter which possibly accounts for the discrepancy. In addition, Allen's samples consisted of food remnants (feathers, etc.) left in the nest which would underestimate insects since most would be swallowed whole. This species is clearly the most beneficial to agriculture since all arthropods recovered were phytophagous insects except two, a wasp (Hymenoptera) and a spider (Arachnida).

The second most abundant raptor collected was the Red-tailed Hawk (Buteo jamaicensis) (Table 1). Small mammals comprised 93% of the diet with the remainder being amphibians. Lowery (1955) also reported small mammals to be the most abundant food taken by the Red-tail (64.3%), followed by birds (17.6%), insects (10.5%), amphibians and reptiles (6.1%) and aquatic forms (1.5%).

A third species, the Cooper's Hawk (Accipiter cooperi), although represented by only 3 specimens, displayed a large variety of food items (Table 1). Amphibians and reptiles made up 50% of the diet followed by insects (37.5%), birds (6.25%) and mammals (6.25%). The low number of birds and the high number of insects is surprising since this species is commonly thought to feed primarily on birds. Our findings, in fact, are the reverse of that reported by Lowery (1955) who listed the diet of this species to be birds (77.0%), mammals (18.7%), insects (3.3%) and amphibians (1.0%). This discrepancy either could be related to our small sample size or could represent a more opportunistic nature of the hawk, which, perhaps in the absence of "preferred" food items, will take whatever is available.

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Table 1. Stomach contents of raptor species found dead on the road in northeastern Arkansas.

<table>
<thead>
<tr>
<th>FOOD CATEGORY</th>
<th>RAPTOR SPECIES</th>
<th>Sharp-shinned Hawk(1)</th>
<th>Cooper's Hawk(3)</th>
<th>Red-tailed Hawk(6)</th>
<th>Red-shouldered Hawk(1)</th>
<th>Marsh Hawk(1)</th>
<th>American Kestrel(2)</th>
<th>Falco sparverius(1)</th>
<th>Barn Owl(2)</th>
<th>Tyto alba(1)</th>
<th>Short-eared Owl(1)</th>
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*Number of specimens

LITERATURE CITED


EARL L. HANEBRINK, ALAN F. POSEY and KEITH SUTTON. Division of Biological Science, Arkansas State University, State University, Arkansas 72467.
STATUS OF THE ENDANGERED BATS, Myotis sodalis, M. grisescens, and Plecotus townsendii ingens, IN ARKANSAS

Two Arkansas bat species, the Indiana myotis Myotis sodalis and the gray myotis (M. grisescens), are listed by the U. S. Fish and Wildlife Service and the Arkansas Game and Fish Commission as endangered. An additional taxon, the Ozark big-eared bat (Plecotus townsendii ingens), will be added to the endangered list pending final legislation. The distribution, status, and certain aspects of the ecology of these bats in Arkansas are currently under study. The following accounts briefly summarize knowledge concerning current status of endangered bats in the state and contain data obtained through March 1979.

Myotis sodalis - The Indiana myotis ranges in the United States from Oklahoma, Iowa, and Wisconsin east to Vermont and south to northwestern Florida (Barbour and Davis 1969). It is known primarily from caves in which it hibernates; summer is spent singly or in small groups in hollow trees or beneath loose bark (Humphrey et al. 1977). The total population is estimated to number approximately 460,000 (Humphrey 1978). In Arkansas, the species is known primarily from the Ozark Mountain region.

Large M. sodalis hibernating colonies, such as those reported by Myers (1964) and LaVal et al. (1977) from the Missouri Ozarks, are not known to exist in Arkansas. However, smaller Indiana myotis colonies hibernate in several caves scattered throughout northwestern and north central Arkansas. The largest known of these is located in Newton County and numbers less than 2,000 individuals. The colony has decreased in size during recent years, quite likely because of human disturbance. In early March 1979, only a single Indiana myotis was found in the cave, although more than 1,000 were present in late October 1978. The cave, located on privately owned land, is well known, easily accessible, and frequently visited. It is, however, within the boundaries of Buffalo National River, and the National Park Service hopes to acquire the property and gate the entrance to protect the colony. The U.S. Forest Service also plans to gate certain caves in the Ozark National Forest to protect smaller M. sodalis hibernating colonies. In summer, only small groups of male Indiana myotis have been found in a few Arkansas caves.

M. grisescens - The range of the gray myotis is concentrated in the cave regions of Kentucky, Tennessee, Alabama, Missouri, and Arkansas (Barbour and Davis 1969, Harvey 1975). Gray myotis are cave residents throughout the year, although different caves are usually used in summer and winter; few roost outside of caves. The total population is estimated to number approximately 2,275,000 (Harvey 1975). The greatest threat to their survival is that a very large proportion of the entire known population hibernates in only a few caves. Like M. sodalis, gray myotis are found in Arkansas primarily in the Ozark region.

Prior to 1970, only four large M. grisescens hibernating colonies were known to occur in the Ozark region, all in Missouri (Myers 1964, Elder and Gunter 1978). In 1970, an additional Ozark M. grisescens hibernaculum was discovered in a Baxter County, Arkansas, cave (Harvey 1975, 1976, 1979). The colony has been estimated to number from 175.000 to 250,000 individuals, the latter being the most recent estimate (17 February 1979). The cave, located on Ozark National Forest land, was gated in 1975 to protect the colony. Banding recoveries demonstrate that gray myotis hibernating in the cave disperse in summer over a large area of Arkansas, Missouri, Oklahoma, and Kansas. Several smaller hibernating colonies, numbering from 5,000 to less than 100 M. grisescens, are scattered throughout northwestern and north central Arkansas.

Summer M. grisescens maternity colonies occur in several caves throughout the Arkansas Ozarks. Because of the presence of one of these colonies, reportedly numbering approximately 100,000 bats (as well as half the known population of a rare troglobitic fish), the Arkansas Highway Department has agreed to modify the proposed route of a highway originally planned for the immediate vicinity of the cave in Benton County. Gray myotis maternity colonies are very susceptible to human disturbance, and gating may be necessary to protect important colony sites.

Plecotus townsendii ingens - The Ozark big-eared bat is known from only a few caves in northwestern and north central Arkansas, southwestern Missouri, and eastern Oklahoma (Harvey et al. 1978). Ozark big-eared bats inhabit caves throughout the year. Harvey et al. (1978) reported on the status of P. t. ingens in Arkansas. Since that time, however, additional relevant data have been obtained. Until recently, the largest known hibernating colony of Ozark big-eared bats ever reported numbered 60 individuals and maternity colonies were completely unknown. During the summer of 1978 we discovered a maternity colony numbering approximately 120 individuals in a Marion County, Arkansas, cave. In early March 1979 we discovered 257 P. t. ingens hibernating in another Marion County cave. Thus, the total number of this taxon known to exist has increased from less than 100 (U. S. Fish and Wildlife Service 1973) to over 300 individuals. Continuing efforts to locate additional Ozark big-eared bat colonies, as well as those of M. sodalis and M. grisescens, are being made so that management plans can be formulated and implemented for the protection and recovery of these taxa.

This study is supported by the Arkansas Game and Fish Commission (with Federal Aid Funds for Endangered Species - project number E-1), U. S. Forest Service, and U. S. National Park Service.

LITERATURE CITED


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In the five-year period from 1969 to 1973, three specimens of the plains harvest mouse, *Reithrodontomys montanus* (Baird), were obtained near Fayetteville, Washington County, Arkansas. An adult male was collected on 7 March 1969 in the sparse vegetation of a closely grazed pasture, and an adult female was obtained on 26 January 1973 in the dense grasses of a hay field. Both were hand captured. The third specimen, an adult female, was live-trapped in the hay field on 12 March 1973. None of the mice were in reproductive condition.

These specimens represent the easternmost known locality for the plains harvest mouse and the first records for Arkansas. Fayetteville is approximately 40 miles due east of the range limit estimated by Hall and Kelso (1959). The Mammals of North America, Ronald Press, N. Y.) and about 80 miles east-northeast of the easternmost Oklahoma record in Muskogee County (Blair, 1939, Am. Midl. Nat., 22:85-133) shown by Hall and Kelso (1959). However, since these publications the plains harvest mouse has been found in Ottawa County in extreme northeastern Oklahoma and further east in nearby McDonald County, Missouri, 7 miles northwest of Jane (Long, 1961, J. Mammal., 42:417-418). The Arkansas records are approximately 40 miles south and 10 miles east of the Missouri site.

The plains harvest mouse occurs in prairie habitats, and the earliest habitat descriptions in the mid-1800’s mentioned extensive areas of original prairie in northwestern Arkansas (D. O. Owen, 1885, First Report of a Geological Reconnaissance Isicl of the Northern Counties of Arkansas, Johnson & Yerkes, State Printers, Little Rock; M. L. Lesquereux, 1860, Botanical and Paleontological Report of the Geological State Survey of Arkansas, p. 295-400 in D. O. Owen. Second Report of a Geological Reconnaissance Isicl of the Middle and Southern Counties of Arkansas, C. Sherman & Son, Philadelphia). Most of the prairie has long been cultivated, yet numerous small but isolated prairie patches remain. This prairie country always could have been inhabited by plains harvest mice despite the long standing high intensity of small mammal trapping near Fayetteville. Hooper (1952, Univ. Mich. Mus. Zool., Misc. Publ. No. 77. p. 1-255) found that in parts of the range the plains harvest mouse is rare and seldom trapped. Furthermore, trapping near Fayetteville has been mainly in forests, or in old field successional stages dominated by broom-sedge grass (*Andropogon virginicus*), rather than in true prairie grasslands. Managed hay fields and overgrazed pastures where the present specimens were obtained largely have been ignored.

Plains harvest mice usually occupy dry uplands sparsely covered with short grasses (Blair 1939; Hooper 1952; Hall and Kelso 1959; Goerta, 1963, Proc. Okla. Acad. Sci., 43:123-125). This matches conditions in the heavily grazed: nearly denuded, pasture of escue grass (*Festuca elatior*) where the first Arkansas specimen was obtained, but is totally unlike the dense growth of grasses in the hay field where the other two were found. Probably the hay field was formerly a managed pasture because escue and Bermuda grass (*Cynodon dactylon*) dominated. However, grazing had been discontinued and the resulting growth was invaded by other grasses; primarily broom-sedge, Johnson grass (*Sorghum halepense*), foxtail grass (*Setaria*) and others. The population of plains harvest mice in Muskogee County, Oklahoma, inhabited the usual xeric prairie situation (Blair, 1939). The Missouri site was described simply as a "grassy area" (Long, 1961).


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**THREE SPECIES OF TRYPETHELIUM NEW TO ARKANSAS**

Stromatic pyrenocarp lichens whose perithecia open by an apical pore have been assigned to the family TrYPETheliaceae. These lichens grow in the bark of trees, but they appear to do no damage to their host. *TrypeThelium* is the type genus of the family; it is characterized by hyaline, longitudinally three- to many-septate ascospores. This paper reports the first collections of three species (*TrypeThelium mastoidaeum* Ach., *T. tropicum* (Ach.) Mull. Arg., and *T. virescens* Tuck.) in the state of Arkansas.

*TrypeThelium mastoidaeum* Ach. is the most abundant of the three species found. It is relatively inconspicuous, with light- to dark-brown pseudostromata of medium height, perithecia with small ostioles, and medium-sized (18-28 x 6-9 μ), hyaline, three-septate spores. It is most frequent on Quercus in Arkansas, but it has also been collected on Acer, Carya and Ilex.

Collected from: Bradley, Clark, Cleveland, Columbia, Dallas, Grant, Hempstead, Jefferson, Montgomery, Pike, Polk, and Union Counties. Specimens cited: G. T. Johnson. Nos. 4086, 4966, 4971, 4974, 4978, 4983, 4985, 4988, 4990, 4994, 4995, 5004, 5116, 5121, 5124, 5135, 5140, 5145, 5151, 5156, 5167, 5448, 5452, 5458, 5461, 5467, 5474, 5509, 5515, 5522, 5526, 5531, 5540, 5544, 5548, 5551, 5571, 5573, 5578, 5578, 5578, 5578, 5578, 5578, 5578, 5578, 5578, 5578, 5578, 5578, 5578, 5578, 5578, 5578, 5578, 5578.

*TrypeThelium tropicum* (Ach.) Mull. Arg. has a jet black perithecia and pseudostromata. The pseudostromata of the Arkansas specimens of this species are not so well developed as in other species of *TrypeThelium*, tempting one to assign them to *Pseudopyrenula*, where Muller-Aruga (Flora, 66:248, 1883) did place this species at one time. However, the ascus in *T. tropicum* are formed from the fusion of adjacent perithecial walls, the perithecia have conspicuous ostioles, usually with pruinose margins, and the asci contain medium-sized (20-26 x 6-8 μ), hyaline, three-septate spores. This is a comparatively rare species; it has been collected sparingly in the river valleys of southwestern Arkansas. *Acer* is the only host on which this species has been collected.


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Trypethelium virens Tuck. has yellow-brown to orange-brown pseudostromata. The ostioles appear as small black dots and the asci have quite large (38-52 x 7-10 μ), hyaline, seven- to nine-septate spores. This species is most frequent on Ilex in Arkansas, but is has also been collected on Quercus, Fagus, Carya, Nyssa, and Prunus. It is found in the Ouachita and Red River Valley areas in the southern portion of the state. Collected from: Bradley, Calhoun, Clark, Cleveland, Columbia, Dallas, Garland, Grant, Hempstead, Lafayette, Montgomery, Pike, Polk, Sevier, and Union Counties.

Specimens cited: G. T. Johnson, Nos. 4936, 4940, 4944, 4949, 4953, 4957, 4961, 4964, 4968, 4972, 4975, 4979, 5106, 5110, 5114, 5117, 5122, 5125, 5133, 5139, 5143, 5146, 5438, 5444, 5449, 5453, 5456, 5459, 5498, 5502, 5507, 5514, 5520, 5528, 5712, 5747, 5755, 5762, 5770, 5777, 5788, 5798.

The known Arkansas distributions of Trypethelium spp. are presented in Figs. 1 - 3. Dots on the maps identify counties in Arkansas in which collections of each species have been made. These distribution maps have significance due to the relatively large number of collections at hand and the fact that there has been also considerable field experience in regions where the species have not yet been found. Trypethelium mastoidenum (Fig. 1) and Trypethelium virens (Fig. 3) are widely distributed in southern Arkansas. Trypethelium tropicum (Fig. 2) has been collected only in the southwestern portion of the state. Apparently these species do not occur north of the Arkansas River, or north of the approximate latitude of Hot Springs, Garland County, Arkansas. It is hoped this note will stimulate other collectors to look for these lichens; the writer believes new county and new host records can be obtained in the southern portion of the state.

Figure 1. Arkansas distribution map of Trypethelium mastoidenum Ach.

Figure 2. Arkansas distribution map of Trypethelium tropicum (Ach.) Müll. Arg.

Figure 3. Arkansas distribution map of Trypethelium virens Tuck.

The study was supported in part by a grant from the National Science Foundation.

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HOVERING FLIGHT IN RED-TAILED HAWKS (Buteo jamaicensis)

"Hovering" is defined as wing-flapping flight which has the purpose of holding a bird stationary in the air. It is commonly used by those species of raptors which hunt over open country where no perches exist, such as kestrels (Falco spp.) over field or moor. Rough-legged Hawks (Buteo lagopus) or Snowy Owls (Nyctea scandiaca) over tundra, Ospreys (Pandion haliaetus) over water. The Red-tailed Hawk (B. jamaicensis), which hunts by preference from a perch at the edge of a field, or sometimes soaring on thermals, hovers only rarely. Red-tails which hunt in mountains or along coasts, regularly take advantage of the up-draft over cliffs to hang in one position, with wings spread and motionless, while they survey the cliff for prey. This does not, however, constitute true hovering. The general lack of hovering in the Red-tail, and the presence of hovering in the Rough-legged, is so regular that it is often used as a diagnostic character to separate these two species (see, e.g., Peterson, R. T. 1947. A field guide to the birds. Houghton Mifflin Co., Boston; or Robbins, C.S. et al. 1966. Birds of North America. Golden Press. N.Y.). The following pages are therefore of interest as it describes what could be considered aberrant behavior in a large number of birds.

On 22 December 1977, Cheryl Lavers and I went to the vicinity of the Craighead/Poinsett County, Arkansas line on Highway 49 to investigate the report of a Rough-legged Hawk. Four Rough-legs were seen within a mile (perhaps a record concentration for Arkansas), all persistently hovering at distances of ten to forty feet from the ground over stubble fields. A 10-15 mph wind from the south no doubt gave the birds more lift, but they still flapped their wings rapidly to maintain their position. These birds were loosely associated with about 15 Red-tailed Hawks, four or five of which were also persistently hovering, at the same heights as the Rough-legs. Although on rare occasions Red-tails have been observed hovering, it is usually at a much higher altitude (150-200 feet).

The area where these birds were congregated, one known to be particularly rich in small rodents (Van Rick McDaniel, pers. comm.), consisted of fields lined with tall trees (chiefly Quercus spp.), interspersed with patches of deciduous woodland. Therefore, it does not seem that competition for scarce prey items, or an absence of perches, occasioned this unusual behavior in the Red-tails.

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CAVE FAUNA OF ARKANSAS: ADDITIONAL INVERTEBRATE AND VERTEBRATE RECORDS

This report represents the third in a series of papers describing the fauna of Arkansas caves. The first paper included records of selected invertebrate taxa (McDaniel and Smith, 1976); the second included a summary of vertebrate records (McDaniel and Gardner, 1977). In this paper, we bring previous records up to date with regard to collections and/or identifications made during the past 2 years.

The number of troglobitic (obligate cavernicolous) known to inhabit any one cave continues to increase, as does the total number of troglobitic taxa reported from the caves of Arkansas. Certainly the cave fauna of Arkansas represents a unique and fragile element of the habitat - an element in need of accurate definition and description, and subsequent protection.

Methodology was as reported earlier (McDaniel and Smith, 1976) in which collection of specimens was minimal and usually for the purpose of identification only. All forms collected by the authors or represented by voucher specimens in the collections at Arkansas State University, or in the taxonomic collections of other recognized researchers. Taxa and localities reported are the result of collection efforts by the authors or their agents.

Related literature was reviewed in earlier papers (McDaniel and Smith, 1976; McDaniel and Gardner, 1977), with the exception of a recent paper (Youngsteadt and Youngsteadt, 1978) containing notable invertebrate records from northwestern and northernt central Arkansas. In some cases, our records overlapped theirs, and were therefore omitted from this paper.

For newly reported taxa, we have again included probable ecological position in the cave environment, and we continue to utilize the terms "troglobite," "troglophilic," "trogloxene," and "accidental" to describe this position (Barr, 1963). Furthermore, to emphasize the cavernicolous status of organisms, we have limited our ecological notation to the cave environment (e.g., Stygobromus a. alabamensis is actually a phreatobite/troglobite, but is herein considered a troglobite). Records of taxa not previously recorded from Arkansas caves are included in the following annotated list; new records for previously recorded taxa are included in Table 1.

PHYLUM ARTHROPODA
Class Crustacea
*Stygobromus alabamensis alabamensis* (Stout), Trogloxene. Jackson Co.: Mason's Cave. Earlier records of this species are listed under *Stygocenotes*, now included in *Stygobromus* (Bousfield, 1973; Peck and Lewis, 1978). The significance of this record lies in the location of this cave at the extreme eastern edge of the Ozark Uplands in Arkansas. The Mississippi Embayment is within 300-400 meters of the cave.

*Stygobromus clantonii* (Creaser), Trogloxene. Izard Co.: Clay Cave. An intriguing specimen, since according to Holsinger (pers. comm.) "(if this population is in fact conspecific with S. clantonii s. str., it extends the range of the species some 150 miles south from central Missouri to northern Arkansas." A single female only was found in a stream having a dense population of *S. a. alabamensis*.

Class Arachnida
Order Phalangida
*Crosby and Bishop, Trogloxene. Independence Co.: Cushman Cave; Izard Co.: Clay Cave; Sharp Co.: Center Cave. All our records are from the front 200 m of these caves.

Order Araneae
Family Theridiidae
*Achaearanea spp.* (Koch), Trogloxene. Randolph Co.: Ravenden Springs Cave. An extremely common spider often associated with human habitations.

Family Agelenidae

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https://scholarworks.uark.edu/jaas/vol33/iss1/1
Cidurina sp., Troglophile (?). Independence Co.: Dodd Cave. A juvenile was removed from the anterior chamber of this cave. The genus includes several cave species.

Family Araneidae

Meta menardi (Latreille). Troglophile. Izard Co.: Needles Cave. The cave orb weaver is found in caves, mines, and similar habitats throughout the eastern U.S.

Family Ctenidae

Ctenus n. sp., Troglophile. Stone Co.: Roasting Ear Cave. Ctenids are foraging spiders, and our specimen was found in the dry front chamber of this cave.

Family Linyphiidae

Meioneta sp., Troglophile. Independence Co.: Dodd Cave. Collected from a dry guano pile near the center of the cave.


Family Lycosidae

Lycosa sp., Troglophile. Searcy Co.: Davis Pit; Sharp Co.: Center Cave. Wolf spiders were found associated with leaf litter on the floor of the cave.

Family Nesticidae

Edmonnellia pallida (Emerton). Troglophile. Izard Co.: Vickery Cave. Formerly Nesticus. This spider is widespread and a common cave inhabitant.

Class Diplopoda

Order Chordeumida

Family Conotylidae

Trichopetalum sp., Troglophile. Searcy Co.: Davis Pit. T. uncum was previously reported from Sharp Co. (McDaniel and Smith, 1976).

Class Insecta

Order Diplura

Family Campodeidae

Phthiocampa n. sp., Troglophile. Fulton Co.: Richardson Cave; Izard Co.: Clay Cave; Stone Co.: Hell Creek Cave, Roasting Ear Cave, Roland Cave. Although a very common cave inhabitant, diplurans are taxonomically very poorly known.

Order Diptera

Family Heleomyzidae

Amoebaerria defesa (Osten Sacken). Troglophile. Independence Co.: Cushman Cave; Stone Co.: Roasting Ear Cave. All specimens of this common cave inhabitant were found in the front chamber of caves.

Aecothoe specus (Aldrich). Troglophile. Izard Co.: Clay Cave. Found only in the front chamber of the cave.

Heleomyza brachypterna Loew. Troglophile. Sharp Co.: Center Cave. Another of the flies that overwinters in Arkansas caves.

PHYLUM CHORDATA

Class Amphibia

Order Anura

Family Hylidae

Hyla versicolor versicolor LeConte. Accidental. Stone Co.: Hell Creek Cave. A single specimen of this frog was found at the bottom of a shaft into the cave.

Assistance in collecting specimens is gratefully acknowledged from S. Clark, G. Gardner, T. Gardner, D. Saugey, and K. Sutton. We especially acknowledge and appreciate the contributions of each of the following systematists in identification of specimens: T. C. Barr, carabids; N. B. Causey, millipedes; J. C. Cokendolpher, arachnids; W. R. Elliot, arachnids and records for Davis Pit; W. R. Gertsch, arachnids; C. J. Goodnight, opilionids; J. R. Holsinger, amphipods; J. M. Kingsolver, leiodids; L. Knutson, insects; W. M. Muchmore, pseudoscorpions; J. R. Reddell, arachnids; G. Styskal, heleomyzids.

LITERATURE CITED


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LICHENS OF ARKANSAS I: A SUMMARY OF CURRENT INFORMATION

The earliest publications on lichens in this country included only a few references to these plants from Arkansas. The earliest of these, written by the "Father of American Lichenology," Edward Tuckerman (1882), listed three species from Arkansas which were collected by Dr. Peters, Much Later, Bruce Fink (1938) listed a total of five species from the state, including those mentioned by Tuckerman. Edward C. Berry (1941) listed 18 specimens from Arkansas in his monograph of the genus Parmelia. This included two new species of Parmelia which he had collected about 11 miles south of Harrison in Newton County. The type species for Parmelia erecta Berry was placed in the Missouri Botanical Garden herbarium
Even with these references to Arkansas lichens, however, very little was definitely known of the general lichen flora of the state until Albert W. C. T. Herre (1945) made a checklist including 54 species. These collections had been sent to him by Delzie Demaree, primarily from Petit Jean Mountain in Conway County and from Pulaski and Drew Counties. Herre predicted that this number was perhaps an eighth of the lichen flora of the state. This may prove to be a correct prediction, as extensive collecting usually has resulted in many additional state records. For example, when Mason E. Hale (1957a) gathered corticolous lichens from 98 sampling stations in the 22 northwest counties of the state, he listed 61 species. Twenty-one of these species were included in Hale’s exsiccate and distributed to a number of the larger herbaria. Other publications by Hale (1954a; 1958a; 1958b; 1957a; 1957b; 1958a; 1958b; 1959; 1962; 1966; 1967) have dealt primarily with clarification of taxa and lichen chemistry, but these papers have included references to Arkansas plants. Hale also has been responsible for the identification of lichens for many field botanists (Moore, 1959; 1975). Hale collected the type specimen for Parmelia hypomelaena Hale from novaculite rocks near Malvern and has filed it in the National Herbarium in Washington.

Monographs of the lichen flora have included citations of plants from Arkansas: Leptogium (Sierk, 1964), Physcia (Thomson, 1963); Lobaria (Jordon, 1973), and Ochrolechia (Howard, 1970). Chemotaxonomic work also often included references to Arkansas lichens (Almeda and Dey, 1973; Bowler, 1972; Culberson, 1961, 1973; Hale, 1962, 1965, 1966). Other publications dealing primarily with distribution patterns of various lichens have included Arkansas in the lichen ranges (Culberson and Hale, 1965, 1966; Ohlsson, 1973; Thomson, 1956). Hale (1969, 1979), in his two keys to the foliose and fruticose lichens of the United States, added perhaps a hundred species to the Arkansas checklist based on the distribution maps in these publications.

The present checklist of perhaps 250 lichens, obtained from the literature, will be published in Arkansas Biota, a publication of the Arkansas Academy of Science.

LITERATURE CITED


EVALUATION OF UNDERGRADUATE COURSES BY BIOLOGY TEACHERS

Eighteen high school science teachers who brought students to a High School Science Day at the University of Central Arkansas were asked to complete questionnaires about the size and organization of their schools, some aspects of their lives as teachers, and their evaluation of selected college courses as far as the usefulness of these courses to a high school science teacher. The questionnaire required only the checking of appropriate blanks.

Of the eighteen teachers who were polled, fourteen were biology majors in college, two were mathematics majors, one was a physical education major, and one was a business administration major. Each of the participants was teaching one or more science courses in high school. The teaching experience of the respondents ranged from one year to twenty years with a mean of 5.2 years. Twenty-eight percent of the teachers taught only biology, and 72% taught biology and another science. Seventy-two percent indicated that they had free periods during the school day that could be used for the preparation of lessons and teaching materials.

The smallest school represented in the survey had 115 students, and the largest had 500. Twelve percent of the schools included grades 10-12, 25 percent had grades 9-12, 25 percent had grades 9-12, and 38 percent were grades 7-12. Table 1 summarizes other information about the schools.

Table 2 indicates the number of teachers who had taken each of the selected courses in college. The percent who had taken each course, and their evaluations of the courses.

It should be noted that only small schools are represented in the study. The pupil-teacher ratio for either biology teachers or for science teachers in general is not high.

Explaining the course evaluations is difficult. Why should General Zoology be given a perfect 1.00 rating and both General Botany and General Biology receive lower ratings? The differences in evaluations cannot be ascribed to large differences in the number of teachers who evaluated the courses because in each case a large majority of the teachers who were polled evaluated each course. The higher rating of zoology compared with botany might be caused by a greater interest in animals than in plants. If this is true, however, how can the fact that botany rated higher than General Biology be explained?

It should be noted that, except for Conservation, the biology courses that rated 1.00 are some aspect of zoology or human biology. Applied Physics, which has a life science emphasis, was rated higher than General Physics. This may be a result of the small number of respondents who had taken the course, or it may indicate the natural antipathy of many biology majors for anything that requires a rigorous mathematical treatment.

Although this study is too small for any of the results to be statistically significant, some of the results are interesting. The ratings of various college courses may indicate a need for continuing education required of biology teachers.

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Table 1. Some characteristics of schools included in study.

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*Teachers did not supply information requested.
UNUSUAL RESULTS FROM PELLET ANALYSIS OF THE AMERICAN BARN OWL *Tyto alba pratincola* (Bonaparte)

A great deal of information concerning the food habits of the Barn Owl, *Tyto alba,* has been gathered through pellet analysis (Bent, 1938; Wallace, 1948; Boyd and Shriner, 1954; Banks, 1965). A comparative literature search and the results of this study both indicate that availability determines the kind and numbers of prey consumed by owls. Barn Owls feed on various species of mammals such as: mice, rats, shrews, moles, pocket gophers, bats, weasels, skunks, and rabbits, although birds, amphibians, and even an occasional insect are preyed upon. Most authorities agree that the Barn Owl is one of our most useful birds of prey, especially in farming communities, since its food consists almost entirely of rodents (Bent, 1938).

The Barn Owl swallows its prey headfirst, and later the nutritious portions (i.e.: soft anatomy) are digested and absorbed, while the indigestible matter (i.e.: bones, hair, feathers) are formed into black, shiny-looking pellets, which are passed forward to remain in the proventriculus until the sight of new food triggers ejection (Wallace, 1948; Smith and Richmond, 1972) disgorging the pellet through the mouth. Therefore, by examining owl pellets, one should gain a fairly good knowledge of the local small mammal population through identification of skeletal material (primarily skull) and hair contained in the pellets.

The primary purpose of our study was to determine the prey items consumed by a Barn Owl from pellet analysis at a winter roost and to associate this with availability of prey items.

Forty-five Barn Owl pellets were retrieved from the floor of the press box at Indian Stadium on the campus of Arkansas State University, Craighead County. Prey species were obtained through careful dissection of each pellet in the laboratory, and identification was based primarily upon skeletal material (i.e.: skulls and mandibles), but also included hair and feather remains as secondary sources. An analysis was made to determine the species preyed upon, the number of species preyed upon, and the frequency with which each species occurred.

A total of 93 skills were removed from 45 pellets, an average of 2.07 skulls per pellet. One species of rodent, the southern bog lemming, *Synaptomys cooperi,* represented the dominant prey item consumed by the Barn Owl and was of particular interest since it represented 54% of the total prey species taken (Table 1). Although *Synaptomys* is found in low damp bogs and meadows throughout the northeastern portion of the U.S., the results are unusual since *Synaptomys* rarely forms dense local populations and therefore rarely represents a significant prey item in the diet of the Barn Owl. Bent (1938) states that the diet of the Barn Owl in the South consists almost exclusively of the cotton rat, *Sigmodon hispidus,* whereas in our study *S. hispidus* represented 17% of the content of the pellets. *Sigmodon* is normally a common rodent in open pastures and semi-brushy areas, and often forms an important constituent in the diet of raptorial birds (Parrmalee, 1954). The winter roost utilized by the Barn Owl in our study was in close proximity (300 meters) to habitat which should support a population of *Sigmodon.* Other species taken by the Barn Owl were voles (*Microtus spp.)* 15%, Passerines (primarily *Sturnus vulgaris* and *Junco hewezi)* 7%, shorttail shrews (*Blarina carolinensis)* 4%, marsh rats (*Oryzomys palustris)*, least shrews (*Cryptotis parva*), and house mice (*Mus musculus*), each of which made up 1% of pellet contents.

Similar investigations fail to report *Synaptomys* as a food item in the South, possibly due to its scant distribution (Burt and Grossenheider, 1964) in most of its range, or due to misidentification as a species of *Microtus.* Nevertheless, availability probably determines the kind and numbers of prey consumed by owls (Boyd and Shriner, 1954). In the remainder of the Barn Owl's range in the Northeast, Midwest, and South.
General Notes

Sigmodon, Microtus spp., and Oryzomys appear to be the major sources of food in the owls diet (Phillips, 1947; Parmalee, 1954; Jemison and Chabreck, 1962; Marti, 1974). Wilson (1938) reports Synaptomys cooperi as a food item in Michigan, but it represented less than 1% of the total prey consumed by the owl. In the west, Barn Owls feed primarily on pocket gophers (Thomomys spp.) and have fed almost exclusively on pelagic birds (mainly petrels) on islands around Baja, California (Banks, 1965).

We gratefully acknowledge the help of Dr. Earl L. Hanebrink, who provided data and technical materials. We also would like to thank the Athletic Department of Arkansas State University for allowing entrance to the winter roost in the press box at Indian Stadium. We are grateful to Dr. V. Rick McDaniel for commenting on the manuscript.

Table 1. Food of a Barn Owl in Craighead County, Arkansas, expressed as the number of individuals taken and the percent occurrence.

<table>
<thead>
<tr>
<th>Prey Species</th>
<th>Species Occurrence (93) total</th>
<th>Percent Occurrence</th>
</tr>
</thead>
<tbody>
<tr>
<td>Synaptomys cooperi</td>
<td>50</td>
<td>54</td>
</tr>
<tr>
<td>Sigmodon hispidus</td>
<td>16</td>
<td>17</td>
</tr>
<tr>
<td>Microtus spp.</td>
<td>14</td>
<td>15</td>
</tr>
<tr>
<td>Passerines</td>
<td>6</td>
<td>7</td>
</tr>
<tr>
<td>Blarina carolinensis</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>Oryzomys palustris</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Cryptotis parva</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Mus musculus</td>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>

LITERATURE CITED


Kenneth N. Paige, Chris T. McAllister, and C. Renn Tumlison. Department of Biological Science, Arkansas State University, State University, Arkansas 72407.

ADDITIONS TO THE STRAWBERRY RIVER ICHTHYOFAUNA

In their initial list of the fishes of the Strawberry River, Robison and Beadles (1974) Fishes of the Strawberry River system of northcentral Arkansas, Proc. Ark. Acad. Sci. 28:65-70) reported 95 species of fishes inhabiting the system. Favorable climatic conditions during the past four years have allowed collections of fishes to be made in the lower wide stream sections of the Strawberry River where steep banks, mud substrates and normally deep pools make collecting especially difficult during most of the year. Collections in these areas during the interim have documented 12 species not previously reported by Robison and Beadles (1974) including the least brook lamprey, Lampera aepyptera (Abbot), chestnut lamprey, Ichthomyzon castaneus Girard, shovelnose sturgeon, Scaphirhynchus platoypus (Rafinesque), paddlefish, Polyodon spathula (Walbaum), gravel chub, Hybopsis x-punctata Hubbs and Crowe, fathead minnow, Phoxinus melops Rafinesque, crystal darter, Crystallaria (=Ammodricta) aspella (Jordan), western sand darter, Ammodricta clara Jordan and Meek, harlequin darter, Etheostoma histrio Jordan and Gilbert, Ouachita darter, Percina ouachitae (Jordan and Gilbert), stargazer darter, Percina utahica (Jordan and Gilbert), and river darter, Percina shumardi (Girard).

Robison and Beadles (1974) originally suggested that the two lamprey specimens reported from the system were Lampera lamottei (Lesueur) based on geographic proximity of other known localities to the Strawberry River; however, subsequent collections confirm the presence of two additional species of lampreys. L. lamottei remains unknown from the Strawberry River system. Seven specimens of mature, breeding L. aepyptera taken on 4-6 April 1975 substantiate the presence of the least brook lamprey in the system. Collections were taken from the following locations: Izard Co.: McJunkins Branch SE of Franklin (Sec. 3 and 4, R7W, T17N) (one specimen); unnamed tributary of Little Strawberry

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River, SE of Oxford (Sec. 30, R8W, T18N) (2); Bull Pen Creek, NW of Wiseman (Sec. 10, R8W, T18N) (1). SHARP Co.: Unnamed tributary of Big Creek (Sec. 33, R5W, T16N) (3).

On 15 October 1978, a single 118 mm specimen of Icthyomyzon castaneus was collected from the Strawberry River at St. Hwy. 115 (Sec. 17, T16N, R3W), Lawrence County. The specimen was still in the process of transforming into an adult; however, several clues to its identity were noted including a well-developed intestine, developing bicuspid teeth in the inner circle of the oral disc and relatively large buccal funnel. Dr. George A. Moore, Oklahoma State University, kindly verified the identification.

Commercial fishermen have provided documentation of the presence of Scaphirhynchus platorynchus and Polyodon spathula near the confluence of the Strawberry and Black rivers where these two large river forms probably utilize the resources of the Strawberry River when conditions are favorable.

The collection of a single specimen of Pimephales promelas, undoubtedly a bait release, was taken from the headwaters of the river approximately 8 mi. S.W. of Salem, Fulton County, on 4 April 1975. This represents the only record of this species in the system.

An excellent collecting site in Lawrence County just upstream from the St. Hwy. 115 bridge (Sec. 17, T15N, R3W) 1 mi. N. of Jesup has yielded records of the additional seven species denoted in this paper. Six collections have been made to date from this locality. A total of eight specimens of Hybopsis x-punctata have been collected at this location over small gravel in the main current. The richness of the diversity of the Hwy. 115 collecting site is demonstrated by the collection of a total of 51 species, including 17 species of echostomatine fishes.

Five percid fishes are added to the stream list. Nine specimens of Cyrtallarua (=Ammocrypta) asprella were taken in three collections at St. Hwy. 115. A total of four Ammocrypta clara was taken over sand habitats at the Hwy. 115 location and N. of the St. Hwy. 58 bridge near Poughkeepssie. Fifteen specimens of Ethostoma histrio have been collected from the St. Hwy. 115 collecting locality. Forty-seven specimens of the two cryptic species, Percina oxachita and P. uranidea, have been taken to date from the St. Hwy. 115 locality on four occasions. Specimens of the Strawberry River P. uranidea were used in the original description of the small darter, Percina tanasi Etnier, in Tennessee (Etnier, 1976). Percina (Imostoma) tanasi, a new percid fish from the Little Tennessee River, Tennessee, Proc. Biol. Soc. Washington, 88 (44):469-488. Thirteen specimens of Percina shumardii have also been taken from the Hwy. 115 location, including a large, 60.2 mm SL (7.1 mm TL) male specimen.

With the addition of these 12 species the Strawberry River is now documented to have 107 species. This richness in diversity is exemplary of the upland streams in the Ozark physiographic province and indeed, compares with the richest streams in North America.

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AGE AND GROWTH OF WHITE CRAPPIE, Pomoxis annularis Rafinesques, FROM A FLOOD-CREATED POND IN MISSISSIPPI COUNTY, ARKANSAS

White Crapppie, Pomoxis annularis Rafinesques, originally were found in lakes, ponds, bayous, and slow-moving streams and rivers from eastern South Dakota to western New York and south in the Mississippi River and Gulf of Mexico drainage to Alabama and Texas. They have been introduced into other suitable waters (Carlander, 1977). In Arkansas, the white crappie occurs in all major rivers (Buchanan, 1973) and reservoirs (Ball, 1972), comprising a significant portion of the annual sport harvest in both (Morais, 1975). Many growth studies have been done involving white crappie directly or as a sympatic species, as evidenced by the bulk of data compiled on the species by Carlander (1977). This paper describes the age and growth of white crappie in Butterfly Hole, a flood-created impoundment of the Mississippi River.

Butterfly Hole is located approximately 2.2 km north of Tomato, section 7, T4N, R13E, Mississippi County, Arkansas, in an area almost entirely devoted to farming. Butterfly Hole was formed during the Fall-Winter flooding of 1974 by flood-stage waters of the Mississippi River. The hold covers approximately 1.5 surface acres with bottom depths ranging from 0.3 to 10.7 meters. Due to its depth, Butterfly Hole has never been dry since its creation. Many such water bodies are created with each flood period, but most are shallow and dry up during the summer months when temperatures average 91°F (Percison and Gray, 1971).

Fifty-four white crappie were collected to determine the growth characteristics of the species in Butterfly Hole, following a complete rotenone kill by the Arkansas Game and Fish Commission.

There is little evidence of sex differences in the growth of white crappie (Carlander, 1977). Therefore, no sexually dimorphic growth patterns were assumed to exist, and no such differentiations were attempted.

Scales for study were selected by the use of the “key scale” method suggested by Lagler (1956). Key scales were designated as those from an area approximately 10 back from the head and 5 down from the lateral line along the right side of the fish. Approximately 20 scales were taken from each fish. Total length in mm and total weight in grams were recorded for each fish upon capture.

Scale annuli counts were made by use of an American Optical dissecting microscope in conjunction with an American Optical Model #561, 7.5 volt light source. Distances were measured on each scale using a USDA metric planners rule from focus to each annulus, and from focus to scale margin along the anterior median of each scale.

The age determinations were made by counting the number of annuli. Since collection was made in late summer, after annulus formation (Hall et al., 1954), the age referred to herein represents the number of the last complete annulus.

The length (66-336 mm) - weight (5.5 - 715 g) relationship was Log W = 0.924 Log L + 0.134. The regression coefficient of 0.924 was significantly different from 3.0 (t54 = 5.33), indicating that the weight of the crappie did not increase as the cube of length. Figure 1 further illustrates the rapidly decreasing rate of weight gain of all white crappie within the hole, following impoundment (1974).

The coefficient of condition, K, was calculated for each of the crappie from the expression: K = W / L3 X 100. The coefficient for the individual fish ranged from 1.45 to 1.95 with an average of 1.64. The average coefficient of the Butterfly Hole crappie was higher than that reported by White- acre (1952) in Crab Orchard Lake, Illinois (0.67), and higher than that reported by Witt (1952) from Lake Norfork, Missouri (1.32) and Lake Taneycomo, Missouri (1.33). Average condition coefficients for the year classes are given in Table 1.

The total length (L) - scale radius (s) relationship for the Butterfly Hole crappie was L = 50.9. f + 48.535 with a correlation coefficient (r) of 0.96. The average calculated lengths at the time of annulus formation are given in Table 2. Comparison of lengths of age-groups I, II, and III revealed no difference at the 0.01 level between the year classes 1975 through 1977. Therefore, the postimpoundment growth was the same for all these year classes.

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General Notes

Table 1. Average coefficient of condition \((K_{TL})\) for year classes 1972 through 1977.

<table>
<thead>
<tr>
<th>Year Class</th>
<th>Average (K_{TL} )</th>
<th>Number of Fish</th>
</tr>
</thead>
<tbody>
<tr>
<td>1972</td>
<td>1.59</td>
<td>1</td>
</tr>
<tr>
<td>1973</td>
<td>1.55</td>
<td>3</td>
</tr>
<tr>
<td>1974</td>
<td>1.51</td>
<td>6</td>
</tr>
<tr>
<td>1975</td>
<td>1.75</td>
<td>31</td>
</tr>
<tr>
<td>1976</td>
<td>1.58</td>
<td>11</td>
</tr>
<tr>
<td>1978</td>
<td>1.93</td>
<td>2</td>
</tr>
</tbody>
</table>

Table 2. The average calculated total lengths (mm) of white crappie from Butterfly Hole.

<table>
<thead>
<tr>
<th>Year Class</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>1972</td>
<td>124</td>
<td>187</td>
<td>250</td>
<td>313</td>
<td>342</td>
</tr>
<tr>
<td>1973</td>
<td>104</td>
<td>165</td>
<td>223</td>
<td>265</td>
<td>296</td>
</tr>
<tr>
<td>1974</td>
<td>117</td>
<td>172</td>
<td>226</td>
<td>263</td>
<td>-</td>
</tr>
<tr>
<td>1975</td>
<td>107</td>
<td>156</td>
<td>200</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>1976</td>
<td>106</td>
<td>149</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>1977</td>
<td>95</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

Average 109 166 215 280 324

Number of fish 2 11 31 6 3

LITERATURE CITED


STEPHEN A. SEWELL, Dept. of Biology, Arkansas State University. State University 72467. (Present address: Soil Conservation Service, P.O. Box 276, Melbourne, Arkansas 72556).

ADDITIONS, DELETIONS, AND CORRECTIONS FOR THE ATLAS AND ANNOTATED LIST OF THE VASCULAR PLANTS OF ARKANSAS

Since the publication of the Atlas and Annotated List of the Vascular Plants of Arkansas (Smith, 1978, Student Union Bookstore, U. of Ark. at Fayetteville, Fayetteville, Ark., 592 pp.), a large number of new county records and new reports and several new state records and deletions have come to our attention. Over 800 new county records, several new reports, and several deletions are covered in a "Quick Copy" list available from the senior author. Approximately half of the new county records in the "Quick Copy" list have been found by Gwen Barber in her study of the flora of Franklin County. The new state records are presented in the following list. Voucher specimens are on deposit in the herbarium at Fayetteville.

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1. COMPOSITAE Anhemis tinctoria L.
   This naturalized European species was recently found by Gwen Barber in Franklin County. Barber 165.

2. LABIATAE Glechoma hederacea L. var. hederacea
   The large-flowered variety of this species was collected from Monroe County by a student in the Plant Taxonomy class, Kim Anderson, Anderson 18.

3. MORACEAE Cannabis sativa L.
   This expected species (p. 517 of Atlas) was recently found in an apparently naturalized population in Franklin County by Gwen Barber. Barber 835.

4. PLANTAGINACEAE Plantago cordata Lam.
   Our thanks to Dr. Tom Clark for sending a specimen of this expected species (p. 517 of Atlas) to the Fayetteville herbarium, collected by David M. Johnson in Randolph County. The specimen lacks leaves and has immature fruit, but is apparently correctly determined. Johnson 484.

5. POLEMONIACEAE Phlox carolina L. subsp. augusta Wherry
   A reedy of our Arkansas Phlox in light of the monograph by Wherry (1955, The Genus Phlox, Morris Arb. Monog. III, Phila., Penn., 141 pp.) indicates that most of what was treated as P. glaberrima L. in the Atlas is P. carolina L. subsp. augusta Wherry. The senior author seriously doubts that this entity should be maintained as distinct from P. glaberrima. McCoy 134.

6. POLEMONIACEAE Phlox carolina L. subsp. carolina
   Some of our material (Craighead, Hot Spring, and Polk Counties) of what was treated as P. glaberrima L. in the Atlas is this entity. Demaree 3397.

7. POLEMONIACEAE Phlox pilosa L. subsp. pulcherrima Lundell
   The dot shown for subsp. fulgida in Miller County in the Atlas is actually material of subsp. pulcherrima. Wherry's monograph shows it for several other southwestern Arkansas counties. Moore 490067.

8. ROSACEAE Rosa canina L.
   Material collected by Richard Davis from Franklin County may represent a local escape from cultivation. Davis 449.

   This cultivated species was collected by Gwen Barber in Franklin County where it is spreading from cultivation to form dense thickets locally by streams, river banks, and old home sites. Barber 503.

10. RUBIACEAE Galium arkanasum Gray var. pubiflorum E. B. Smith
    A new variety of this species, endemic to Montgomery County, has recently been discovered by the senior author and will be described in a coming issue of Brittonia. Smith 3358.

11. SCROPHULARIACEAE Parentucellia viscosa (L.) Caruel.
    This Eurasian species was first found in Arkansas by Gwen Barber in Franklin County. Barber 886.

12. VERBENACEAE Physa incisa Small
    This species was collected recently in Little River County, later in Perry and Franklin Counties. It is so similar to P. nodiflora that we suspect much of our "P. nodiflora" is probably P. incisa. This problem deserves additional study. Smith 3378.

13. GRAMINEAE Bouteloua hirsuta Lag.
    This Great Plains species was recently collected in Miller County by Jerry L. Roberts. Roberts 895.

14. LEMNACEAE Spirodea oligorhiza (Kurtz) Hegelm
    First collected in Arkansas by Marie P. Locke and known from her collections now, by Jerry L. Roberts, Clark, and Jefferson Counties. Locke 2677.

15. ORCHIDACEAE Spiranthes lucida (H. H. Eat.) Ames
    This expected species (p. 523 of Atlas) was recently collected in Stone County by Paul Redfearn. Redfearn 31747.

EDWIN B. SMITH and M. GWEN BARBER. Department of Botany & Bacteriology. University of Arkansas at Fayetteville, Fayetteville, Arkansas, 72701.

UNUSUAL CONCENTRATION OF SCARLET SNAKES (Cemphora coccinea) IN VILLAGE CREEK STATE PARK, ARKANSAS

In Arkansas, the Scarlet Snake (Cemphora coccinea) is not considered abundant at any locality where it has been found. Because of the secretive habits of this species, most no doubt escape the attention of collectors.

One specimen was collected by Dellinger and Black Occas. Pap. Univ. Ark. Mus. No. 611, 1938 in the Ft. Smith area and placed in the Univ. of Arkansas at Fayetteville collection, and several others were reported from the Ft. Smith area. Parker (Proc. Ark. Acad. Sci. 2:15-30, 1947) deposited a single specimen from Greene County in the Univ. of Michigan collection. Dowling (Ocas. Pap. Univ. Ark. Mus. No. 3, p. 31 1957) reported two specimens, UADZ 727 and UADZ 94 from Pike and Washington Counties and mentioned that there were few records of this species listed for Arkansas. Recent reports from central Arkansas were mentioned by Reagan (Ark. Natural Plan Publ. pp. 101-105, 1074). Byrd and Hanebrink (Herc. Review 7:123, 1976) reported two specimens, one from Izard County and one from Sharp County. No more than one specimen has been reported from any one county other than the reports by Dellinger and Black for the Ft. Smith area.

Since 1975, nine additional specimens have been found in Village Creek State Park located in Cross and St. Francis Counties in eastern Arkansas. The first specimen was collected as it crossed a gravel driveway in early July 1975. A second specimen was dug up in about two inches of humus on a ridge top during trail construction in late July of the same year. Two additional specimens were collected during trail construction in midsummer of 1976. In 1977, Scarlet Snakes were collected as they crossed park roads on the nights of 31 May and 1 July. Three more specimens were collected during the summer of 1978. On the evening of 24 June, a Scarlet Snake was found on the road near the park entrance. Another was found dead on the road on 4 July and measured 48.6 centimeters in total length. A final 42.3 centimeter specimen was found dead on the road on 9 July.

Village Creek State Park covers 7000 acres within the Natural Division of Arkansas known as Crowley's Ridge. The dominant tree species are White Oak (Quercus alba) and Beech (Fagus grandifolia). Other common species include various oaks, Sweetgum (Liquidambar styraciflua), Tulip Poplar (Liriodendron tulipifera), Sugar Maple (Acer saccharum), Mockernut Hickory (Carya tomentosa), and Sycamore (Platanus occidentalis).

Despite their striking markings, Scarlet Snakes elude collectors due to their burrowing habits. None Scarlet Snakes were collected at Village Creek State Park during the years 1975-1978. This represents the largest number collected in a single locality in Arkansas. All were found on roads during or after rain or were uncovered from forest humus during trail construction.


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PUBLICATION POLICIES AND SUGGESTIONS FOR AUTHORS

The PROCEEDINGS OF THE ARKANSAS ACADEMY OF SCIENCE appears annually. At least one of the authors of a paper submitted for publication in the PROCEEDINGS must be a member of the Arkansas Academy of Science. Each paper should contain results of original research, embody sound principles of scientific investigation, and present data in a concise yet clear manner. The COUNCIL OF BIOLOGY EDITORS STYLE MANUAL, published by the American Institute of Biological Sciences, is a convenient and widely consulted guide for scientific writers. Authors should strive for directness and lucidity, achieved by use of the active voice. Special attention should be given to consistency in tense, unambiguous reference of pronouns, and logically placed modifiers.

Preparation of Manuscript

It is strongly recommended that before submitting a paper, the author ask qualified people to appraise it. The author should submit two copies of the manuscript, tables, and figures. Manuscripts must be double-spaced (preferably typed with a carbon-ribbed typewriter on 8½ x 11 inch bond paper with at least one inch margins on all sides. Do not hyphenate words on the right-hand margin. The second copy may be carbon-ribboned.

An abstract summarizing in concrete terms the methods, findings and implications discussed in the body of the paper must accompany a feature article. The abstract should be completely self-explanatory.

A feature article comprises approximately five or more typewritten pages. A PROCEEDINGS printed page is equal to approximately three and one-half typewritten pages and the author is assessed a page charge for those papers exceeding two printed pages. A separate title page including the title in capital letters, the author’s names and addresses should be included with the manuscript. Feature articles are often divided into the following sections: abstract, introduction, materials and methods, results, discussion, acknowledgments, and literature cited. These sections should be centered and capitalized. Subheadings should begin at the left-hand margin, but more than one subheading should be avoided.

A general note is usually one to two typewritten pages and rarely utilizes subheadings. A note should have the title (capitalized) at the top of the first page with the body of the paper following. Abstracts are not used for general notes. The authors name and address should appear at the end of the manuscript. For other information concerning general note format consult Vol. 31 of the PROCEEDINGS.

Abbreviations: Use of abbreviations and symbols can be ascertained by inspection of recent issues of the PROCEEDINGS. Suggestions for uniformity include the use of numerals before units of measurement (5 millimeters), but nine animals (10 or numbers above, such as 13 animals). Abbreviations must be defined the first time they are used. The metric system of measurements and weights must be employed.

The literature cited section should include six or more references; entries should take the following form:


HUDSON, J.W. and J.A. RUMMELL. 1966. …….


If fewer than six references are cited they should be inserted in text and take these forms: (Jones. The adrenal cortex, p. 210, 1957) (Davis. J. Anim. Ecol., 2:232-238, 1933).

Tables and illustrations: Tables and figures (line drawings, graphs, or black and white photographs) should not repeat data contained in the text. The author must provide numbers and short legends for illustrations and tables and place reference to each of them in the text. Legends for figures should be typed on a separate piece of paper at the end of the manuscript. Do not run tables in the text. Illustrations must be of sufficient size and clarity to permit reduction to standard page size; ordinarily they should be no larger than twice the size of intended reduction, and wherever possible no larger than one manuscript page for ease of handling. Photographs must be printed on glossy paper; sharp focus and high contrast are essential for good reproduction. Figures and labeling must be of professional quality. Notations identifying author, figure number, and top of print must be made on the back of each illustration. All illustrations must be submitted in duplicate. Tables should be typed with a carbon-ribbed typewriter and in the exact format that the author wishes them to appear in the text. Tables will be printed using the offset process and thus must be of professional quality when submitted. Note preferred placement of figures and tables in the margins of the manuscript.

Procedure

It is the policy of the Arkansas Academy of Science that only papers presented at the annual meeting are eligible for publication and that the manuscript is due at the time of presentation. In accordance with this policy, manuscripts submitted for publication should be given to the section chairman as the paper is being presented. Correspondence after this time should be directed to the editor. The paper is then submitted to referees for checking of scientific content, originality, and clarity of presentation. Attention to the preceding paragraphs will greatly speed up this process. Judgments as to the acceptability of the paper and suggestions for strengthening it are sent to the author. If the paper is tentatively accepted the author will rework it, where necessary, and return two copies of the revised manuscript together with the original to the editor. Usually a time limit for this revision will be requested. If the time limit is not met, the paper may be considered to be withdrawn by the author and rejected for publication. All final decisions concerning the acceptance or rejection of a manuscript are made by the editor. When a copy of the proof, original manuscript, and reprint order blanks reach the author, they should be carefully read for errors and omissions. The author should mark corrections on the proof and return both the proof and manuscript to the editor within 48 hours or the proof will be judged correct. Printing charges accruing from excessive additions to or changes in the proofs must be assumed by the author. Reprint orders are placed with the printer, not the editor. Page charges, where applicable, and excessive printing charges will be billed to the author by the Academy of Science.

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Biological Abstracts
Chemical Abstracts
Mathematical Reviews
Recent Literature of the Journal of Mammalogy
Science Citation Index
Sport Fishery Abstracts
Wildlife Review
Zoological Record
Review Journal of the Commonwealth Agricultural Bureaux

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